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SPACES OF MEANING: AN ENACTIVE ACCOUNT OF BODILY SPACE

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Abstract: *While the interdisciplinary field known as Enactive Cognitive Science (ECS) has become increasingly prevalent in recent years, the theme of spatiality is a notably absent or, at best, understudied topic within the literature. This absence is especially puzzling when considering how deeply interconnected spatiality is with many celebrated themes of ECS, such as embodiment, intersubjectivity, affectivity, temporality and dynamic coupling with one's environment generally, all of which feature a spatial register. Indeed, ECS regularly employs the biosemiotic-spatial term 'Umwelt' yet rarely thematises the structure of this space as such. Adding to this puzzle is the fact that one of the most flourishing research areas in the cognitive neuroscience of spatiality – that of peripersonal space – had strong philosophical ties from the beginning. Not long after the discovery of peripersonal neurons, some of its key developers explicitly noted the compatibility between PPS and phenomenological accounts of bodily space (Rizzolatti et al., 1997). While there have been notable exceptions in the form of research articles (e.g., De Preester, 2012; Jackson, 2014; Gallese & Sinigaglia, 2010), this striking compatibility has not yet received doctoral-length or monographic attention. Simultaneously, PPS scholarship itself remains plagued with conceptual and definitional issues (Hunley & Lourenco, 2018; Bufacchi & Iannetti, 2018) that stand to benefit from interdisciplinary re-evaluation. To address these lacunae in the scholarship, I combine the resources of cognitive neuroscience, phenomenology and semiotics to explicate bodily space from an embodied-enactive standpoint. Firstly, I develop a theoretical account of lived space by utilising phenomenological and semiotic literature, especially Heidegger, Merleau-Ponty, von Uexküll and Peirce. Using this account of 'lived space' as a theoretical baseline, I interpret a series of empirical studies through this conceptual lens, dividing the empirical literature into studies that investigate spatial interactions with both 'Objects' and 'Others'. This culminates in an interdisciplinary, enactive model of bodily space, in which I propose that human beings engage their spatial surroundings not as a geometric grid or abstract volume, but as a qualitatively-structured space of meaning. In applying this model, I showcase how it simultaneously contributes to its antecedent philosophical disciplines, contemporary discourses in enactivism and toward building a more comprehensive definition of peripersonal space.*

Contents

“*There is no absolute up or down, as Aristotle taught; no absolute position in space; but the position of a body is relative to that of other bodies. Everywhere there is incessant relative change in position throughout the universe, and the observer is always at the center of things*” - Giordano Bruno (1584/1998).

“The fact that what is at hand can be encountered in its space of the surrounding world is ontically possible only because Dasein itself is ‘spatial’ with regard to its Being-in-the-world" (Martin Heidegger, 1927/2010, p.104/102).

“*Meaning is the pole star by which biology must orient itself, not the impoverished rules of causality which can only see one step in front or behind and to which the great connections remain completely hidden*” (Jakob von Uexkull, 1934/2010, p.162).

“*What defines place as something separate from the space taken up by a body is the relations of that body with other entities... For there is an intimate and indissociable bond between the body and the places it inhabits*” (Edward S. Casey, 1997, p.164/p.206).

Introduction: Peripersonal Space - *What*, *Why* and *How*?

I. What is Peripersonal Space?

This project aims to better understand human spatiality. To achieve this end, it shall utilise the methodological tools and interdisciplinary framework of enactive cognitive science (ECS) which can seamlessly incorporate discrete (but compatible) disciplines such as phenomenology, pragmatism, semiotics, neuroscience and clinical psychology under a single banner (Gallagher, 2023). The most coherent and well-researched juncture upon which this interdisciplinary analysis should take place pertains to the neuroscientific construct known as 'peripersonal space' (PPS), which has also been referred to as 'bodily space' (Gallese & Sinigaglia, 2010, Jackson, 2014). *Why* PPS stands out as the optimal thematic candidate for this research - in addition to *how* we shall conduct it - shall be discussed in further detail below. For now, it is prudent to briefly provide a literature review as to *what* 'Peripersonal Space' is.

In providing an initial, schematic outline of the construct of peripersonal space (PPS), we will first briefly review the extant neuroscientific evidence that has accumulated over the past 45 years. The existence of a body-centred, multimodal peripersonal space mapped by the brain was first hypothesised by Rizzolatti et al. (1981) as a theoretical means of highlighting the interconnection between somatosensory and visual processing (Pellegrino and Ladavas, 2015) localised to the ventral premotor cortex. Two years later, further indirect evidence for PPS was found by Rizzolatti et al. (1983), following a surgical ablation to the Macaque postarcuate cortex, which was found to inhibit reach-to-grasp actions. Subsequently, a specific class of neurons was discovered that seemingly undergirded this once-hypothetical construct by Fogassi et al. (1992), who discovered that visual neurons in Brodman's area 6 coded visual stimuli in a body-centred spatial frame of reference emphasising the spatial area surrounding the body. Collectively, this evidence strongly indicated that the brain-body treated the space around *itself* very differently from other areas of space (i.e., on a body-centered, interactive basis) and that this cognitive-experiential phenomenon featured discrete neural correlates.

Over a decade after Rizzolatti and co-author's (1981) original hypothesis, more direct evidence for the existence of peripersonal space arrived in the form of intracranial recordings, confirming the existence of so-called ‘peripersonal neurons’ (PPNs) (Graziano & Gross 1993; Graziano, Yap & Gross, 1994). Originally assumed to respond solely to tactile stimuli (Graziano, 2018), it was discovered that these neurons also activated whenever objects were placed nearby or approached the monkey. For instance, an object that was extended towards the monkey’s head would cause the ‘tactile’ neurons to fire once the object entered a certain proximity (see Graziano, 2018). This further supported the idea that spatial, perceptual and motor capacities were all interconnected according to a body-centered perspective that was dynamically structured (Rizzolatti et al., 1981, 1988).

The mounting neurophysiological evidence thus strongly supported the proposed interconnection between spatial perception and the motor system, vindicating Rizzolatti’s (1981) original hypothesis that the space around the body was uniquely processed on an interactive, cross-modal basis. Indeed, the discovery of PPNs was remarkably analogous to the discovery of mirror neurons (MNs), discovered by the same research group that hypothesised PPS’ existence (Rizzolatti et al. 1988; 1996; Gallese et al., 1996). Indeed, the discovery of mirror neurons was essentially in parallel with the Parma team’s investigation into peripersonal space (Iacoboni, 2008). Like MNs, PPNs were found quasi-fortuitously in the brains of macaque monkeys in the format of single-cell recordings taken from intra-cranial electrodes, in frontal areas F5 and F4 in macaques (Graziano et al., 1994; Gross and Graziano 1995; Fogassi et al. 1996).

Peripersonal neurons were then discovered to inhabit several neural regions: the ventral premotor cortex and the posterior parietal cortex (Brozzoli et al. 2012) and the VIP area (Duhamel et al., 1997; Bremmer et al., 2001). Moreover, like MNs, while PPNs were first discovered in the Macaque brain, subsequent human subjects research found peripersonal neurons in the human brain (di Pellegrino et al., 1997). PPS is also connected with the ventral and dorsal premotor cortex (Fogassi et al., 1996; Graziano et al., 1997), intraparietal sulcus (IPS) and putamen (Graziano et al., 1997; De Vignemont, Serino, Wong & Farne, 2021, p.5). Furthermore, it was found that PPNs are not only sensitive to visual and tactile stimuli as initially discovered, they also respond to auditory and interoceptive stimuli present within the peripersonal region (Fogassi et al., 1996; Graziano et al., 1999; Ferri et al., 2015; Adrizzi & Ferri, 2018). Thus, PPNs are intrinsically multimodal neurons, receptive to several kinds of sensory information (i.e., the sight, sound, feel and odour of an object), while the automatic integration of these sensory channels serves to determine the size and contours of the peripersonal region itself (Serino, 2019). Moreover, while their focus is always centred around the body, peripersonal neurons may emphasise a particular, 'online' body part, such as the face (Gentilucci et al., 1988; Serino, 2019) or hand (Bassolino et al., 2010; Zanini et al., 2021). As such, one's spatial embeddedness in an environment is dynamically updated by all sensory modalities in addition to several other qualitative factors, as shall be explicated later.

More recent neuroscientific findings have continued to confirm this hypothesis. For instance, Brozzoli et al. (2010) discovered that engaging in grasping actions enhances visuo-tactile integration around the space of the hand, even before the action is completed, so that "performing actions induce a continuous remapping of the multisensory peripersonal space as a function of on-line sensory–motor requirements" (Brozzoli et al., 2010, p.796). As Serino (2019, p.145) adds, the neural topography of PPNs supports this idea as "vPM is actually a motor region, and area F4, in particular, directly projects to the spinal cord and to M1". PPS is thus inseparably connected to the motor system and is integral to the brain-body's ability to act in space.

This takes us to the related construct of the 'receptive field' (RF), which denotes the amount of space that a sense-specific neuron will respond to; i.e., the area or distance at which auditory, visual or tactile stimuli active their corresponding neurons (Fogassi et al., 1996). Peripersonal neurons can feature comparatively large receptive fields due to the tendency for these RFs to expand (Bufacchi & Iannetti, 2018). Not all PPNs respond to events at all distances, as some respond to objects 10cm away from the body while others respond to objects on the threshold of one's reaching ability (Graziano et al., 1999). PPNs are, of course, receptive to entities near the body since, if PPS is indeed a "multisensory-motor interface" with the world (Serino, 2019), it must prioritise spatial entities that the body can plausibly interact with.[1] But PPN receptive fields are highly plastic and adaptive. In a significant sense, then, peripersonal space is an *extended-embodied* space insofar as it is a spatial region anchored to the body - its primary and enduring point of reference – but automatically expands outwards or retracts when necessary, entailing that its very extendibility is always prefigured into its encoding in the brain (Fogassi et al., 1996; Iriki et al., 1996; Serino, 2019).

But recall that one's PPS is neither solely nor always anchored to one's entire body in a uniform way. Rather, PPS can seemingly be anchored to and emphasise *particular* parts of the body in relation to tasks, dynamically prioritising body parts or the entities that are close to or relevant for that body part (Gentilucci et al., 1988; Graziano et al., 1997;

Bassolino et al., 2010; Zanini et al., 2021). Indeed, neurophysiological evidence suggests that peripersonal neurons in circumscribed brain regions correlate with particular body parts. For instance, as Clery et al. (2015, p.318) note, citing prior evidence: "VIP neurons encode visual information in a gradient of eye- to head- frame of reference, while tactile stimuli are encoded in a stable, unique head-centred frame of reference (Duhamel et al., 1997; Avillac et al., 2005)", whereas arm-related PPS is associated with areas F5 and 7b (Rizzolatti et al., 1988; Rizzolatti & Luppino 2001; Raos et al., 2006).

Of further intrigue to Graziano and colleagues (1997, 1999) was the fact that conscious awareness seemingly is not a necessary condition for PPN activation. The macaque's peripersonal neurons would fire upon approaching objects even when the monkey was anesthetised, so long as the object was placed in front of the monkey's eyes (Graziano et al., 1997, 1999; Graziano & Gandhi, 2000). Thus, seemingly no or little conscious perception of the stimuli was required (on the part of the monkey) to evoke the characteristic PP neural responses. Accordingly, if PPN activity is not under conscious control, then the modulation of spatial experiences is, at least in many cases, entirely non-volitional and automatic. This shall be pivotal for our definition of PPS as 'enactive interface' later. The organism in no way chooses to carve out a region of space as 'peripersonal' nor controls its responses to stimuli there. By implication, the brain-body maps PPS without the recruitment of conscious thought, thereby reflecting a more primordial, deeply-rooted mode of spatial existence. Accordingly, we can henceforth designate the spatial relation between the agent and environment as 'spatial embeddedness'.

Thus, the plastic, body-part reference frames that scaffold the current manifestation of PPS can change rapidly and automatically (Serino, 2019), showcasing how peripersonal space's neural representation is always in reference to both the body itself and to things near or approaching the body in a task-related and context-specific way. In a review, Serino (2019, p.138) employs the example of a bee that flies first around one's arm and then around one's head. Responsive to the flying insect buzzing around, PPS becomes 'tuned in' to each different body part that the bee moves toward, tracking it. Interestingly, this is the case even when the agent's gaze is directed away from the body-part, or the position of the body changes in the midst of an activity (Rizzolatti et al. 1997; Graziano and Cooke, 2006).

These reflections bring us directly onto the functionality of PPS, an area of intense and ongoing study and debate (e.g., Cardinali et al., 2009; de Vigemont & Iannetti, 2015; Clery et al., 2015; Bufacchi & Iannetti, 2018, De Vignemont et al., 2021). As an interface that mediates (or blurs the traditional distinction between) 'self' and 'environment', perhaps the most obvious biological function of PPS is one of protection (Graziano & Cooke, 2006). Peripersonal neurons are receptive to objects near the body in a bubble of space purportedly operating as a kind of 'alarm system' or invisible "second skin" (Graziano, 2018, p.1). Several experimental findings appear explainable with this hypothesis. For example, Fogassi et al. (1996) found that fast-moving stimuli were detected earlier than slow-moving stimuli while Taffou & Viaud-Delmon (2014) found that threatening objects produce faster responses and trigger PPS expansion. In sum, *qua* 'second skin' (Graziano, 2018), PPS supposedly operates as an outer protective barrier surrounding the more vulnerable, 'real' body, the former acting as a kind of primary defence system for the latter.

Importantly, however, protection and defence in the most literal sense cannot encompass the entirety of peripersonal spatiality. Defence appears to be only *one* function of peripersonal space (de Vignemont et al., 2021).[2] Because the boundaries of PPS are not fixed, they are routinely characterised as 'plastic', 'elastic', 'flexible' or 'dynamic' by experimental researchers (e.g., Clery et al., 2015). Indeed, Ciaunca et al. (2021) use the same 'second skin' metaphor but instead emphasise the contextual functionality of PPS, not its defensive properties.

Unsurprisingly, one's bodily size is one factor determining overall PPS size (Longo and Lourenco 2007). But as noted by Clery et al. (2015, p.319), a staggering "variety of endogenous and exogenous factors" modulate PPS size and shape, reflecting the multitude of ways in which embodied agents qualitatively engage surrounding spaces and the things encountered therein. In fact, one may observe an essentially identical extension at the metric level (e.g., increase in PPS size) triggered by a striking variety of diverse, even conflicting, causes. This metric *homogeneity* stemming from a functional-situational *heterogeneity* is sometimes even labelled 'paradoxical' (Masson et al., 2021). Accordingly, attempting to dissolve such paradoxes by showcasing their underlying situational logic is one primary goal of this work. However, this heterogeneity has led to widespread issues surrounding the optimal definition of PPS (de Vignemont & Iannetti, 2015; Hunley & Lourenco, 2018, Bufacchi & Iannetti, 2018).

If PPS prioritises the space surrounding the body, how must cognitive scientists conceptualise the area of space lying outside of PPS? The area of space that is visible but outside of the agent's zone of manipulability is termed 'extra-personal space'.[3] Intriguingly, if the participant senses their body to be located at a different place compared with its objective location, their PPS will be anchored to its *sensed* location rather than its *objective* position. As Adrizzi & Ferri (2018, p.79) explain: "Interestingly, recent studies have shown that PPS is centred at the subjectively perceived location of the bodily self, rather than at the location of the physical body". As shall be discussed, these boundaries are not necessarily static and might intersect in certain cases. This fact thus opens the door for a model of spatiality that is not always linked with the objective body's location in physical co-ordinates.

To recap, as a 'multisensory-motor interface' (Serino, 2019) that facilitates interactions between the embodied agent and the surrounding world, entities encountered within the realm of peripersonal space are perceived and engaged very differently to those entities encountered outside of it, as originally hypothesised by Rizzolatti et al. (1981). Of course, PPS is not only important for simply *perceiving* objects within reach; indeed, its functional significance hinges upon one's ability to *actually* reach for and grasp said objects, as well as coding unreachable objects *approaching* the body, which partially explains its famed plasticity. However, what about objects not simply near to or approaching the agent, but being physically wielded by the agent? Several foundational PPS experiments have discovered that one's PPS is profoundly modulated by tool-use itself (e.g., Iriki et al. 1996; Berti and Frassinetti, 2000; Costantini et al., 2011; 2014), the size of which is determined by the length and design of the tool and the task it is paired with (see Farnè et al., 2005; Martel et al., 2016).

Indeed, because tools expand the spatial area in which agents can physically engage their environment, Graziano (2018) claims that the agent's PPS "wraps around" the tool in use, purportedly treating it as an extension of the agent's body (see Iriki et al., 1996). The notion that PPS allows the body to incorporate tools is now a foundational and well-replicated finding in PPS (see Holmes & Spence, 2004; Martel et al., 2016; Serino, 2019). De Vignemont (2018), however, has claimed that the agent does not completely embody the tool since pain is not felt in the tool like in real limbs. Whatever the case, however, tool-use measurably influences PPS size and shape to reflect how a larger portion of one's surrounding environment is rendered available for interaction. An interesting variant of this experiment demonstrated that this phenomenon pertains not only to physical tools but virtual tools (Bassolino et al., 2010) and even to mere tool-use observation (Costantini et al., 2011; 2014). Tool-use thus figures heavily in all accounts of peripersonal spatiality, modulating cognition at both motor and perceptual levels and fundamentally transforming the sensorimotor relationship between agent and world. As this is one of the most robust findings in PPS scholarship, the optimal way of depicting this spatial relationship in accordance with both theoretical and experimental evidence shall be a major theme in this project.

Additionally, it has been found that PPS is highly responsive to the agent's emotional state as well as to the emotions of others, the nuances of which are increasingly revealed experimentally. For instance, in the presence of fear-inducing stimuli, the PPS of the fearful subject expands (Vangoni et al., 2012; Taffou and Viaud-Delmon, 2014; Ferri et al., 2015), yet it also reacts similarly to the presence of a fearful other (Ellena et al., 2020; 2021). PPS has also been found to correlate with more permanent traits such as anxiety (Sambo & Iannetti, 2013) and claustrophobia (Lourenco, Longo & Pathman, 2011). Moreover, Adrizzi and Ferri (2018) found that higher interoceptive accuracy correlates with a narrower PPS. However, this does not necessarily imply that affective modulations relate only to 'inner' influences over PPS, as our subsequent discussions of mood should demonstrate (**1b.1.4**; **2.2.3**).[4]

Furthermore, in line with the 'intersubjective turn' in the neurosciences (De Jaegher, 2018), there is also mounting evidence that PPS is profoundly influenced by social factors. Considering the importance of intersubjectivity in mind, coupled with the facts that space lies 'outside' of the agent and PPNs appear related to mirror neurons, it is perhaps unsurprising that peripersonal space is highly amenable to social influences (e.g., Caggiano, 2009; Costantini et al., 2010; Teneggi et al., 2013 Ellena et al. 2020; 2021) and seemingly serves as an example of the socially extended bodily self (Froese & Fuchs, 2012). The role played by peripersonal space in MN responses appears to be that of modulating how the agent (pre-reflectively) interacts with the observed party, taking place in what has been termed a "we-centric shared space" (Gallese, 2003, p.172). Even morality, a paradigmatically complex and multifaceted 'higher-order' phenomenon, can measurably influence the brain's mapping of bodily space (Iachini et al., 2015; Pellencin et al., 2018; Fini et al., 2020).

Finally, there is emerging evidence that PPS may represent a previously under evaluated component of several clinical conditions. Conditions as diverse as restrictive-type anorexia (Nandrino et al., 2017) and trauma (Rabellino et al. 2020) seemingly feature bodily spatial signatures. But perhaps the most compelling evidence pertains to autism spectrum disorder (ASD) and schizophrenia (SZ). Noel et al. (2017) characterise ASD and SZ as approximating a respective proneness or disinclination to merge spatial boundaries with others. Thus, Noel and colleagues argue that peripersonal spatiality in schizophrenia is characterised by exceptionally strong boundaries, while ASD is characterized by exceptionally weak boundaries. Developing a detailed language for adequately capturing spatial experiences in dialogue with scientific evidence is doubly important if clinical conditions continue to be shown to feature a bodily spatial component.

As such, PPS proves responsive and even essential to movement, tool-use, emotion, perceived emotion, co-operation, personality traits and a whole host of other factors which, taken accumulatively, call for a renewed, enactivist model of how the intercorporeal self exists in the public and practical world. In providing even this scant overview of the neuroscientific construct of peripersonal space, it became apparent that describing the peripersonal system with a solely neurophysiological lexicon is inadequate for capturing the totality of the way that our brains (or rather: brain-bodies) engage their spatial surroundings. Neurophysiological description alone cannot exhaust the full spectrum of the construct known as PPS. That is to say, solely describing events occurring 'inside' the brain as quantifiably measured by neuroimaging (e.g., topographical location in the brain or PPS metric extension) is inadequate for producing a complete account of embodied spatial cognition. A brain lacking resonance with pragmatic, affective and social factors would not feature the dynamics of PPS as typically observed, which means that a novel conceptual framework is required to give voice to these multivariate influences (Fuchs, 2018).

Thus far, several competing operational definitions of PPS have been proposed (e.g., Brozolli et al., 2012; Hunley & Lourenco, 2018; Bufacchi & Iannetti, 2018; Serino, 2019), which we will discuss at various points throughout this thesis. While we shall present our own operational definition later, De Vignemont & Iannetti (2015, p.4) helpfully propose 5 factors characteristic of PPS that we should bear in mind when we later provide our own definition:

> (i) Bodily reference frame: The PPS is anchored to specific body parts, and moves when the body parts move. (ii) Multisensory vigilance: The perception of objects and events occurring in PPS triggers the allocation of attention. (iii) Sensorimotor relevance: Objects and events perceived in PPS are represented in terms of possible actions. (iv) Plasticity: The boundaries of PPS are flexible.

At this juncture, it is prudent to note that these reflections, while not yet thematised at substantial length, are by no means controversial in 'traditional' cognitive neuroscience. On the one hand, the cognitive-experiential and behavioural correlates of neural activity are always at the forefront of research in cognitive neuroscience (Sullivan, 2015). Experience and consciousness are thus vital, even ineliminable, pieces of evidence for revealing the nature of PPS, even from 'standard' accounts (Varela et al., 1991). Moreover, statements convergent with our own enactive approach are profuse in the available literature. For instance, Bassolino et al. (2010, p.804) note: "an important property of PPS is the possibility of being modified as a function of experience", while Spaccasassi et al. (2021, p.2150) claim: "objects located inside PPS are represented in terms of potential actions… PPS is not solely a metrical representation of the space around us but includes a more complex (operational) representation".

Even as far back as late '90s, Rizzolatti et al. (1997) positively compared PPS with Merleau-Ponty's spatial phenomenology. Correspondingly, Gallese & Sinigaglia (2010, p.130) argue that "bodily space is basically and constitutively given to us as the horizon of our own action possibilities". More recently, Gallese (2018, p.33) frames motor spatiality in explicitly embodied-enactive terms that strongly evoke phenomenological and biosemiotic descriptions of lived space when he argues that "the functionality of the motor system literally carves out a pragmatic Umwelt, dynamically surrounding our body" and that the inescapably sensorimotor dimension to spatial cognition means that "the visual world is always also the horizon of our potential pragmatic relation to it" (Gallese, 2016, p.300). The present thesis, therefore, aims to develop upon these insights.

While mapping peripersonal space's neural correlates is incontrovertibly a highly fruitful endeavour that continues to generate important results, our contribution to the literature is not orientated toward discovering new neural regions but further cataloguing, and philosophically contextualising, its functions and cognitive-experiential correlates while attending to conceptual and definitional problems and debates (Hunley & Lourenco, 2018). Without such conceptual work, one may remain stumped by the 'paradoxes' stemming from identical, metric PPS responses that stem from highly divergent experimental tasks (Masson et al., 2021). Indeed, De Vignemont et al. (2021, p.6) recently asserted in a review that "one of the main challenges in the field is to offer a satisfactory definition of peripersonal space that is specific enough to account for its peculiar spatial, multisensory and motor properties."

To be sure, a detailed investigation of PPS from an embodied-enactive standpoint, as conducted here, contributes toward explaining, contextualising and defining the famously liquid notion of PPS. We aim to accomplish this by understanding peripersonal space's influences, constraints, triggering conditions, first-person characteristics and distinctions from similar constructs, all of which simultaneously expand the construct and content validity of PPS whilst helping researchers better understand its functionality. Moreover, closing the gap between the cognitive-phenomenological and neurophysiological dimensions of PPS permits a richer understanding of human spatiality, demonstrating how scientific evidence can both enrich and support existing philosophical accounts and vice versa (Varela, 1996), revealing the 'cognitive correlate' to discoveries made by neuroscience proper. Heightened focus on these 'subjective' aspects are particularly crucial when considering the disruptions in spatiality found in clinical disorders, as it is in the patient's subjective life that these disorders manifest most prominently. The most pertinent remaining question left to ask, then, is *which kind of* meta-theoretical model is appropriate for conceptualising this 'cognitive-experiential' dimension of peripersonal spatiality and thereby optimising our definition of it?

II. A (very) Brief History of Space

As suggested, an explication of 'peripersonal space' necessitates a detailed conceptual model of space *proper* that somehow remains congruent with (and explicatory of) the vast array of empirical findings discussed above. If a model of a qualitatively-structured spatiality appears integral for developing our wide-ranging account of PPS, then which theoretical account is most appropriate for doing so? Certainly, 'space' can be employed in a myriad of ways across disciplines, to the extent that the family resemblance between such conceptions might more resemble distant cousins than siblings. Since our interdisciplinary account liberally incorporates evidence from across both science and philosophy, might one look to definitions of space provided elsewhere in the sciences or, alternatively, within the canons of classical philosophy?

Before proceeding further, it is integral to first briefly discuss different operational definitions of space as to evaluate their degree of compatibility with the concept of PPS as revealed by the empirical data detailed above. Firstly, we will give an extremely brief overview of how 'space' is treated in the history of philosophy. For Plato, space was something ideal but receptive (Casey, 1997) while, for Aristotle, space was a 'continuous volume or magnitude', in a an account of space that, compared with Plato's, was closer to geometry than to mathematics (Evans, 1955). Moving to the early modern period, Descartes (1641/2013) focused heavily on space's material extension, which he took to be definitive of space itself and substantially separated from mental phenomena, leading to his famous division of reality into two substances: *res extensa* and *res cogitans*. In the 17th century, both Locke and Leibniz subscribed to a relational view of space , albeit for different (Casey 1997, p.211) while Leibniz developed an "new geometry of space which was fateful for the determination of spatiality qua site" (*ibid*., p.205).

As part of his 'Copernican revolution', in Kant's *Critique of Pure Reason* (1781/1965, p.71/B43-A27), space is intuited as something outside and infinite but only knowable via man's cognitive capacities:

> Solely from the human standpoint that we can speak of space, of extended things, etc. If we depart from the subjective condition under which alone we can have outer intuition, namely, liability to be effected by objects…the representation of space stands for nothing whatsoever. This predicate can be ascribed to things only in so far as they appear to us, that is, only to objects of sensibility.[5]

Continuing in the tradition of German idealism, Fichte's notion of space is a jointly "geometrical, transcendental and political system" that he aimed to integrate into a singular account (Martin, 2014). Increasingly, however, from the late 17th until the 19th century: "Space on the modernist conception ends by failing to locate things or events in any sense other than that of pinpointing positions on a planiform geometric or cartographic grid" (Casey, 1997, p.201). The abstraction of space and its severance from qualitative characteristics thus seems almost complete.

More recently, Lefebvre (1991), adopting a more sociological approach to space, argues that the Renaissance concept of public space was concealed by developments in the nineteenth century, which was characterised by an increasingly privative and quantitative notion of space. Lefebvre argues that the dominance of capitalist finance left the everyday, social and aesthetic dimensions of urban locations underdeveloped, increasing alienation with deleterious effects on communal space. Casey (1997) adopts a similar story of change from the perspective of metaphysics that broadly reflects the absorption of the qualitative into the quantitative, the intellectual consequences of which reverberate to this day.

Despite the penetrating insights of these philosophical accounts, none of them strike us as particularly conducive with the contextual, body-centric, asymmetrical and ever-shifting nature of peripersonal space as disclosed by the empirical evidence. If discursive treatments of space in metaphysics, logical and even sociology are ill-suited for our purposes, could scientific models of space fare better? After all, we aim for this thesis to contribute toward a *neuroscientific* model of human spatiality. Might we reapply scientific findings conducted elsewhere to the study of the brain as a natural phenomenon continuous with the other natural sciences?

Astronomy offers a model of space which may figure as the layperson's idea of an academic treatment of space but is clearly inappropriate. Geometry likewise suffers from obvious adequacies: while PPS changes in measurable size, we know that identical metric changes may occur for vastly different tasks. If PPS is three-dimensional and relational, what then about topology? In fact, throughout the nineteenth century, in mathematics and natural philosophy, topology became seen as increasingly essential since "topology was the science investigating the properties of physical continuity in actual space" (Epple, 1998, p.381), which cohered well with the continued mathematisation of physics (and therefore space), as also recounted by Casey (1997), which also renders it suboptimal for understanding bodily space.

What, then, of accounts found in physics? Perhaps the two most famous historical physicists are Newton and Einstein who may serve here as case examples. Newton pioneered a notion of absolute space (Rovelli, 2006, p.32) which conferred "reality a global frame [in which] every object [has] the equal dignity of a position in a uniform space". This was then famously challenged by Einstein's rejection of absolute space. Einstein is, of course, famous for his concepts of 'special relativity' (1905/1987), which was then followed by 'general relativity' (1915/2015). In these models, time and space were thus united into the compound word 'spacetime' which was found to be curved and relative. Interestingly, on Rovelli's (2006, p.29) account, while space itself is relative, *spacetime* is absolute in the Newtonian sense.

Each of these rich accounts of space from across science and philosophy display remarkable heterogeneity, encompassing a staggering variety of scientific and philosophical positions, so much so that is almost foolish to categorise them together. However, if we were to be foolish nonetheless, one might argue that a detectable and salient commonality unifying each of these diverse accounts is precisely what renders them sub-optimal for the model of human spatiality pursued here. Specifically, each account of space listed above conceives space as either an abstract or quantitative phenomenon. It might be further stated that such accounts of space are the products of intellectual speculation and complex analysis conducted by (typically gifted) human beings; yet this is not the format in which space is presented to human beings in their everyday lives - scientists and philosophers included.

Despite the undeniable importance, application and intellectual impressiveness of abstract and/or quantitative models of space, they seemingly do little to reveal how human beings – and their brains – experience spatial reality *before* abstract objectification, which pertains precisely to the structural dynamics of PPS. Of course, philosophers and scientists must use their brains to perform such complex feats (which thus feature discrete neural correlates) and we do not imply that one model of space is superior to another. Yet, we are here attempting to understand the phenomenon of bodily space as it emerges in adaptive attunement with the variety of tasks, functions, emotions, object-interactions and social situations that one finds oneself immersed in on a daily basis.

We might, therefore, propose that we are seeking the *pre-reflectiv*e cognitive correlates (PrCC) to spatiality, i.e., how space manifest before objectification can occur. As PPS seemingly denotes a kind of space which is pre-reflective, outside of volitional control, sensitive to changing conditions and experientially meaningful, quantitative measurement falls short of exhaustively describing the characteristics of this distinctly human spatiality. Meaning and context are, instead, ineliminable ingredients for understanding how human beings experience space in a primordial sense.

So, if metric and de-contextualised accounts of space prove unsatisfactory, perhaps cognitive psychology might offer a better model? After all, psychology often aims to faithfully relay experience and cognition.[6] Once more, however, it is not clear whether traditional cognitive psychology is fully compatible with all of embodied or pre-reflective spatial cognition. For instance, spatial ability is defined in Linn and Petersen (1985, p.1482) rather abstractly as “skills in representing, transforming, generating and recalling symbolic, non-linguistic information” while other experimental tasks measure ratio-scaling or shape rotation in an arguably somewhat disembodied manner (e.g., Tolorado & Shallice, 2004; Bernadis & Shallice, 2011).

Such cognitive and psychophysical investigations, while highly revelatory, treats space as somewhat abstract, devoid of its contextual placement in the lived world. For instance, when an agent’s PPS alters due to witnessing the emotional expressions of others (Ruggiero et al., 2017; Cartaud et al., 2018), for example, it is not clear that any symbolic information is being represented, transformed or recalled. Neither is ‘space’ itself thematised as an intentional-object such as when one judges how much liquid a beaker can hold. Rather, one’s PPS, as an extension of the lived body *(Leib)* (Husserl, 1913), is constitutive *of* the global spatial situation itself. Moreover, a spatial disorder may engender deficits in everyday activities that manifest in how one practically engages with objects and others in space, leaving symbolic manipulation (e.g., 3D shape rotation) intact. People with ASD, for example, display deficits in intersubjective bodily space (Noel et al., 2017; Candini et al., 2019; Mul et al., 2019) yet may not incur difficulties whatsoever with symbolic representation or mentally rotating shapes; in fact, such abilities may even be superior in ASD subjects (Nakano, 2012). Apparently, then, classically cognitivist accounts may not be fit for purpose here, or at least non-exhaustive.

The human capacity to perform symbolic manipulation or complex geometry certainly features neural correlates because human beings use their brains to accomplish such feats. But in PPS research, these thematic treatments of space as an objectified 'thing' take a backseat, at least insofar as the brain-body's perspective itself is concerned.[1] We might here follow Heidegger and label this kind of pre-reflective spatial experience as 'primordial' because it structures human spatiality at a level prior to that of explicit cognition, serving as the foundation for more explicit, conceptual dimensions of thought. Put simply, humans could not do geometry or physics if they were not *first* spatial beings-in-the-world. Moreover, it is spatial *experience* that neuroscientific models aim to capture as the 'cognitive correlate' to their neurophysiological discoveries (e.g., how the agent experiences near-space as a region for interaction).

At this juncture, it remains important to reiterate that the framework adopted here is not somehow in opposition 'mainstream' cognitive neuroscience. On the contrary, neuroscientists investigating PPS have repeatedly highlighted that models of space primarily defined by space's metric measurability fail to tell a complete story. Indeed, Ferri et al. (2015) highlight that the experimental evidence suggests that PPS is inherently 'functional', not 'metric', while Caggiano (2009, p.406) write "the presence of mirror neurons that encode space [do so] not in metric but in operational terms". Similarly, Bufacchi & Iannetti (2018, p.1083) think that viewing the spatial relationship between minds and other entities as defined solely by metric proximity "does not explain the effect of other factors, such as stimulus valence, lateral motion and social interactions that are instead explained by considering contact-related action relevance". Bufacchi and Iannetti (p.1083) go on to critique something approximating a Cartesian model of space, which

[1] Of course, complex mathematical processes are ineliminable for the experimental investigation of peripersonal space itself.

views entities as occupying points on a grid, rendering their relationship as solely intelligible via quantitive measurement, instead highlighting that:

> The concept of contact-related behavioural relevance fits well with the perspective of interactive behaviour: rather than conceptualising behaviour as a stepwise process from sensory input to cognition to motor output, the interactive behaviour framework describes behaviour as a set of simultaneous processes specifying potential motor actions and selecting among them.

Finally, as Bufacchi and Iannetti cogently illustrate, defining PPS as merely 'the space around the body' fails to even distinguish between an alive or deceased human being. While a corpse undeniably occupies a physical location in objective space, it does not (we might hope) engage the world in the same format as does a living, breathing human. Drawing from the phenomenological tradition, a living person engages their surrounding world in the modality describable as 'lived space'. It is indeed as a 'lived body' that the agent pre-reflectively experiences their spatial surroundings as a meaningful place that elicits context-driven (inter)actions. Our main target, then, is exactly this kind of 'primordial' or 'lived' space, with a further view to observing how this form of space coheres with experimental data in the neurosciences.

To summarise, human spatiality as revealed in the empirical PPS literature appears to be something inherently situational, interactive, intersubjective and task-dependent, displaying a remarkable adaptivity and plasticity according to the situation. These modes of spatial engagement with the world must be carefully and faithfully relayed in their own terms whilst being incorporated into a science-compatible model of human spatiality. However, fully accounting for these features invites a turn away from the spatial constructs and concepts proliferated in geometry, physics, metaphysics and even cognitive psychology. If the conceptual model of space most appropriate for understanding PPS is best defined as 'lived space', the relational structure of which hinges upon meaning, then a further question naturally arises: *which conceptual resources are most appropriate for building such a model of spatiality?*

III. Towards a Model of Lived Space[2]

Mounting empirical evidence suggests that, in most everyday circumstances, human beings do not engage their spatial surroundings as something approximating an empty container, geometric grid or infinite volume. We can certainly retain the notion found throughout many other disciplines that space is a nexus composed of relations (see Casey,

[2] Some core ideas here, as elsewhere in this thesis, are reiterated in Sykes (2021) and Sykes (2023). I refer the reader there for further clarification.

1997) and that these relations (and the *Gestalt* emergent from them) are amenable to dissection and analysis. However, since “metric virtues premised on their continuity and selfsameness over time” (Casey, 1997, p.201) the plastic nature of PPS cannot be grounded on quantitative models of space. Instead, the glue fastening these relations together, rendering space intelligible (both individually and collectively) in the primordial sense indicated above are those of *meaning*, *context* and *signification*, all of which appear conceptually incompatible with a physicalist, Cartesian-geometric or even computational model of objective space.

Just as phenomenologists and cognitive scientists have long distinguished between the ‘lived’ and ‘objective’ *body* (Husserl 1921/2001, 1913/1989; Merleau-Ponty 1945/2012; Gallagher, 2005), at the heart of the present analysis is a proposed distinction between ‘lived’ and ‘objective’ *space*. Or indeed, following both Merleau-Ponty (1945/2012) and Gallese & Sinigaglia’s (2010) term: ‘bodily space’.[3] For present purposes, I shall use peripersonal space and bodily space interchangeably. Not only was the term ‘bodily space’ employed (as shall be shown) rather prophetically by Merleau-Ponty (1945/2012) but, as Gallese and Sinigaglia (2011, p.132) stipulate, “peri-personal space *is a* bodily space characterized by an action-dependent dynamic plasticity” [emphasis added]. Indeed, ‘bodily space’ naturally extends the notion of a ‘lived body’ (*Leib*), which has arguably been a noteworthy success story of phenomenological and neuroscientific cross-fertilisation (e.g., Gallagher & Cole, 1995; Cole, 2008; Raoul & Grosbras, 2023).

Indeed, the presence of meaning seemingly provides the organising principle that underpins the famous adaptability that seems inherent to peripersonal spatial cognition. Changes in the meaning of one’s surroundings instantly confer a multitude of spatial perspectives that structure how the surrounding world is intrinsically laid out to the embodied agent within it. But how then does an agent solidify spatial meaning within a *particular* situation? In a semiotic account of space, Gaines (2006, p.177) writes: “spatial relationships are always possible at many levels and from different points of view; but without a fixed point of view there is no hierarchy among possible interpretations”. Space *qua* empty container represents such a ‘void’ in which without a “fixed point of view”, bereft of any hierarchy of meaning or value can be established and one’s situated spatiality is left groundless and adrift. While *objective* space is ultimately and necessarily centre-less (Casey, 1997), *lived* space is only intelligible to the extent that an embodied ‘here’ acts as

[3] See also Jackson (2014).

its nucleus. Indeed, as discussed above, PPS is anchored to the subjectively-experienced body, rather than the body's location in objective space (Noel et al., 2015; Adrizzi & Ferri, 2018).

Importantly, however, peripersonal space is also anchored to the embodied individual as he is situated in an intersubjective-cultural setting. This means that one's peripersonal space is not akin to an isolated capsule that drifts through the Universe but is anchored to the interconnected social networks, cultural systems and public world in which it is embedded. Moreover, if the empirical evidence suggests that 'qualitative' factors are powerful determinants of the way in which the brain-body meaningfully and immediately relates to its surrounding space, then drawing upon disciplines explicitly designed for disclosing the intricacies of meaning, context and signification stand to enrich an inquiry into peripersonal space's role in consciousness. Accordingly, semiotics and phenomenology are two paradigmatic disciplines capable of achieving this, as each of these disciplines takes 'meaning' as its investigative theme (Zlatev et al., 2018) as both have been well-utilised in similar enactive accounts (e.g., Gallese, 2005, 2011, 2016; Gallagher, 2005, 2020, 2023; Gallagher & Zahavi, 2012; Paolucci, 2019, 2020; Stjernfelt, 2006; Varela, 1996; Violi, 2008, 2017)

While, to my knowledge, an embodied-enactive interpretation of PPS has not until now received monographic or doctoral-length attention, the compatibility between PPS and certain philosophical accounts has not gone unnoticed in the scholarship. Indeed, as early as the 1990s, Rizzolatti et al. (1997) acknowledged peripersonal space's striking similarities to Merleau-Ponty's phenomenology of bodily space. More recently, De Preester (2012) and Jackson (2014) have noted how tool-use modulates peripersonal space in a manner similar to phenomenological accounts. Moreover, as noted by Gallagher (2018), Merleau-Ponty's notion of intercorporeality is strikingly compatible with PPS functionality while Gallese & Sinigaglia (2010, 2011) likewise highlight the compatibility between PPS and phenomenological accounts of embodiment. More broadly, Gallese (2011) suggests that PPS is an essential element with regards to the wider, on-going synthesis of neuroscience with phenomenology, likewise explicitly citing Merleau-Ponty's notion of *praktognosia*.

Turning once more to semiotics, the biosemiotic term '*Umwelt'* has long been a central, even foundational, concept in ECS (Weber & Varela, 2002; Thompson, 2007; Colombetti, 2018). The *Umwelt* is, of course, a spatial term ('Um' signifying 'around' in German), essentially translating to: 'the surrounding world'. According to von Uexkull (1934/2010) and his followers, how one experiences a spatial event or perceives certain entities in this world depends one one's sensorimotor abilities and even one's place within wider cultural networks of meaning (see Paolucci, 2011, 2020, 2021). Indeed, the widely-acknowledge founder of semiotics, C.S Peirce, is cited as highly influential for the Enactivist approaches in more than one key text (e.g., Chemero, 2009; Gallagher, 2023). Applying semiotic theories to an enactive account of bodily space (see **1b.2.3**), we can argue that we engage space in a variety of semiotic schemas that, even if divergent, never renege on their embodied nature. In *Cognitive Semiotics,* Brandt (2020, p.41), writes:

> When awake, we find ourselves in two distinct forms of spatial organization, namely a frontal angle of opening and orientation spanning from our sensing body and fanning out towards possible objects of sensory attention… and a 'surround' space in which we are situated as a mobile entity in the middle of a stationary place.

A further nexus of overlap is found in the way in which human beings engage material objects. In his semiotic analysis of spatiality, Gaines (2006) examines how technology and modern communication tools expand one's sense of lived (not objective) space. The experimental literature paints a similar picture here since, as will later be analysed in depth, long-term effects from technology usage (namely, the computer mouse) leave a permanent imprint upon bodily space (Bassolino et al., 2010). Thus, technological aptitude engenders both short-term and long-term effects on PPS so that semiotic analyses of culture must work alongside an evolutionarily-instantiated biological system (Graziano, 2018), heavily supporting Eco's (1997/1999) suggestion that cognitive semiotics must encompass and unify both natural and cultural domains in its analyses (see also Gaines, 2006).

Applying insights from phenomenology and semiotics to contemporary issues in PPS research will therefore help shed light on several outstanding questions regarding how humans navigate their pragmatic, tool-using and intersubjective socio-cultural spaces as concretised in the lived body. A variety of questions present themselves, such as: *Does space influence how affordances solicit agents to action*? *Does emotion impact bodily space? How is tool-use framed by particular contexts? To what extent is inter-spatiality necessary for social co-operation? Are 'higher-order' cognitive factors immediately incorporated into 'lower-order' spatial-sensorimotor cognition or are they separate?* Incorporating the philosophical disciplines listed above into our interdisciplinary account contributes toward solving such questions (and others) by generating the terminology and conceptual framework necessary for articulating the obscure features of lived space. All of this amounts to what Merleau-Ponty (1945/2012) designates as a lived, 'situational' instead of an objective, 'positional' spatiality.

However, this broadly theoretical account must nonetheless conform with the wide range of empirical data currently available on peripersonal space (especially cutting-edge publications from the last 5 years which have yet to be theoretically digested), either supporting or further enriching this extant behavioural, clinical and neurophysiological evidence. Moreover, findings from the present account should be at least potentially capable of informing subsequent experimental design as well as generating testable hypotheses. For our findings to be of maximum applicability to experimental science, the empirical studies examined in the subsequent chapters shall be described in precise detail, which avoids potential criticisms as to 'cherry picking' or misinterpretation.

In addition, expounding the structure of human spatiality is important for the wider project of 4E cognitive science, where spatiality is a surprisingly understudied theme. Surely, as a 'buffer' (De Vignemont et al., 2021) or 'interface' (Brozzoli et al., 2011; Serino, 2019) that facilitates interactions between the embodied agent and world, bodily space performs a pivotal role with respect to each 'E' comprising the field of 4E cognition (i.e., Embodied, Extended, Enactive and Embedded). Current evidence suggests that PPS is anchored to one's *body*, while tool-use *extends* this embodied space around the object that one uses. Furthermore, PPS is continually reconfigured on the basis of *interactive* opportunities presented to the agent but in a highly context-sensitive way. Finally, the spatial interface surrounding one's body serves to *embed* the agent in their physical surroundings, simultaneously distinguishing them *from* while connecting them *to* their environment, allowing PPS to automatically reflect changes within this very environment. With these tenets in mind, it may even be justifiable to argue that the underdeveloped topic of spatiality may potentially serve as something like a 'missing link' to the wider 4E project (**4.2.2**).

Thus, neuroscientific research into embodied spatiality offers an abundance of material pertinent for developing upon philosophical analyses of space, which, in turn, can inform and enrich scientific definitions of concepts and experimental design (e.g., Costantini et al., 2011). Accordingly, if philosophical and scientific approaches are complementary, positioning each into a "mutually informative relationship" (Varela, 1996) should elicit valuable insights. Fortunately, it does not appear to be the case that neuroscience and philosophy are pulling in drastically different directions here, as each appears to agree on broad conceptual territory, if not in all the fine details. Despite this convergence, there may nonetheless exist sites in which conceptual territory is competed for rather than shared. As such, we must remain attentive to the areas in which these disciplines intersect as well as where they may compete and give voice to concerns that arise from adopting an interdisciplinary approach.

For instance, di Pellegrino and Ladavas (2015, p.126) utilise the term ‘experience’ to claim: “In everyday life, we experience the space around us as a unitary and seamless whole”. Is this true? That depends. Husserl developed the phenomenological reduction as a way of exorcising inherited assumptions that he viewed as polluting our capacity for philosophical inquiry. If we take ‘experience’ to be synonymous with our everyday assumptions – Husserl’s ‘natural standpoint’ – then experience does indeed fail to provide us with the categories necessary for dividing space from the ‘seamless whole’ into the regions of significance that the empirical literature itself suggests are so critical. Rather, it is by returning to lived experience with the possession of fine-tuned methods for exposing its underlying logic that we make conceptual progress. Thus, from a phenomenological and pragmatic perspective, we *do* experience space in accordance with what experimental peripersonal space research suggests, albeit not on the reflective plane. Accordingly, this project seeks to develop tools and terms for better articulating the pre-reflective dimension of spatial experience in a manner congruent, not in contradiction, with the experimental literature.

Finally, it must be noted that the experimental PPS literature has produced several unresolved debates and theoretical dilemmas that stand to benefit from the interdisciplinary approach pursued here. For instance, De Vignemont and Iannetti (2015) articulate a “dual model” of PPS, denoting the diverse roles of *bodily protection* and *goal-directed action*. This distinction is important as it prevents PPS from an overtly naturalistic interpretation that takes it as merely a threat-avoidance system (‘*body protection*’). Instead, ‘*goal-directed action*’ positions PPS firmly within a conceptual framework of motor-intentionality. But what constitutes a ‘goal-directed action’ conceals a great nuance; such actions may include aspects of habit, language, culture and social role, all of which produce greatly heterogenous qualitative profiles. Correctly designating such acts by their intentional and situational characteristics will be further explored in the following chapters.

Moreover, Hunley and Lourenco (2018, p.1) argue that progress in peripersonal space research "has been hampered by the lack of an agreed upon definition of PPS" because of its malleability and the construct's overlap with other key concepts in the cognitive sciences.[8] One possible reason that PPS has eluded a fixed definition is that its core characteristics escape articulation in terms of measurable distance (see Bufacchi and Iannetti, 2018) or even a protective vs. goal-directed dichotomy (de Vignemont and Iannetti, 2015), and is highly amenable to various social influences (Bogdanova et al., 2021). Generating a satisfactory definition of PPS that encompasses all its motoric, intentional, affective and intersubjective properties is, therefore, another feasible outcome of this project that stands to enrich the scientific literature. This is why the interdisciplinary framework of enactive cognitive science, capable of wielding tools provided by 'sciences of meaning' like semiotics and phenomenology, stands as the perfect pitch on which this revaluation of PPS can take place.

On a brief note, prominent neuroscientific accounts (even those influenced by phenomenology) often speak of peripersonal space as a 'representation'. Here, a conceptual and terminological dispute might arise relating to the now-(in)famous 'representation wars'.[9] Generally speaking, disciplines that interpret neuroscientific data must remain tethered to some of the rules of discourse that mediate the interpretation of such findings. However, phenomenology and (some forms of) cognitive semiotics (e.g., Paolucci, 2021) prefer to conceive the agent as actively engaging the world on the basis of projects, goals and tasks which are directly presented to the agent as infused with meaning. To these disciplines, space is foremost something actively engaged, not calculated and represented;[10] to the extent that we understand space, we understand it non-thematically as an arena of meaning in which to partake in practices, not as a representational data set divorced from our worldly dealings. At the same time, describing the *brain* as having a representation of space (i.e., the neural correlate to the agent's first-person, *non-representational spatial experience*), may remain consistent with this enactive interpretation and the term's employment in neuroscientific accounts. Accordingly, this project will remain continually attentive to the optimal language appropriate for detailing PPS depending on the problem being tackled and alert the reader where necessary.

IV. Summary

In sum, by synthesising the fields of neuroscience, semiotics and phenomenology, the present interdisciplinary account of spatiality is poised to make several contributions to the scholarship. These contributions include: comparing and cataloguing discrete philosophical accounts of space, generating a language faithful to lived spatial experience, revealing bodily space's invariant neurophenomenological structures, making sense of experimental data through conceptual clarification, showcasing the undervalued role of spatiality in ECS and, in the case of **Chapter 3,** better understanding clinical conceptions of disorders of bodily space. In pursuing these ends, I simultaneously aim to promote the 'enactive interface' interpretation of PPS itself, showcasing brain, body and environment as a unitary phenomenon that is in accordance with enactivist principles (see Gallagher, 2023).

To recap what we have detailed thus far, after providing a brief overview of the PPS literature, we detailed the inadequacy of classical models of space for accurately cataloguing spatiality's meaningful cognitive-experiential dimension, highlighting instead the coherence between PPS and a phenomenological-semiotic model of qualitative spatiality structured by meanin, i.e., 'lived space'. Subsequently, in pursuit of this goal, **Chapter 1** will attempt to provide a comprehensive model of lived space by recruiting two major figures from phenomenology (Heidegger & Merleau-Ponty) and semiotics (von Uexküll & Peirce) alongside their respective secondary literatures. While this could operate as a standalone philosophical project in itself, it retains the added benefit of conferring a conceptual blueprint through which we can filter subsequent interpretations of the empirical evidence.

Thereafter, combining the resources of neuroscience, cognitive semiotics and phenomenology with an eye to the most fertile areas in which they overlap, this thesis divides bodily space literature into two broad sections: A) '*Objects*' and B) '*Others*'. **Chapter 2** shall examine how agents spatially understand and engage spatial objects within surrounding space. **Chapter 3** shall examine how agents understand and interact with other human beings within surrounding space. By disaggregating spatial experience into these broad subdomains, I aim to illuminate how agents encounter physical objects and other human beings in harmony with both enactivist principles and existing scientific data. Thereafter, **Chapter 4** shall provide a detailed summary of our work, using our findings to probe unresolved conceptual issues in PPS literature and showcase how this project jointly contributes to relevant discourses in enactive cognitive science, philosophy and cognitive neuroscience. In our first port of call in **Chapter 1** I shall develop a detailed conceptual account of 'lived space' appropriate for these forthcoming analyses.

Chapter 1: A Philosophical Account of Lived Space

Chapter Overview

As we have just seen, mounting neuroscientific evidence implies that, as explicitly highlighted by several neuroscientists, peripersonal space is dynamic, flexible, operational, pragmatic, sensitive to potentiality and, above all, continually modified by experience. Accordingly, this chapter aims to provide further form and depth to a compatible account of human spatiality by introducing conceptual resources that encompass all of these stated qualities in a manner that, I argue, cannot be fully accounted for by traditional cognitivist-computational paradigms, at least in their strongly disembodied and/or representational forms.

In broad terms, what is attempted here, among other things, is a characterization of the 'lived' dimensions or *pre-reflective cognitive correlate* to the neural instantiation of peripersonal space. That is, how the brain-body innately perceives and engages its spatial surroundings before having the opportunity to directly thematise spatial properties, such as in spatial rotation tasks (e.g., Tolrado and Shallice 2004; Bernadis & Shallice, 2011; Cipolotti et al., 2012) or ratio scaling (Möhring, Newcombe & Frick, 2015). Using objective or metric conceptual frameworks of space, the pre-reflective cognitive correlate or lived dimension is somewhat tricky to explicate in conjunction with a distinguishable neural correlate, as it is, by definition, something that exists prior to objectification and to complete cognitive control and awareness, despite profoundly structuring consciousness as such. Indeed, instead of investigating how agents think *about* spatial properties, we are here interested in how agents are spatially embedded *in* their meaningful environments, alongside the neural correlates underlying this relationship.

This is all to say that the kind of spatiality of interest here is more aptly described as qualitative and situational instead of quantitative and positional. Above all, it appears that the factors modulating bodily space, determining its shape, size and tone from moment-to-moment are precisely factors which *mean* something to the spatially situated agent. To adequately and comprehensively capture this relationship, we can draw upon disciplines devoted to the exposure, description and analysis of meaning; namely, phenomenology and semiotics. These disciplines provide a foundation to ground the subsequent analyses of scientific evidence.

Thus, by combining conceptual resources provided by the disciplines of phenomenology (**part A**) and semiotics (**part B**) with empirical findings in psychology and neuroscience, we intend to provide an interdisciplinary, embodied-enactive account of spatiality that coheres with other major topics in 4E cognitive science. In addition, this chapter serves as a standalone piece of philosophical research on space's role in key texts of semiotics and phenomenology and also places them in dialogue. To cement the general theoretical foundations that this project will take, we will analyse two exemplary thinkers from each tradition: Martin Heidegger, Maurice Merleau-Ponty, Jakob von Uexküll and Charles Sanders Peirce.

Part A - Phenomenology

Phenomenology of Spatiality I: Heidegger

Introduction

Spatiality has an important, if somewhat understated, role in Division I of *Being and Time* (1927/2010). Indeed, as Harrison (2007, p.629) claims, while the "themes of space and spatiality are central to Heidegger's discussions, they are often secondary to his overt aims and themes". However, Malpas (2000, p.207) adds that "it is clear that spatiality plays an important role both in the Heideggerian critique of technology and in Heidegger's account of that being-in-the-world which we can also refer to as dwelling". Indeed, Heidegger clearly believes that a phenomenological-ontological investigation of spatiality represents a key battleground in his intended destruction of the Cartesian model of subject-object dualism as attempted in *Being and Time* (Casey, 1997; Malpas, 2008). Heidegger aims to suspend the extant substance dualism that he sees artificially dividing a spatially extended world (*res extensa*) with the world of thought (*res cogitans*), instead demonstrating that Dasein is fundamentally *always* contextually and meaningfully entangled with spatial entities and situationally embedded in meaningful places. In *Being and Time*, Heidegger (1927/2010, p.108/111) sums up this interrelationship thusly:

> Space is initially discovered in this spatiality with being-in-the-world. On the basis of the spatiality thus discovered, space itself becomes accessible to cognition. *Space is neither in the subject nor is the world in space*.... Dasein is spatial in a primordial sense. And because Dasein is spatial in the way described, space shows itself as *a priori*.

From a Heideggerian standpoint, space is neither completely external to the agent nor is it a construct or projection of his mind; space is instead *brought forth* by the lived event of Dasein's worldly existence. This means that while lived space does not derive solely from the agent's consciousness, it nonetheless requires the agent (*Dasein*) to manifest concretely. For instance, without the enactive agent (or better: a community of them), an object's usefulness cannot manifest. A book must be readable by *someone*. Yet, on Heidegger's account, it is incorrect to subsequently conclude that objects' use-values are of diminished ontological status with respect to their objectively measurable Euclidian properties. Readopting a traditional lexicon, objects' 'object*ive*' qualities are not ontologically more 'real' than their 'subjective' qualities. Thus, following Heidegger, our working notion of space is not grounded upon the *res extensa* characteristic of objective Euclidian space that must fundamentally differ in its substantiality to space cognised by an ontologically separate *res cogitans*. In contrast to a sharp dualism between mind and matter (in which a thinking consciousness is placed *inside* objective space and must represent its contents to understand it), human beings are inextricably spatial beings, with space greatly co-constituting the *Da* ('there') of *Da-sein* ('being-there').

Accordingly, the kind of space characteristic of lived space is neither a quantifiable volume nor something substantially independent of consciousness (Dasein) requiring translation into the *res cogitans*. For our current purposes, Heidegger's primary role is to deliver a comprehensive and wide-ranging description of qualitative, lived space that is philosophically liberated from metric, objective space. Newly freed from traditional metaphysics and "container-physics" (Sloterdijk, 2012), space can be retrieved as it exists before thematisation, in the form of what Heidegger called 'primordial' and what contemporary enactivists call 'pre-reflective cognition'. Thus, in this section, Heidegger will help lay the groundwork for detailing the pre-reflective cognitive correlate to PPS in a manner distinctive from objective models of space or computational models of spatial cognition. In pursuit of this, this chapter focuses on five central notions in Heidegger's writings on spatiality as: *ready-to-hand, worldhood and innerworldly objects* (1) *place, region and dwelling* (2), *de-distancing and directionality* (3), *mood* (4) and *bodily space* (5).

1.1 Ready-to-hand, Worldhood and Innerworldly objects

In *Being and Time* (1927/2010), Heidegger dedicates himself to describing the so-called everydayness of Dasein's being-in-the-world. Applying this examination to space, we first find that we are always surrounded by numerous entities of various kinds (both concrete and abstract). This is referred to as the "*Umhafte der Umwelt*": the surroundingness of the surrounding world. Indeed, Heidegger claims that:

> The closest world of everyday Dasein is the surrounding world [*Umwelt*]…. The expression Umwelt contains a reference to spatiality in its component 'around' [*Um*]. The quality of 'around' which is constitutive for the surrounding world does not primarily have a [metrical] spatial meaning. Rather, the spatial character which uncontestably belongs to a surrounding world can be clarified only on the basis of the structure of worldliness (66/66).

If we must apparently first clarify what 'world' means *before* understanding its modification as *surrounding* world (*Umwelt*), what then is the structure of 'worldliness' that supposedly clarifies the *Um-welt's* nature?[4] Heidegger emphasises that what is nearest takes up a large part of our situated ('worlded') spatiality.[5] For present purposes, I emphasise what in Heideggerian terminology is termed the *existentielle* character of space; this applies to how agents exist spatially in a surrounding environment consisting of usable material objects and fellow human beings. While 'innerworldy entities' undoubtedly encompass more than physical objects, they are nonetheless the most pertinent to the present discussion. Indeed, object interactions are an integral ingredient of any account of lived space as our surrounding world is structured for us primarily on the basis that objects feature a readily-accessible, pragmatic significance as things that we have meaningful "dealings with" [*Umgang in*] (67/66).

Methodologically, then, examining the *Umwelt* composed of nearby objects permits us to describe the surrounding world's structure in perhaps the clearest, least abstract and most readily visualisable way. Thanks to their perceptually and intersubjectively accessible nature,[6] a material *Umwelt* is the most amenable to experimental and third-person investigations.[7] Yet, as we shall see, the positive sciences are not the disciplines best suited for revealing the cognitive correlate to the brain-body's most immediate relation to its *Umwelt*. Heidegger's famous discovery of the modality of 'ready-to-hand' is of great importance here. In this modality, the world is engaged as a kind of *Gestalt*, whereby things are presented to us as entities soliciting appropriate interaction. This modality of being is juxtaposed to the 'present-to-hand', in which objects are de-contextualised (made 'worldless') and only available as individuated items bearing objective properties.

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[4] Malpas (2012) notes that for Heidegger animals possess *Umwelt* but are constrained by it and within it. By contrast, humans possess *Welt*. See also Storey (2016).

[5] Indeed, the naturalistic neuroscientist can concur that the brain appears to prioritise nearby objects as they have the greatest immediate significance our survival. However, nearness for Heidegger has a far broader meaning; a medieval European society may be 'nearer' to a notion of the Divine, for instance. Thus, what is the case at the level of '*Welt*' also applies to its more restricted, local version; *'Umwelt'*. We will use both terms synonymously unless otherwise stated.

[6] "Look at that salt shaker sitting on the table."

[7] That is, if we were to focus on the spatiality of a native inhabitant of the Amazon rainforest, we could include the ecological environment *and* their typical set of tools, even if this is not exhaustive of that *Welt*.

By contrast, in the modality of ready-to-hand, material objects in space are encountered primarily as tools (*Zeug*). Heidegger also uses the Greek term *pragmata* to clearly emphasise their pragmatic, relational character. Tools, '*Zeug'* or '*pragmata*' obtain their functional meanings in conformity with the 'world' in which they are grounded. This entails that, upon encountering an object, we pre-reflectively see its use-value (we see the bicycle *as* transport, the kitchen knife *for* cutting) as well as their constitutive place within a greater network of significance (we can use bicycles on pavements and roads, kitchen knives are for cutting particular foodstuffs when cooking). This interconnected and multi-layered nexus of significance thus *scaffolds* our spatial consciousness (or rather, spatial being-in-the-world) instead of featuring *inside of* consciousness. For Heidegger, this contextual scaffolding implicitly structures worldhood. As he puts it: "'worldly' means a kind of being of Dasein, never a kind of being of something objectively present 'in' the world.... something belonging to the world [is called] innerworldly" (p.65/65).

In further clarifying ready-to-handiness, Heidegger (p.68/68) claims: "We shall call the beings encountered in taking care *useful things* [*Zeug]* In our dealings we find utensils for writing, utensils for sewing, utensils for working, driving, measuring". Thus, an object is ready-to-hand when it manifests as a *for-something* tool in relation to some activity.[8] It may seem obvious that the world is available to us via perceptual cognition without any effort on our part. If all is well, I can simply open my eyes and see a world of three-dimensional, spatially extended entities immediately present to my sight. However, Heidegger insists that this perceptual self-evident-ness applies equally to the "handling, using, taking care" of things, all of which feature "their own kind of 'knowledge'" (67/67). Put simply, there is a strong phenomenological distinction between looking at and using a tool. An object thus retains its worldliness when engaged non-object*ively*: it *belongs* to engaged, contextual interaction and not to detached contemplation. Phenomenologically, I can access inner-worldly objects *qua* tools just as directly and immediately as I can perceive their extension and materiality by glancing upon them.

Accordingly, we should not prioritise the perception of an object's extension and materiality, thinks Heidegger, whilst glossing over its ready-to-handiness (i.e., its use-value). Quantitative measurement fails to capture the practicality of *Zeug* because *Zeug* have the 'quality' of *um-zu,* and *um-zu* function by referring onto a task, project or way of

[8] As stated, while some non-physical objects can still be accessed as ready-to-hand, this is beyond the scope of the present analysis.

life that is (phenomenally) beyond whatever is provided by the entity *qua* measurability. By definition, an object's usefulness refers to something else; "the different kinds of 'in order to' such as serviceability, helpfulness, usability, handiness, constitute a totality of useful things" (69/69). Thus, the mug's use-value is that I can pick it up to drink from it.[9] It is through this phenomenological connection between tool and task that its 'useful' character becomes apparent. The sheer materiality of the coffee mug, constrained as it is to its position and properties, cannot disclose its useful, 'for-drinking' quality.

Thus, as "things belonging to the world", and obtaining their utility from thereof, tools have the quality of being *inner*worldly: they are not objectively inside a container called 'world' but obtain meaning against the background context brought forth by worldhood. At their most fundamental, objects are inner-worldly: their existence *belongs to* a world, so they cannot be conceived of *as they really are* without acknowledging the significance that worldhood confers. To ignore the background context that confers functionality to the tool (i.e., '*de*-worlding' it) would be tantamount to failing to understand what an object *is* at its most primordial level. A key *is* its function of unlocking and this functional only exists in relation to locks, doors and buildings. Without a background knowledge of locks, doors, houses, buildings and so forth, the key would be a meaningless configuration of metallic contours. For such reasons, Heidegger viewed phenomenology and ontology as intertwined (Heidegger 1929/1984; Carman, 1996; Blattner, 1999). Thus, innerworldly objects encountered as ready-to-hand disclose the so-called 'surrounding nature' of Dasein's 'surrounding spatial world'.

To again adopt the most '*existentielle*' manifestation of this phenomenon (Aho, 2005), we see that material objects *qua* tools refer to tasks for which the tool is suitable. We encounter tools (or *zeug* or *pragmata*) when they impress upon us a context-sensitive usefulness without needing to reflect on them as such deliberately. In my office, I am surrounded by objects proper to the academic world. To use them, I need not (always) analyse and cognitively dissect their purpose during each and every instance when I see them. Furthermore, their very presence determines the nature of my specific surrounding world: an office full of ski equipment or exotic lizards is not an academic office. Tools thus disclose the *Umhafte der Umwelt* (surrounding quality of the surrounding world), insofar as altering the objects present would also change the nature of that *Umwelt*. An office

[9] Affordances are dealt with later in greater detail. See **2.1.**

suddenly stripped of all objects cannot disclose the world of work; phenomenologically, it is not the same room. This notion brings us onto the next section.

1.2. Place and Dwelling

Spatiality, whether lived or objective, is constituted by relationships that bind two or more entities together. We thus return to a traditional idea in science and philosophy that space is relational (Casey, 1997; Rovelli, 2006) but we add that these spatial relations need not be mapped in solely numerical terms. The 'near' of 'near-space' earns its definition by virtue of its anchorage to Dasein. By contrast, Cartesian space features no 'here', so it is not anchored to any particular place (Casey, 1997). Rather, a certain position in space is defined according to its Euclidian dimensions (depth, width, height) and geometric location, ensuring that any relationship between entities must conform to these properties (Viljoen, 2010). Objects may be nearby each other in some quantifiable way, but only a human world with a perceiving-acting being provide the necessary conditions for the emergence of lived space founded upon meaning-relations, i.e., a place.

For these reasons, *Zeug* cannot be extracted from their proper context while still retaining their most prominent qualities, their overall phenomenal character. Their 'being' is inherently that of things belonging to a particular place, which, for our purposes here, is a meaningful surrounding environment composed of tools or others. In the modality of ready-to-handiness, Dasein encounters utensils as interact-able tools grounded within wider contexts without explicitly thinking about them (Dreyfus, 1990). While the kind of *Umwelt* of interest to us is one consisting of spatial entities physically available to the agent, it is still characterised by its overall global character that is non-identical to its 'mere' geographic location. Indeed, as we shall see, global context is one of the most important factors governing this logic of relationality between agents and entities.

The global context of the *Umwelten* that we find ourselves absorbed in does not arise solely from, say, the length of the kitchen or the volume of the ocean, but the meaning disclosed by such zones as cultural places that invite contextual actions at certain times (Malpas, 2008). Heidegger illustrates this difference with reference to a room in a house, which he takes as "not as what is 'between four walls'" in the sense of empty space occupying a position but rather as something "useful for living" (69/68). Alternatively, we might elucidate the distinction as follows: the room according to a measuring tape or an architect's blueprint is in no way fully interchangeable with the room discovered as a place for human dwelling. While both aspects are equally 'real', it is the latter format that accords with Heidegger's phenomenological understanding of space, and it is the latter that accounts for primordial spatial experiences of the surrounding world of interest here. Accordingly, near space is receptive to factors that make our surroundings "useful for living" as much or more than their metric properties. I can 'be comfortable or uncomfortable' or 'dwell' in a place (home, hospital, prison, dentist, physiotherapist, sports stadium) in a way that is not representable as a mark on a geographic coordinate (Dreyfus, 1990, Malpas 2000, 2008).

'Place' is, therefore, one prominent contextual factor that permits innerworldly entities (e.g., material tools) to acquire significance *qua pragmata* in accordance with the logic of this global, meaning-given nexus. Phrased differently, an object's affording-features are, to a significant extent, determined by the setting in which the affording-object appears to us. A household object retains its 'true' character when encountered in the house. Should I encounter a coffee mug at the bottom of the sea-bed while scuba diving on holiday, it will not offer the same strength of utility as if I saw the very same mug on the kitchen counter. The *place* of the kitchen table versus the *place* of the seabed thus presents the 'same' mug in powerfully different ways. The place provides the object's background and this, in turn, feeds into the quality of the affordance. Context thus breathes life into the object by providing a background against which it has a purpose, a position in which it has a place, which phenomenologically, penetrates the agent's consciousness before reflection arrives on the scene.

Thus, Heidegger uses the term 'dwelling' to describe the way in which Dasein exists *in* a place (Harrison, 2007; Malpas, 2008). Dwelling in a place presupposes familiarity, and familiarity is perhaps the optimal condition for primordial spatiality to showcase itself. As Harrison (2007, p.628) notes: "'subject' and 'world', 'inside' and 'outside', 'private' and 'public' are lines or planes descending from the event of dwelling". If this 'event of dwelling' is primary for lived space, then Dasein's spatiality is always grounded in a time and place, and it is from this concrete particularity that the surrounding world is found as intelligible. When we dwell in familiar spaces, we navigate around them without relying on reflective thought to constantly interpret our surroundings and carefully plan every movement. Phenomenologically, we have integrated ourselves into the space and pre-reflectively experience ourselves as a constitutive part of it. Though Heidegger largely eschewed a biological continuum between humans and animals (Storey, 2016), we might draw an analogy between the human *Umwelt* and animal territory. A territory is a place that can be seen as an extension of the organism, a kind of boundary demarcating an area as ‘safe’ and ‘mine’. For this reason, territory modulates the situatedness of the organism by rendering entities within the territory with different characteristics from those found outside of it.[10]

All of this should show that a meaningful place retains a ‘correlate’ of Euclidian space (it *can* be measured, after all) without being its interchangeable equivalent.[11] For instance, a University might occupy a single geographical location or its campuses and offices might be spread across a city or country. However, while we can subject this University to objective measurement, these measurements would fail to showcase how the phenomenon of place automatically grounds agents present there within a mode of living, generates specific object-affordances, solicits agents to appropriate interaction, modulates affective states and appropriate behaivour, and so forth. Such eminently qualitative aspects, crucial for the agent’s ability to make sense of spaces, resist complete quantification. Therefore, while retaining our working notion that bodily space is a physical space (its extension is objectively measurable and neurophysiologically mappable), we suggest that even this physical space remains a qualitative *place* of context also, which, in turn, co-determines how the ‘innerwordly’ objects found there manifest to the agent. By recognising the importance of both qualitative and quantitative space, we realise that a *singular* conceptual framework cannot equally reveal *both;* i.e., mathematics and physics cannot disclose a place’s worldy character, which is constituted by ready-to-hand equipment, solicitations to appropriate action and by possessing particular character such ‘homeliness’, ‘excitement’ or ‘formality’ (i.e., lived space).

1.3. De-distancing and Directionality

How then can we divulge the nature of the reciprocal spatial relationships existing between agents and things in more refined detail? We maight elucidate the character of this relationship by invoking classical spatial terminology (e.g., distance and direction) but highlighting their uniquely phenomenological dimension. As Arisaka (1995) highlights, Heidegger’s spatial phenomenology ultimately rests on the idea that lived space is a ‘Situation’ and not a ‘Position’. Integral to a spatiality of situation is that certain aspects of our surroundings are salient and others not. When certain things coincide with our situated attunement, we are naturally drawn closer to them. As Shepperd (2016, p.756)

[10] We will deal with the concept of territory in greater detail below when discussing the spatial biosemiotics of von Uexküll (**1b.1**).

[11] Much in the same way that first-person experience and third-person neurophysiological activity are correlated yet not interchangeable.

writes, "When Dasein encounters an object, being or concept, his or her attention must 'make room' for that thing". Heidegger's phrase for this relation is 'de-distancing' [*Ent-fernung*], which denotes a kind of presence or act of integration between the agent and the object.

Once more, we find that the 'nearness' brought about by de-distancing does not share the same meaning phenomenologically as it does objectively. Heidegger writes:

> The things at hand in everyday dealings have the character of *nearness* [*Nahe*]... Beings 'at hand' have their various nearnesses which are not ascertained by measuring distances. Their nearness is determined by the handling and use that circumspectly 'calculate'.

Nearness is not inseparably tied to objective distance because Dasein is capable of remaining in one objective position yet can bring certain aspects of the world nearer by noticing them, using them, understanding them, emphasising them, paying attention to them, etc (De Preester, 2012; Sheppherd, 2016).[12] Thus, if the bird outside my window captures my attention, it suddenly becomes nearer in a phenomenological sense than the book on my table (Petitmengin, 2017). Thus, in Heidegger's words: "what is supposedly 'nearest' is by no means that which has the smallest distance from us. What is 'near' [*Nachste*] lies in that which is in the circle of an average reach, grasp, look" (107/104). Lived space is, therefore, defined by other entities, and more specifically by nearby entities that I can sense or acknowledge in some way.

Thus, to reiterate, whereas ontic, material objects can modulate our de-distancing, their type of de-distancing may be unrelated to their objective distance from us. Heidegger forwards the example of a commercial radio, one of the earliest mass media artefacts, foretelling the drastic spatial reconfigurations engendered by so many modern devices today: "With the radio, Dasein is bringing about today a de-distancing of the 'world', by way of expanding and destroying the everyday surrounding world" (106/103). Why does Heidegger choose this example? Since the radio can be on or off, it superbly demonstrates the discrepancy between objective and phenomenal distance. When the radio is 'on', claims Heidegger, the phenomenological distance between the radio and the listener decreases (the listener must now make more 'room' for what its presence brings to the situation). Yet, its *objective* spatial location remains identical to where it is when switched off. Despite no changes in objective distance, the fact that we now cannot help but hear what emanates

[12] Scholars such as Cerbone (2000) and Basak (2016) have criticised Heidegger's usage of attention as a spatial category, as it may threaten his emphasis on the publicness of Dasein. In an interesting parallel, attention is also an important but confounding concept in relation to PPS; De Vignemont et al. (2021) leave it is an open research question as to whether or not PPS and attention may be interchangeable in some regards.

from the radio brings the radio closer because it 'takes up more room' within our current spatial situation.

Further still, even non-useful things that might not otherwise qualify as ready-to-hand are still not merely objective entities, since:

> Useful things have their place, or else they 'lie around', which is fundamentality different from merely occurring in a random spatial position… the actual place is defined as the useful place as this thing for this useful thing for… in terms of a totality of the interconnected places of the context of useful things at hand in the surrounding world (103/100).

Moreover, some entities may be included 'in the background' of our perspective. Useful things like the glasses perched on one's nose or the pavement used to walk on are categorised by Heidegger as phenomenally remote because such entities constitute the *background* to one's situatedness to such a profound extent that they cannot be explicit 'reference points' of spatial orientation. The painting that I look at or the café that attracts my notice feature as things that I am directly engaged with, while the pavement I walk on or the glasses I see with, while 'there', are incorporated into my ability to have any specific spatial-intentional orientation in the first place. They exist in the background of my world-oriented activity and thus transparently modulate my directionality towards other innerwordly entities.

Therefore, in lived space disclosed phenomenologically, things are brought near to us if and when they 'take up' situational 'room'. Accordingly, we 'de-distance' entities whenever we are solicited by or orient ourselves towards them, bringing them directly into our current projects and dealings. Instead of finding entities located at various numerical coordinates of quantifiable distance, the objects and persons surrounding us co-constitute and enliven the quality of our surrounding world by presenting various interaction-potentials that 'fill up' our *Umwelten*. Indeed, our spatial being-in-the-world is founded upon the fact that there are *always* things closeby in some sense or another. Thus, as an ontologically relational entity, Dasein must be directed toward some things of higher priority or salience over others. We are always using, looking at, or thinking about something; as such, in lived space, *something* is always phenomenally near to us.

However, whenever we de-distance things, we do so from a particular perspective. This brings us to the related phenomenological notion of 'directionality' [*Ausrichtung*]. Both de-distancing and directionality allow inner-wordly entities to become ready-to-hand, since, as Dasein, we bring things nearby in accordance with a particular opening that we have onto a particular meaningful region. By possessing a directionality, I am situated in a certain orientation whereby certain objects in my field 'belong' (e.g., I expect to see doors separating rooms), whereas other times spatial zones are strongly demarcated to objectively nearby zones in my surroundings. Consider the enormous difference between the solid ground of a boat with the ocean that lies just a metre away from it. These spatially close 'zones' have vastly different meanings and implications (especially if one cannot swim). We thus always already exist in a surrounding world of things that gives meaning to the various directions around one's body. Just as I always have a left, right, up and down, tools, for example, are not scattered about randomly or interchangeably in their locations. As Heidegger himself puts it:

> The context of useful things in a world must already be given to Dasein. The fact that I am always already in a world is no less constitutive for the possibility of an orientation than the feeling of left and right (109/106).

While Heidegger is disappointingly sparse in examples here, an obvious example would be the orientation provided by the sky, which is always (hopefully) 'up'. Or, the ceiling as the region from which light emanates. On the other hand, for Heidegger, our sense of left and right is anchored to specific entities existing *in* each direction, and not from any subjective feeling of an absolute left or right as articulated by Kant (Arisaka, 1995). Indeed, this highlights a general difference between the philosophy of Kant and Heidegger: in Kant, spatiality is to be found with the subject, whereas for a phenomenologist, it is to be found in the world.

Importantly for our own, uniquely interdisciplinary analysis, it is also here that Heidegger reveals that signs can be ready-to-hand insofar as they facilitate absorbed engagement:

> In the being-in-the-world of Dasein itself, the need for 'signs' is already present. As useful things, signs take over the giving of directions… [and] keep the circumspectly used regions open, the actual whereto of belonging, going, bringing, fetching (108/105).

Again, the perspectival quality of lived space contrasts with objective space because lived space is imbued with salience that is often defined by functionality: "We understand the region as that to which the context of useful things at hand possibly belongs, a context which can be encountered as something directional, that is, containing places and as de-distanced" (111/108). With physical (if not Kantian) space, the agent-centred 'here' is done away with entirely. This point coheres with our earlier discussion regarding how space is only devoid of meaning whereupon we deliberately remove it by standing back and thematising it:

> Where space is discovered non-circumspectly by just looking at it, the regions of the surrounding world get neutralized to pure dimen-sions. The places and the totality of places

> of useful things at hand, which are circumspectly oriented, are reduced to a multiplicity of positions for random things. The spatiality of innerworldly things at hand thus loses its character of relevance [and] its specific character of aroundness. (112/109).

We might also assume that de-distancing and directionality disclose the more individual (but not always private) aspects of spatiality, as opposed to relative publicness of 'world' and 'place' (Arisaka, 1995; Cerbone, 2000; Basak, 2016). At the individual level, Dasein confers orientation to space by providing a grounding in which space can assume a concrete form. This type of (lived) space thus takes Dasein as its eternal centre so that he things which surround me mean something *to me*.[13] Or, as Heidegger tells us: "There is never a three-dimensional multiplicity of possible positions initially given which is then filled out with objectively present things… the 'above' is what is 'on the ceiling', the 'below' is what is 'on the floor', the 'behind' is what is 'at the door'" (103/100-101). Indeed, just as contemporary direct (Kreuger, 2018, Gallagher, 2020) and embodied simulation theories (e.g., Gallese, 2006, 2016; Gallese & Sinigaglia, 2018) of social cognition stipulate that not all empathic acts require explicit reasoning. By analogy, the positions that surround me are not *first* three-dimensional positions that *then* have to have meaning applied to them by an act. Rather, they intrinsically show themselves as meaningful zones directly related to my own directionality as I directly perceive them. This speaks to the fundamental reciprocity between the presentation of space and my own orientation towards it, which will become clearer still in the following section on 'mood'.

1.4. Mood

For Heidegger, Being-in-the-world is categorically understood as something constitutively modulated. Mood [*Stimmung*] is one important way in which Dasein is attuned to the world, which is separate (and more fundamental) than the world as disclosed by both faith and reason (132/136). For Heidegger, mood is fundamental to the extent that it "crucially affects our engagement with the world and the ways in which we respond to entities within it" (Wollan, 2003). Even if just taking our mode of 'everydayness', we always find ourselves in *some* kind of mood or other, so that "we never master a mood by being free of mood, but always through a counter mood" (132/136). Mood, however, showcases the interrelationship between Dasein and world as inherently bidirectional; mood can easily be

[13] It should be noted that Dreyfus (1990), Cerbone (2000), and Basak (2016) have all criticised Heidegger for failing to include the body in his account of orientation and/or failing to distinguish personal, oriented space from public, intersubjective space. We might argue that Merleau-Ponty picks up the slack regarding bodily orientation, which shall be discussed below.

triggered by the aspects of the world to which I am currently exposed (exciting news *produces* a good mood) while, simultaneously filtering elements of the world according to its own governing logic (this same good mood dampens my response to negative stimuli). Therefore, the 'same' objects surrounding me might bring joy in a pleasant mood or irritation in an unpleasant one. As such, Heidegger's study of mood is pivotal for developing a model of lived space.

I will add here that mood is somewhat comparable with what neuroscientists sometimes term an 'affective state', because, in contrast with emotion, 'state' designates a kind of globality and temporal extension not found in a fleeting or some intentionally-directed emotions (e.g., surprise at seeing a friend at a random place) (Panksepp, 2011, 2012). However, empirical accounts are not always sufficiently clear with regard to distinguishing between degrees of pervasiveness (Ratcliffe, 2002). Mood is perhaps distinct from emotion insofar as emotion presents objects in the format of a dyadic intentional relationship. I am *fearful* of the barking dog or *pleased* by the playful puppy. While these states feature phenomenological significance, they differ from the kind of phenomenal universality conferred by mood. It may be that my mood features no demarcated intentional-object, though it can certainly influence how a class of (or all) intentional-objects show up to me. Because mood presents the world in a particular way, it is not an intentional-object in itself but rather another background phenomenon (Dreyfus, 1990). For our purposes, spatial experience is one fundamental facet of being-in-the-world that is modulated by mood. When gripped by mood, I am subject to a kind of global disposition to my surroundings that modulates several innerwordly entities that I am currently near to. Accordingly, as one's mood ebbs, flows and alters, so too does one's corresponding relationship to the entities that are found within lived space.

For this reason, mood represents another paradigm case for distinguishing between phenomenal and objective space. Returning to Heidegger's example of a room, if I were to use a measuring tape to measure its width, it should not offer me one answer if it is in an apprehensive mood and another if it is in a gregarious mood. I would certainly ask for a refund if this were so! However, as an inherently meaningful and situated phenomenon, *lived* space does not retain identical properties over time (Casey, 1997). In spatial terms, mood might filter my degree of receptivity to other nearby entities, how far they appear to me, whether they appear threatening or appealing, or whether I am oriented towards others in a defensive modality or remain open to them in an expansive, welcoming modality. Mood thus globally filters spatial experience in a manner that may *intersect* with properties like distance or size but are decidedly non-identical with them.

On a final note, constitutively related to mood is Heidegger's notion of 'Care' [*Sorge*]. In fact, Heidegger subordinates mood to Care because Care is perhaps the fundamental facet to being-in-the-world (Dreyfus, 1990). Our *Umwelten* are structured on the basis of our projects, which, in turn, are grounded in the phenomenal fact that we are interested in and absorbed in a particular mode of living. We fundamentally prioritise certain things and people over others and intrinsically incorporate our possible future into our current situation. Indeed, this is why Heidegger says we have "concernful dealings" [*besorgende Umgang*] with useful equipment (p.68/68). On a more local scale, lived space *cannot* be a mere homogenous zone devoid of significance if we are to interact spatially with other entities in the way that human beings typically do. My spatial surroundings are therefore laid out for me on the basis of pockets of significance, which is quite unlike the way a CCTV camera, devoid of both any ability to interact or of any interest in what it captures, may 'see' the exact same space. By stark contrast, the enactive agent is pre-reflectively driven by its mood-disclosed concerns, projects and ambitions which structure the inherent form and content of lived space. These concerns, which permeate every moment of one's spatial existence, are only intelligible for a complex living organism situated in a meaningful, socio-cultural context that fundamentally has concern for its own very existence.

1.5. Bodily Space

Famously, Heidegger essentially side-stepped the issue of Dasein's embodiment in *Being and Time* (Cerbone, 2000, Malpas, 2000, 2008; Basak, 2016, Storey, 2016). But it is quite telling that he did so precisely in the section dedicated to spatiality, simply including in his discussion that "the Spatialization of Dasein in its 'corporeality', which contains a problematic of its own not to be discussed here, is also marked out in accordance with these directions" (p.109/106). According to Malpas (2000, p.221), this is because Heidegger "seems effectively to consign the body to the realm of Cartesian spatiality". Indeed, for Descartes, the body was part of the materially extended world (*res extensa)* which motivated his proposed ontological split between it and the thinking *res cogitans*. However, the last segment of the above quotation from Heidegger implies that, at the very least, we can take Heidegger's ontological analysis of Dasein's spatiality to *also* apply to the body, even if only ontically. Concurrently, Aho (2005, p.2) argues that:

> For Heidegger, any analysis of the body is regional and 'ontic' because it deals strictly with the characteristics and capacities of beings (*Seiendes*). The primary goal of *Being and Time* is an inquiry into the being (*Sein*) of beings.

It is the later Heidegger's work in which we see the theme of embodiment receive more attention (Aho, 2005; Ha, 2016). Indeed *Kant and the Problem of Metaphysics* (1997) Heidegger writes that:

> The original unity and the immanent structure of the relatedness of a human being which to a certain extent has been fettered in a body and which, in the fetteredness in the body, stands in a particular condition of being bound up with beings.[14]

Using this quotation, Ha (2016, p.55) adds that, as a place-bound and acculturated entity,[15] "incarnated Dasein is rooted in the traditional world and is harmonized with Others", in contradistinction to the Cartesian *Cogito* or extended body. Dasein is thus thrown into the world in the form of its body; accordingly, no account of its being-in-the-world – and certainly not its being-in-space – would be possible if one excluded the body, even if one skipped over it (as the early Heidegger did) for thematic purposes. It is at least clear from the secondary scholarship that Dasein's spatiality is not *dis*embodied and that the body is not excluded from any other of the key notions described in this section. Indeed, Heidegger's term of art, that of 'ready-to-*hand*', foregrounds a specific human body part. Even in *Being and Time*, we see how Heidegger links the body's facticity to its orientation towards nearby useful equipment:

> Nevertheless, things at hand and in use for the body, such as gloves, for example, that must go along with the hands' movement must be oriented in terms of right and left. Tools, however, which are held in the hand and moved with it, do not go along with the specifically 'handlike' movement of the hand. Thus, there are no right- and left-handed hammers, even though they are held with the hand as gloves are (108-109/106).

Malpas (2000, p.221) adds that:

> Dasein is always situated in a public space with respect to which, as a consequence of its concrete, embodied location, it already has a certain orientation; it is precisely on the basis of this structure, in which both equipmentality and embodied locatedness play equally essential roles, that distance.

Thus, for Heidegger, orientation, tool-use and situatedness all intertwine and co-constitute each other, giving form to Dasein's unique mode of spatiality. The disclosedness of things as near or remote is itself made possible by Dasein's situated bodily embeddedness in its world. Moreover, it has sometimes been claimed throughout phenomenological scholarship that Merleau-Ponty synthesised Heidegger's notion of

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[14] Quoted from Ha (2016, p.43).

[15] Casey (1997) echoes the idea that qualitative place (in contrast to quantitative space) has found its way back into philosophy by way of embodiment.

being-in-the-world with Husserl's writings on the lived body, so that Husserl's and Merleau-Ponty's idea of the lived body is that of an agent situated in a world in which things acquire sense in accordance with the body's form in alignment with Heidegger's account of worldhood *in Being and Time* (e.g., Carman, 1999; Aho, 2005). This compatibility and mutual enrichment are also taken for granted in the present work.

Tragically, any protracted engagement on Heidegger's part with Merleau-Ponty's phenomenology of embodiment is absent, with Heidegger directing his critical focus instead to the phenomenology of Jean-Paul Satre in the *Zollikon Seminars* (1964/2001). Regarding this text, Aho (2005, p.16) wants "to suggest that the analysis of the body in the Zollikon Seminars is an 'ontic-existentiell' inquiry" which he compares to Merleau-Ponty's phenomenology. Here, we will retain that idea that bodily space pertains to the ontic dimension of Dasein, which renders it compatible with scientific inquiries. In the *Zollikon seminars* (p.112/86), in which Heidegger speaks to an audience of psychiatrists, we arrive at perhaps the closest thing to a Heideggerian account of embodiment. Heidegger deals with the problem of spatially delimiting the lived body:

> I am seated here at the table and fill this space enclosed by my epidermis. But then we are not speaking about my being-here, but only about the presence of a corporeal thing in this place. Perhaps one comes closer to the phenomenon of the body by distinguishing between the different limits of a corporeal thing [*Körper*] and those of the body [*Lab*]. The corporeal thing stops with the skin. When we are here, we are always in relationship to something else. Therefore, one might say we are beyond the corporeal limits. Yet, this statement is only apparently correct. For I cannot determine the phenomenon of the body in relation to its corporeality. The difference between the limits of the corporeal thing and the body, then, consists in the fact that the bodily limit is extended beyond the corporeal limit Thus, the difference between the limits is a quantitative one. But if we look at the matter in this way, we will misunderstand the very phenomenon of the body and of bodily limit. The bodily limit and the corporeal limit are not quantitatively but rather qualitatively different from each other.

The topics touched on in the above quotation, such as the flexible spatial limits and fluctuating boundaries of the human body, or the difference between qualitative and quantitative bodily space, shall be routinely returned to throughout this thesis. However, since, as discussed, embodiment was not a major thematic focus of Heidegger's phenomenological analyses, we can instead better rely on Merleau-Ponty's close reading of bodily space in the remaining half of this section to better catalogue the body's role in the constitution of lived space.

1.6. Overview

Finally, we can answer the question: 'How does Heidegger's phenomenological disentanglement of lived space from objective space inform our current aims?' Central to Heidegger's phenomenology of spatiality is that, unlike objective space, lived space is never experienced as something static, homogenous or decontextualised whereby all areas of space are positional and interchangeable, as in objective accounts of space (Casey, 1997). While 'de-worlding' space is a prerequisite for successfully uncovering its objective properties, the resulting construct is *not synonymous* with the meaningful places that ground our contextual actions or allow objects to show up as tools, which is Heidegger's (and ours) key interest.

The Cartesian-Newtonian model of space, based upon the concept of a mechanical *res extensa*, does not cohere with the way in which the brain-body understands its surroundings during the majority of everyday circumstances. Instead, we might claim that the human brain is likewise embedded in the world and entwined with its spatial surroundings in a manner ultimately prior to reflection's ability to thematise, calculate and hypothesise about spatial properties. Unless one is an architect drawing up blueprints or a decorator measuring the walls to ascertain the correct amount of paint to buy, one does not primarily engage any spatial zone *as* a measurable and quantifiable grid. In parallel, the brain is not automatically cognisant of the exact length of the hallway or the atomic weight of the classroom door handle but engages the hallway as a passage for walking and the door handle *as* something yielding access to the classroom and can do so without thematising either procedure in reflective cognition. In essence: "space can only be understood by going back to the world. Space does not become accessible by depriving the surrounding world of its worldliness" (*BT*, 113/110). On Heidegger's account, all of these aspects of space are given to me just as directly and immediately as my visual perception of their spatial extension.

Therefore, just like Heidegger's Dasein, when the brain-body orients itself in a setting, navigates towards its goals, reacts appropriately to affordances or interacts with others, it is attuned to the modality of 'lived' and not 'objective' space. It is this spatial modality that constitutes what we call the 'pre-reflective cognitive correlate'. Aligning Heidegger's phenomenology with our attempt to reveal the lived space in which the brain-body is embedded vis PPS, we found that conceptualising space as something extant and homogenous appears incompatible with the flexible, dynamic and situation-driven 'properties' exhibited by PPS, which ceaselessly underlie the agent's interactions within the world. In sum, the famous plastic and dynamic features of peripersonal space, both as experienced and lived by human beings and studied by scientists, appear closer to the spatiality of Dasein as articulated by Heidegger than to space described through scientific disciplines such as physics, geometry or chemistry. Even psychophysics falls somewhat short of the mark when it comes to revealing the 'cognitive correlate' of the peripersonal system. However, while lived space is ever-fluctuating, it is nevertheless amenable to description at a structural level. This shows us that non-objective spatial models need not eschew adopting a structured terminology or conceptual framework. In fact, these seem to be prerequisites to understanding how the brain-body is embedded pace.

Above all, Heidegger has furnished us with a great number of phenomenological descriptions pertaining to lived space that also demarcate it from objective space. Despite Heidegger providing us with this detailed set of concepts useful for revealing the structure of lived space, is his account nevertheless lacking in some areas? A critic might (and has) point out that Heidegger's rich descriptions of being-in-the-world lack an account of embodiment (e.g., Cerbone 2000; Malpas, 2000, Basak, 2016). Moreover, Heidegger deals only very sparsely with any scientific literature, which will be indispensable in our subsequent investigations. As such, we can better flesh human spatiality in its embodied format in the following section.

Phenomenology of Spatiality II: Merleau-Ponty

Introduction

Our primary resource here will be the text widely considered as Merleau-Ponty's *magnus opus*: *Phenomenology of Perception* (1945/2012). Space and spatiality are recurrent themes in this seminal text and Merleau-Ponty devotes considerable attention to their study throughout it. Spatiality's importance lies in the fact that articulating and redefining the boundaries between the body and the world in which it is embedded is central to Merleau-Ponty's overall philosophical strategy. Romanyshyn (2000) argues that Merleau-Ponty's philosophy is, in fact, defined by exposing this fundamental body-world relation. Like Heidegger, Merleau-Ponty believes that the situated agent actively engaging the world is the proper starting point for understanding human spatiality (and consciousness generally), as opposed to any disengaged cognising of objective spatial properties. However, quite unlike Heidegger, Merleau-Ponty believed that such a position could sometimes be enriched by scientific evidence, and the resulting phenomenology could, in turn, offer interpretative value for that same scientific evidence. This makes Merleau-Ponty especially pertinent for our interdisciplinary approach adopted here, where we will heavily utilise his account of spatiality as encountered in *PoP*.

Merleau-Ponty conceptualised human spatiality first and foremost as a concrete, pre-reflective, bodily-centered embeddedness within cultural, social and material contexts, an interrelationship so fundamental for human consciousness that he poetically described it as “communication with the world more ancient than thought” (302/265). This evocative phrasing intends to illustrate that our relationship to the world (via space) exists prior to any propositional formulation of spatial properties that can be thematised in reflective cognition. Any abstract account of space must already rest upon this originary “ancient communication”. Lived space is, therefore, located neither solely ‘in’ us, nor solely ‘in’ a separate, external world. Rather, spatiality emerges out from the interplay between spatialised bodies and other spatial entities. The specific content of this interplay (e.g., *which* tools I use and *what* environment I inhabit) varies for each culture or empirical individual. Yet, at the structural level, human spatiality still features a generally recognisable and reportable form.

Indeed, Merleau-Ponty clearly asserts that “spatial perception is a structural phenomenon” (332/293), which entails that, however complex it may be, human spatiality is not condemned to obscurity and is fully amenable to articulation through philosophical interrogation, provided one has possession of the correct conceptual utensils. Assessing the phenomenological and empirical psychological literature available to him, Merleau-Ponty faced an analogous difficulty as to the one present in contemporary PPS research. Namely, neither the brain nor the phenomenal body appears to understand space *primarily* as a metric or quantitative field. Indeed, we rarely meditate upon spatial properties when acting in the world. Furthermore, by abstractly reflecting on what space is, the phenomenon of space as originally experienced is consequently obliterated. This tension motivated Merleau-Ponty to formulate an existential-phenomenological conception of spatiality that cohered with the phenomenon of space as given both in lived experience *and* in the experimental and clinical literature, which will continue to be of vital importance for our own interdisciplinary model of lived space.

In Merleau-Ponty’s account, we observe firsthand the emphasis that phenomenologists frequently place upon ‘primacy’ (see Dreyfus, 1996; Maratto, 2012). From this standpoint, while abstract models of space are not rejected, they are deemed methodologically unsuitable for describing how human beings *are* in space at an originary plane. While the

Cartesian-Kantian and Newtonian traditions are indeed revelatory of several dimensions of space, according to Merleau-Ponty, "the experience of one's own body teaches us to root space within existence" (184/149). With this is mind, space is optimally considered as something that the agent 'discovers' in their engaged dealings with the world. Accordingly, real knowledge of space is not *only* uncovered thematically or by visual representation. Rather, it is always implicitly known as a part of one's fundamental embeddedness within one's world. For Merleau-Ponty, then, any traditionally scientific, mathematical or metaphysical mode of analysis remains incompatible with revealing spatiality's most primordial structure, because such disciplines "lack an actual starting point or an absolute here that could gradually give direction [*sens*] to all the determinations of space". However, this starting point can be provided by phenomenologically examining the concrete agent as spatially embedded in the world.

Phenomenology, then, is assigned the task of deploying its fine-tuned descriptions of lived experience to better articulate how spatiality arises from this so-called "starting point or absolute here" conferred by the body and does so by carefully cataloguing the pre-reflective dimensions of spatial experience alongside its manifestations in observable behaviour. Thus, while Heidegger largely sidestepped the bodily dimensions of spatiality (which, for Merleau-Ponty, are essential to the 'absolute here'), recruiting Merleau-Ponty helps us reinsert the body into our analysis of lived space. Clearly, such a move is integral for the embodied-enactive interpretation attempted here. In pursuit of this aim, this current subsection examines five central notions in Merleau-Ponty's writings on embodied spatiality: *Spatial level* (1), *Body schema* (2), *Habit* (3), *Depth and Movement* (4) and *Lived Space* (5).

2.1. Spatial Level

A central spatial notion that inaugurates the 'Space' chapter in *Phenomenology of Perception* is the so-called 'spatial level', a proposed alignment between perception, action and world that is structured by 'anchorage points': vantage points or salient entities present to perception, which enable a coherent spatial orientation that grounds the agent within their situation (Talero, 2005). We have already seen that Heidegger situated the agent's direction of 'left' and 'right' in the world, not in the subject's inner sense of direction (**1a.1.3**). How familiar Merleau-Ponty was with this relatively brief section in *Being and Time* remains unclear, as it is not cited. But Merleau-Ponty does bring to our attention certain experimental studies (Stratton, 1899; Wertheimer, 1912) that lend credence to this phenomenological insight while providing a more detailed account of the body's role in directionality and spatial orientation, culminating in a proto-sensorimotor account of spatiality.

The experiments that Merleau-Ponty cites employed various tactics to alter the participant's sense of spatial orientation, such as goggles that invert visual perception from left to right or up to down. As Merleau-Ponty puts it: "At the beginning of the experiment, the visual field appears simultaneously inverted and unreal because the subject does not live in this field and is not geared into it" (p.299/262). These spatial disorientation experiments briefly 'de-world' the body by misaligning it with one's surroundings so that, even if their 'objective' space remains completely unchanged, "the subject is not geared to the utensils it contains [and] he does not inhabit the room" (298/260). Merleau-Ponty then sets his sights on what he takes to be an unsophisticated inference from these experimental findings; namely, that agents eventually readjust to their new, disoriented sense of space by realigning it with their previous, 'absolute' sense of orientation as provided by the symmetry of the body.[16] Merleau-Ponty agrees that the things that we encounter in the *Umwelt* confer to us our ultimate sense of direction. But importantly, "we do not here fall into the realist error of assuming directions in space as given with the visual spectacle". That is, *perception alone* cannot provide any ultimate sense of orientation; spatial orientation is a relational phenomenon that always emerges from perception and action.

The empiricist may believe that one's sensory modalities receive a stream of input regarding the external world that gradually form into a coherent picture of space and objects. Contra to the empiricist's reading of spatiality, however, Merleau-Ponty believes that only the entire lived body as an enactive, forward-facing entity can establish a spatial level: "the body considered as a mosaic of given sensations does not trace out any direction [but] the body *as an agent* plays an essential role in establishing a level" (emphasis added; 297/260). That is, the body does not just passively receive and synthesise a tapestry of incoming sensory input and build a model of space upon it, but rather it 'moves towards' its surroundings, engaging and recruiting space with its motor-abilities that gradually confer order upon one's surroundings. To be 'geared into' the world is, therefore, not to perceive things passively before building them into a coherent 'picture' but to find oneself

[16] Recall that, as Arisaka (1995) notes, this was essentially the Kantian viewpoint that Heidegger already took aim at.

already immersed among them, which naturally serves to orient one's body in space without conscious effort.

To achieve further clarity here, we should focus upon what exactly permits disorientation to revert back to orientation. Merleau-Ponty claims that "Wertheimer's observation shows precisely how the visual field can impose an orientation that is not the orientation of the body" (297/260). In manipulating one's visual input (so that I see my legs above me), I at first fail to operate within the world smoothly due a perception-action disconnect. Eventually, however, my surroundings seem to 'set' alongside my body so that what I perceive seems 'normal'; a new spatial level has been established. Enactive perception normalises and, because the body acts upon the things one sees, it too becomes absorbed into the new spatial level. A coherent sense of orientation in the spatial world is thus predicated on one's ability for action (see Gallese, 2014). Upon this action-perception synthesis or 'vertical circular causality' (Fuchs, 2018) arises the spatial level, an equilibrium between the embodied agent and the environment that is stabilised via continual interactive feedback loops until the agent becomes a transparent part of a meaningfully organised spatial milieu. Furthermore, this enactive body-space relationship is not only encapsulated within the present moment because:

> What counts for the orientation of the spectacle is not my body, such as it in fact exists, as a thing in objective space, but rather my body as a system of possible actions, a virtual body whose phenomenal 'place' is defined by its task and its situation (298/260).

Simply put, visual perception's content hinges upon our *capacity* to meaningfully act there. Unlike the objective body, which occupies a geometrically delineated spatial position in a mappable topographical location, the lived body is a goal-orientated, future-facing and situationally-dependent sensorimotor opening onto the world, always (partially) oriented towards its situational possibilities at the confluence of perception and motor-possibility. Embodied spatial orientation thus "appears at the intersection between my motor intentions and my perceptual field" whereby a "pact is established that gives me possession of space and gives to the things a direct power upon the body (p.261/298). Crucial for our embodied-enactive analysis of spatiality that links spatial perception with spatial action, Merleau-Ponty adds that:

> When my actual body comes to coincide with the virtual that is demanded by the spectacle, and when the spectacle comes to coincide with the *milieu that my body projects around itself*... it sets itself up between *my body as the power for certain gestures*...[and] the perceived spectacle as the *invitation to these very gestures* (298/261; emphasis added).

Already, then, Merleau-Ponty foresaw that spatiality was a *sensorimotor* phenomenon, a pragmatic fusion between incoming sensory information and outfacing action potentiality, which cloaks the surrounding world with a kind of coherency permitting one to orient themselves in it pre-reflectively (Talero, 2005). The disorientation experiments disrupted this prior coherence endowed by the spatial level so that when the experiment ceased, agents were once again confused by reverting to their original sense of direction. An actual example listed was the participant extending their left hand towards an object that required the right hand.[17] This only furthers Merleau-Ponty's argument that there is no pre-given 'absolute' sense of direction and orientation for bodily space. Rather, continued practical and *relational* comportment within the world grants us our sense of both. Indeed, continued interaction with entities in the world harmonises the kind of normative sense of spatial coherence that we typically take for granted. Merleau-Ponty's interpretation also clearly aligns with and expands Heidegger's aforementioned critique of Kant on orientation, who argued that subjects must derive their sense of 'left' and 'right' from a bodily feeling. For the phenomenologist, in contrast: "orientation is not a matter of 'feeling' but depends on practical actions" (Arisaka, 1995, p.7). Also like Heidegger, Merleau-Ponty believes that this illuminates a clear disconcert between objective and lived space:

> Experience reveals, beneath the objective space in which the body eventually finds its place, a primordial spatiality of which objective space is but the envelope and which merges with the very being of the body. As we have seen, to be a body is to be tied to a certain world (149/184).

We might therefore label the interrelationship between the body (as an always present motor-intentional capacity) and the surrounding environment (a field of interactable things) as a well-aligned spatial interface, albeit not one comprised of separate substances. The spatial level is this mode of coherence that naturally emerges from such an interrelationship, which, even if disrupted, eventually reemerges following sustained and meaningful *Umwelt*-engagement.

Accordingly, for Merleau-Ponty, the spatial level serves as a background phenomenon (Dreyfus, 1996, 2000), grounding and orienting other actions; he claims that: "An orientation of space is not a contingent property of the object, it is the means by which I recognize the object" and "each level in which we live in turn appears when we drop

[17] The spatial coherence between the correct hand and an oriented object were the focus of later experimental investigations into affordances and PPS (e.g., Buccino et al., 2009). These empirical examples will be discussed throughout **Chapter 2** in greater detail.

anchor in some ‘milieu’ that is offered to us (p.301/264). If ‘Milieu’ – the background phenomenon supposedly scaffolding the spatial level - is here also synonymous with ‘context’, then we must see that context is never the sole craft of any one individual but a pre-established source of meaning that the individual brings to life when entering into its fold (Carman, 1999). The door shows up *as* unlockable when I am nearby it and holding a key, just as it would for anyone in my position. The dancefloor elicits dancing at the correct time and place (i.e., at night with others, not in the morning when cleaning it). ‘Milieu’ thus showcases that space is rarely a ‘snapshot’ represented by a knowing *Cogito* but rather an arena of solicitations to be taken up as a part of a wider form of life into which one is embedded (Talero, 2005).

Indeed, in contrast to Descartes’ ontological severance of body and environment, the so-called ‘worldliness’ of the body ensures that its space is always a *place* in which it is naturally at home. ‘Spatial level’ is but one instance of this belongingness, so that “we must not [say] that our body is *in* space... It *inhabits* space” (174/140) and “I am of space and time; my body fits itself to them” (175/141). Accordingly, a lived body that ‘inhabits’ and is ‘of’ space is non-identical with a knowing subject that contains space within its own intellectual apparatus. Nor can there be an ‘absolute’ cardinal direction that governs in advance *all* movement and perception of the world. Rather, the spatial reality in which we actively partake absorbs our lived body, moulding its shape and contours from the first moments of life. Simultaneously, however, this orientation necessarily conforms to the facticity of our bodily structure, thus bringing about the unitary phenomenon designated the ‘spatial level’. We observe disruptions of this harmony in the clinical and empirical literature, illuminating its otherwise obscure structure.

‘Spatial level’ thus helps reveal the harmonious interpenetration between the agent and their *Umwelt* as always structured by a kind of normativity, whereby objects and others make sense to us according to the logic of the world that they occupy (see Talero, 2005). As inherently spatial beings, we are continually and pre-reflectively geared toward maintaining coherent, practical and meaningful relationships with our surroundings, the structure of which is so inherent that it is not obvious until it undergoes experimental manipulation. Thus, the relationship existent between agents and objects is in fact something like a spatial *union*. This holistic phenomenon allows what Heidegger terms ‘innerworldly entities’ to continually be on-hand for us as available equipment that are contextually embedded in a meaningful background.

In lived space, the agent's bodily-motor capacities, combined with things encountered therein, confer familiarity, stability and navigability to the agents present there. In this model, objects and the embodied agent are themselves disposed towards an optimal manifestation ('grip') of their relationship (Dreyfus, 2000, 2002). As such, the notion of spatial level reminds us that we rarely see things from any random, interchangeable perspective, but rather as a fusion of sensory perception and motoric possibility that grounds our normative orientation within the world. But as Merleau-Ponty concedes, "the constitution of a spatial level is only one of the means of a constitution of an integrated world" (298/261). This takes us to our next topic.

2.2 Body Schema and Motor-Intentionality

In reinterpreting the neuropsychological construct of the body schema first articulated by Head and Holmes (1911), Merleau-Ponty consistently emphasises its innately spatial dimensions. Yet, the body schema cannot be reduced to the mere sum of objective body parts (Gallagher, 2005). The objective body schema (a collection of organs, tissues, bone) *does* occupy a point in geometric space. But again, such a description applies equally to a corpse. Indeed, the extent to which the body schema includes 'external' entities into its own schematic is key to Merleau-Ponty's phenomenological reinterpretation, as he notes that contemporary intellectualist, empiricist, and even *Gestalt* accounts ultimately fail to account for what the body schema is by restricting its definition to the body *proper* (Sykes, 2021a). Central to Merleau-Ponty's phenomenological rereading of body schema and its relationship to the world is the fact that: "The motor experience of our body is not a particular case of knowledge, it offers us a manner of reaching the world and the object; a praktognosia" (175/141).[18] The body schema is thus one's perpetual and ultimate source of 'know-how' when it comes to dealing with the world (see Jackson, 2014).

Merleau-Ponty insists that we engage and understand our surrounding world directly, without creating representations of it that are stored in the mind in conformity with a rule-governed intellectual apparatus. How, then, should we account for such acts of know-how? On Merleau-Ponty's account, the pre-cognitive body schema is the phenomenon that retains this non-representational working knowledge of how to interact with the world. Or as Merleau-Ponty himself phrases it: "My body has its world or understands its world

[18] It is noteworthy that in cognitive neuroscience, Gallese (2011, 2014) frequently cites the notion of 'praktognosia' when expounding how the motor system acts in space. This connection will be further developed later. See also Gallese and Sinigaglia (2010).

without having to go through 'representations', or without being subordinated to a symbolic or objectifying function" (175/141). Merleau-Ponty adds that the "objective size and position of one's own body" cannot serve as a primary reference point either, because the body schema transcends the body's material boundaries. That is, the lived body need not mirror the objective body by terminating sharply at the epidermic layer. The world-embedded spatial structure of the body schema emerges from a situated dialogue between the enactive body and its surroundings so that its schematic components always include the very space of the objects that one utilises during bodily-motor activity: "the word that is read is a modulation of visual space, the motor execution is a modulation of manual space" (179/145).

Merleau-Ponty provides his redefinition of the body schema in the same subchapter in which he introduces another of his key terms of art, that of 'motor-intentionality' (MI) (140/112). Like the distinction between body schema and body image (Gallagher, 1986, 2005; Gallagher & Cole, 1995), MI helps explain the difference between concrete movement with a clear intentional-object and abstract movement that is self-propelled without an intentional referent. Indeed, body schema and MI are inseparably connected: entities in the world are the motor-intentional referents of the body schema's outward-facing orientation. The lack of a concrete object of motor-intentionality, as found in abstract movement, impedes patient Schneider from committing the requested action.

While the abstract movement has "intellectual signification" it has no "motor signification" which otherwise solicits the agent's actions and enables a part of the body schema to align with an object, permitting a fluid action to take place. Subsequently, Merleau-Ponty (172/139) puts forth the strong claim that "motoricity [is] unequivocally [an] original intentionality". In the very same paragraph, he also introduces his famous notion of the 'I can' (juxtaposed to 'I think that'), which designates that the agent's primary intentional relation to the world is one of a set of contextual possibilities to be taken up by the lived body in space which, in turn, determine the body's own schematic structure.

To recap, situated motoric acts such as reading and typing alter sensorimotor space and, consequently, the body schema itself. Or, as Merleau-Ponty succinctly phrases it: "The subject who learns to type literally incorporates the space of the keyboard into his bodily space" (180/146). Merleau-Ponty's use of 'literal' here may initially seem hyperbolic. But since he is clearly not reading 'literal' as a body horror-esque fusion between man and machine, how, then, is such 'incorporation' literal? *In-corporation* is literal because we are here speaking of *lived* bodily space, which extends beyond the body's material borders to include the tool into its spatial interface (i.e., its schema) with the world. An emergent spatial structure now includes both agent and tool within a singular, situated system:

> If I am seated at my desk and want to pick up the telephone, the movement of my hand toward the object, the straightening of my torso, and the contraction of my leg muscles envelop each other; I desire a certain result and the tasks divide themselves up among the segments in question" (185/150).

At the global level, it is the task-at-hand (e.g., writing, sewing, hammering, driving, sailing) – a reference point for the body's motor-intentional orientation - that determines the form and content of this spatial synthesis. The conclusion Merleau-Ponty wants us to draw here is that the body schema is therefore not only structured by body parts as discrete, independent entities but by the common signification provided to them by the task-at-hand, which serves as the convergence point at which the whole body as a unified, enactive entity is directed toward. It is the task-at-hand that actively aligns relevant parts of the body and tools into a singular configuration which retains practical knowledge of how to appropriately engage objects in bodily space. To give an example, if I retain a skill of archery, my schema retains the pre-reflective knowledge required to utilise a bow and arrow to hit a target and 'activates' whenever I pick them up. This process also reorients my motor-intentional orientation. Tasks map onto the contours of my body schema which allow me to pre-reflectively utilise them correctly when the moment arises. With simpler actions such as grasping, the body may even accomplish them without reflective input, acting fluidly in space while the cognitive mind deals with other issues (see Kelly, 2000, Dreyfus, 2002 and Cappuccio, 2023).

As Merleau-Ponty sums up the pre-reflectivity of motor-intentional action: "No sooner have I formed the desire to take hold of an object than already, at a point in space that I was not thinking about, my hand as that power for grasping rises up toward the object" (181/147). Grasping can thus take place without a cognitive 'watchman' guiding the entire process (Kelly, 2000), which Merleau-Ponty attributes to the motor-intentional affiliation between body schema and its intentional-objects. Moreover, if an action requires multiple body parts for its execution, they are likewise brought into alignment to complete the task below the threshold of conscious deliberation:

> All of these movements are available to us through their common signification. This is why, in the very first attempts at grasping, children do not look at the hand, but at the object. The different segments of the body are only known through their functional value and their coordination is not learned (185/151).

Merleau-Ponty thus already intuited a principle central to our own account, namely, that the lived body encompasses the scope of possible movements that the body can make within its own space. Crucially, this entails that the always-spatialised body schema is co-constituted by a temporal profile whereby "the normal subject has his body not only as a system of current positions but also, and consequently, as an open system of an infinity of equivalent positions" (177/143). Accordingly, the body schema as manifest through its tasks and concrete worldly solicitations also somehow includes its *potential* configurations in its very schematic structure. When the time arises, my body is capable of appropriate action, say, to catch a thrown object or to put items into a carrier bag. But its experience of witnessing the object thrown or standing at the checkout inherently includes the immediate possibility of this forthcoming action, which is pre-reflectively anticipated. It is this aspect of the body schema that neuropsychological patient Schneider lacks (Goldstein & Gelb, 1918), who, due to a brain lesion, is imprisoned in the concrete present (see Marotta & Behrmann, 2004; Sykes, 2021a).

In sum, as an inherently situated entity, for the body schema: "places in space are not defined as objective positions in relation to the objective position of our body, but rather they inscribe around us the variable reach of our intentions and our gestures" (179/144). As such, we should reemphasise that our body's potential reach or, alternatively, the limits of one's motor-intentional powers, profoundly co-constitutes how the schema exists in relation to its current space or 'place'. An elevator, boxing ring, hallway or open field all 'carve out' different spatial 'degrees of freedom' regarding the extent of one's potential movements that serve to ground the agent's body schema in relation to their surroundings. Crucially, this does not necessitate that the agent must constantly run various representations of their body in line with concurrent environmental representations but rather that one's place in space is first and foremost a situated embeddedness *out of which* affordances and action-possibilities manifest (Dreyfus, 2000; Kiverstein and Rietveld, 2014; Cappuccio, 2023).

Finally, the motor-intentional body schema also confers a kind of identity that remains a steadfast foundation throughout all of the empirical changes in places, positions and environmental contexts that the agent undergoes (Talero, 2005). Thus, the body schema stabilises around the situated body, retaining 'on-hand', whatever was learned in prior situations. On this topic, Merleau-Ponty adds that "acquiring a habit as the reworking of the body schema presents significant difficulties for classical philosophies, which are always inclined to conceive of synthesis as intellectual synthesis" (178/143). Instead, we encounter a synthesis between worldly tasks and bodily-motor capacities across time. This point then brings us directly onto our third identified theme of ‘habit’.

2.3 Habit

As discussed previously, the remarkable spatial unification that arises between the body and the tool modulates one’s spatial being-in-the-world during the temporary period of its actual, empirical usage, subsequently imparting a permanent imprint upon it. The name for this imprinting is ‘habit’, encompassing an enduring configuration between the agent, tool and task. Like C.S Peirce, Merleau-Ponty bestows great importance to the notion of ‘habit’ because habit “expresses the power we have of dilating our being in the world, or of altering our existence through incorporating new instruments” (179/145). Thus, the body schema, alongside an acquired understanding of these “motor significations” (178/144) enabled by habit, essentially co-constitute embodied spatiality. If human spatiality is first established through our body, and tools alter our body schema by disclosing new horizons of potential action, then it is through habit that alterations in our being-in-the-world become longitudinally instantiated, thus becoming more definitive of one’s existence. As Merleau-Ponty summarises this phenomenon: “the body has understood and the habit has been acquired when the body allows itself to be penetrated by a new signification, when it has assimilated a new meaningful core” (182/148).

Habit thus reduces or eliminates the necessity for consciously engaging in explicitly self-aware motor-intentional behaviour (Colapietro, 2021, Cappuccio, 2023). Accordingly, habit can cement a tool as a stable and lasting component of one’s lived body, in juxtaposition to a tool that one picks up rarely for some unusual task or for which we have acquired little know-how. Regarding lived space, a newly-acquired habit means that one has incorporated a novel way of engaging the spatial surroundings that has deposited a modification in the body schema, engendering a novel receptivity to the latent affording-features present in objects and environments without conscious effort.[19] For Merleau-Ponty, when one learns how to use scissors, they need not *decide* whether particular objects can be cut; when holding the scissors, appropriate objects simply *appear* cut-able. Habit thus emerges when a skill or mode of being inhabits the lived body and this modulation is longitudinally reflected in the body schema, allowing one to participate pre-reflectively in the activity at hand whenever it manifests itself.

[19] See Rietveld & Kiverstein (2014) for the analogous notion of the ‘landscape of affordances’.

The kind of habits with which a culture is familiar, to a great extent, define that culture itself. Essentially, this means that the world of, say, the Victorian, Aztec, Viking or Mesopotamian person were all constituted by the different habits that conferred to them the nature of their particular form of life (see Kiverstein & Rietveld, 2014). Therefore, via habit, surrounding space itself becomes recruited and stylised so that, as a cultural scaffold to one's lifeworld, one 'belongs to it' and thus no longer requires large quantities of processing power to perform skilful actions in it. These habitual configurations remain with the lived body, co-constituting the agent's very embeddedness in space. This is how, as Merleau-Ponty suggested, habits are not just explicit memory-items stored in a cognitive repository but dimensions of know-how activated at the appropriate moment (Dreyfus, 2002). The age-old example of riding a bike is informative here. For example, when riding a bicycle, habit entails that my leg movements on the pedals, my hands on the handlebar, my eyes and the path ahead and my sense of balance automatically coalesce into a unified motoric event (Ratcliffe, 2012). Habit thus confers a deep-seated stability to our being-in-the-world since "even if our body does not impose definite instincts upon us from birth… it at least gives the form of generality to our life and prolongs our personal acts into stable dispositions" (182/147). These 'stable dispositions' can be activated whenever the world beckons them, such as when the habitual typist views their keyboard:

> The subject knows where the letters on the keyboard are just as we know where one of our limbs is… When I glance over the text offered to me, there are no perceptions awakening representations but rather wholes that arrange themselves at the present moment…When I take my place before my machine, a motor space stretches out beneath my hands where I will play out what I have read; (179/145).

As discussed in the previous subsection, tools facilitate alterations of our embeddedness in space simply by giving themselves over to our use; subsequently, they then cease to exist as intentional-*objects,* instead entering into what Dreyfus (1996) calls 'background coping'. That is, they *constitute* motor-intentionality by modulating intentional access to other entities. For a tool to enter into 'background coping' it must have changed the way that we access *other* intentional-objects, typically in a manner that would not be possible for the body by itself. The pen allows access to writing, for example. In this way, the useful object is rendered transparent so long as we literally use it to enact a goal-directed action. Merleau-Ponty explains this well when he says: "If I want to become habituated to a cane, I try it out, I touch some objects with and, after some time, I have it hand: I see which objects are within reach or out of reach of my cane" (178/144). Eventually, bodily space stabilises around the way space is disclosed by the cane, permitting interaction with other things so that the cane ceases to appear as a separate entity, instead assuming a role previously or otherwise accomplished by the body (i.e., sighted navigation). For the habitual cane-user, the phenomenon is described as follows:

> Habit does not consist in interpreting the pressure of the cane on the hand like signs of certain positions of the cane and then these positions as signs of an external object – for the habit *relieves* of us this very task (189/153-154).

In fact, this embodiment of tools is so profound that Merleau-Ponty claims: "when the cane becomes a familiar instrument, it no longer begins at the skin of the hand but at the tip of the cane" (188/153). As with the typist whose "motor space stretches out beneath his hands" when typing, the cane acts as a constitutive component of bodily space whilst in use, and, if one is a *habitual* cane user, then it assumes a greater presence within one's bodily spatial relation to the world, providing them with another form of direct access to the environment *qua* space of meaning. A tool that you have considerable degree of skill in wielding thus becomes constitutive of your bodily world-embeddedness just as much the body itself since both body and tool equally render surrounding space as manifestly interactable in an enduring and meaningful configuration.[20]

2.4 Depth and Movement

We can now turn to two more aspects of space – depth and movement - which are traditionally more closely tied to spatial *perception* yet nonetheless foreground the role of the active body. Indeed, Merleau-Ponty is not committing the cardinal sin of viewing perception as a merely passive phenomenon. Objectified space, Merleau-Ponty claims, runs into problems that have traditionally provoked a problematic rejection of experienced space or relegated it to the status of illusion. For example, objectified space must commit to the unreality of depth due to how the retina receives information in only two dimensions. On Berkeley's (1710/1999) account, since height and width are easier to map onto objective, quantitive measurement, depth is more closely aligned to a perceiving agent immersed in a world of sensory presentations that offer themselves to the situated agent. But the notion that depth might owe its existence to the world-embedded agent's perspective does not diminish its ontological reality for Merleau-Ponty. Indeed, depth is "the most existential dimension" for this very reason as, in accordance with Berkeley's

[20] This statement is highly preemptive of PPS research in that one's PPS 'wraps around' the object that the individual is using (Graziano, 2018). The compatibility between these accounts will be discussed in depth in **Chapter 2**, **section 3**.

position, depth “is not indicated upon the object itself, it clearly belongs to the perspective and not to things” and can thus help to “overcome the classical alternative and clarify the relation between the subject and object” (305/267) by showcasing the ‘subject’ as completely immersed in a spatial world of which it is a participant rather than cognising it as a detached spectator (see Talero, 2005).

In depth as it is disclosed phenomenologically, entities are not primarily separated from each other in the format of quantifiable intervals. That is, it doesn’t quite make sense to say things in perception are ‘deeper’ than others in the same way they might be wider or taller. Objects are not (only) separated from us by an objectively measurable distance but by the phenomenal ‘distance’ (i.e., accessibility) between the object and the sensorimotor system’s ‘hold’ on it. As the distance between me and an entity increases, my sensorimotor hold on it (its ability to influence my senses or to elicit my body into an action-ready state) decreases in lockstep. At the sensorimotor level, a *decrease* in ‘hold’ in the agent-object relationship is the primary and most immediate way that an *increase* in distance is understood. Proximity is thus a continuum of the strength of hold that tools have over perceiving agents in a shared space.

To better understand this phenomenon, let’s refer to Merleau-Ponty’s chosen example of seeing a fellow human being. The man who is further away “is a less articulated figure [since] he offers my gaze fewer and less precise holds [and] is geared [less] into my exploratory power” (310/272). When he is further away, I have fewer opportunities to perceive an expression, react to a movement or form an impression of his intentions. His hold over my situation diminishes because less details are present and because interaction with him appears increasingly less likely. Accordingly, his ‘reality’ for my spatial situation has decreased. Interestingly, even in cases in which an object is actively moving away:

> We ‘have’ the object that is moving away, we do not cease ‘to hold’ it and to keep a hold on it… the increasing distance merely expresses that the thing begins to slip away from the hold of our gaze and that it joins with it less strictly (311/273).

Typically, in Merleau-Ponty’s phenomenology, embodied acts (which certainly includes perception) are motivated or solicited by elements in the world. In the dimension of depth, unlike in width or height, things in space intertwine, overlap and remain for us the centre of a perceptual world, whereby inner-spatial entities are laid out before us first and foremost via their interact-ability. The likelihood and availability of one’s capacity for object-interaction dictates the strength of the hold that the entity wields over one’s lived body. This is how depth and distance are experienced primordially. Thus, phenomenological categories such as "availability" and "usability", grounded upon distance, are significant determiners of lived space's inherent structure in a manner that is not interchangable with objective space. This is why, *contra* Berkeley's relegation of depth to illusion, depth for Merleau-Ponty is "the dimension according to which things or elements of things envelop each other" (314/276) and thus "a relation from me to things" (316/278) which therefore renders it the most 'existential dimension'.

This takes our discussion from 'depth perception' to 'motion perception' (pp.317/279-332/293). Opposing Zeno's paradox just as he opposed Bishop Berkeley, Merleau-Ponty argues that motion is not just some property tacked onto an independently existing object. Rather, Merleau-Ponty claims that movement is a 'fact'; that is, I am directly presented with a moving object as a specific entity defined as *being-in-motion*. Unsurprisingly, Merleau-Ponty claims that our experience of movement is mediated through one's body insofar as the body provides a stable, invariant background that determines the status and trajectory of the moving thing (e.g., a bird flies from *my* left to my right or the dog runs *towards* me) that allows it to obtain its status *as* moving (Carman, 1999).

In other words, for a thing to be in motion, it must be relationally grounded in a perspective that sees it as such. Importantly, we should never judge the thing-in-motion as some derivation of the static thing. Movement is instead a reality of the things perceived that is just as real as when they are stationary; as a phenomenon in-itself, movement's meaningful context is scaffolded by one's bodily position and situational orientation. Indeed, Merleau-Ponty's phenomenology of movement once more recalls the spatial level: "As with up and down, movement is a phenomenon of levels, every movement presupposes a certain anchorage that can vary" (331/292). Moving objects manifest on the basis of being rooted within an anchorage point that co-determines the appearance and significance of the moving thing as relevant to one's own situational context, e.g., *Where am I currently located*? *Am I sitting, standing or lying down*? *Is the approaching object dangerous or desirable*?

Once more, we have seen that treating space as an objective grid devoid of a centred, meaningful perspective in which to orient surrounding perceptual phenomena fails to remain faithful to the realities of spatial experience. Even when focused upon an anchorage point dictating trajectory is not itself an intentional-object but another phenomenon that *co-constitutes* bodily space because it facilitates one's motoric *access* to other intentional-objects in particular ways. An anchorage point is, in other words, a background phenomenon akin to the spatial level or habit in that all such phenomena pre-reflectively modulate one's spatial embeddedness at a structural level. Whether or not I perceive the train that I am sitting in move or, rather, instead see the adjacent train visible from the window move (to reuse Merleau-Ponty's still-familiar example) depends upon my anchorage point, which may rapidly switch back and forth, determining the content of all my spatial sensations.[21] Yet, I do not necessarily take this or that train as an intentional-object explicitly; rather, each serves as the foothold from which the following sensations emerge. An anchorage point is, therefore, part of the 'background', a foundation out of which the interplay of perceptual phenomena in motion or in relation obtain significance.[22]

2.5 Lived Space

While all of the above accounts of spatiality should be classified as 'lived', Merleau-Ponty wishes to draw our attention to another aspect of human spatiality that is less immediately concerned with perception, traditionally conceived. In a sub-chapter entitled 'lived space', Merleau-Ponty deliberately mirrors and reapplies Heidegger's phenomenology of so-called 'lived time', which he sharply contrasts with objective time. In brief, Heidegger (1927/2010) designates time as measurable by clocks as 'vulgar time', a derivative of the primordial time experienced by human beings (Blattner, 1999).[23]

Lived or 'primordial' time is not homogenous, with a steadily emerging future absorbing the past and replacing it in sequential, linear fashion. Merleau-Ponty reappropriates this mode of thinking and applies it to the domain of spatiality. In both cases, quantitative, measurable means of accessing a phenomenon (i.e., time and space) fail to map onto the way that these phenomena present themselves *within* lived experience. Metres and miles cannot (exhaustively) inform us of how we are immersed in our spatial surroundings just as nanoseconds and weeks cannot, in any profound sense, inform us of the temporal rhythm and structure of our immediate experience. Thus, just as we never find ourselves encapsulated in some 'now' without a past that brought us here, when we face our spatial

[21] This point evokes Noel et al. (2015) and Adrizzi and Ferri's (2018) claim that the subjectively-perceived body is the locus for PPS, not always the objective body. However, it remains an open question as to whether Merleau-Ponty's specific example of the train could transfer to the experimental setting.
[22] Fuchs (2018, p.49) provides a rather Merleau-Pontian summary of the same general phenomenon: "each perception of a moving object contains not only the object itself, but also its motion dynamics, the background of the visual field... thus perception is not a momentary snapshot of a stimulus configuration but rather a dynamic, intentional and attention-directed process which ultimately includes the whole system of brain, body and environment".
[23] Heidegger was by no means completely unique in this regard; his work closely followed the phenomenology of Husserl and the philosophy of Bergson.

surroundings, "an initial perception without any background is inconceivable. Every perception presupposes a past of the subject" (333/294).

Merleau-Ponty is here more explicit regarding the differences between lived and objective space. Positing an analogy between spatiality and sociality, he claims that, just as we do not primarily perceive 'objective' faces and eyes (but rather their meaningful gaze and expression), so too do we not perceive objects, buildings and landscapes *primarily* as brute entities featuring metric heights and widths upon which we *subsequently* colour with significance; rather, we encounter them (e.g., the apple, the school, the meadow) as *already* coloured with significance and meaning. In a further social-spatial parallel, just as only ambiguous social gestures require thematisation (i.e., an unknown hand gesticulation), only unknown or confusing objects and buildings are initially experienced as de-contextualised phenomena to be subsequentially decoded in a sequential manner via explicit reasoning. In lived space, spatial phenomena are inherently encountered as meaningful wholes against the background logic of world. Applying this logic to spatiality nets the following passage from Merleau-Ponty:

> In the natural attitude, I have no *perceptions*, I do not posit this object as next to that other one along with their objective relations. Rather, I have a flow of experiences that implicate and explicate each other just as much in simultaneity as they do in succession (332/293).

As such, while spatial perception is not built out of an accumulation of micro and macro-structures, it can always orient towards macro or micro elements of the spatial givens. This can potentially operate on a variety of scales. As Merleau-Ponty illustrates, my focus can be drawn to the house, to the front door, the door handle, or the keyhole in the door handle. Thus, as spatially-embedded agents, we can seamlessly move from wholes to parts at will: "Everything that makes up part of my environment is perceived, and my environment includes 'everything with whose existence or absence… I practically reckon" (335/377). What can be 'reckoned' *is,* therefore, my environment itself.

Furthermore, in stark contrast to a centre-less objective space, both the agent's biographical past and cultural context[24] constitute the background to their immediate spatial experiences (Talero, 2005). Behind perception there exists a system of relations which is gathered together and 'held in place' by the body: stairs that can be ascended, doors that can be opened, water fountains that can be drunk from (see the notion of the 'landscape of affordances', Rietveld and Kiverstein 2014). Thus, a tapestry of affording-

[24] These are not always separate; one's biography always has some link to a one's culture. One cannot be a Roman general in 21st century England, for example.

features held together by the invariant presence of one's body automatically structures one's experience of surrounding space at the most primordial level. This entails that the sensory stimuli continuously emerging from my surroundings are always encoded with meaning relevant to my specific situation. If alone in the woods at night, "a passing shadow or a creaking tree have a sense; there are warnings everywhere, without anyone who is doing the warning" (343/303). Meaning thus infuses lived space at every level, correlating perceptual contents to the spatial situation in which one finds oneself. That is, in the above example, auditory stimuli are not *just* vibrations across airwaves but pre-reflectively emerge *as warnings* in relation to one's global context and one's specific locatedness in a contextually meaningful space.

As is customary, Merleau-Ponty believes that such claims can be further evidenced by recruiting the neuropsychological deficit literature which joins up with Heidegger's account of 'lived time' as something that projects Dasein/the agent into its future possibilities. Without explicitly drawing an analogy with the Schneider study that informed his account of the body schema, Merleau-Ponty interprets spatial disorders as essentially characterised by a projective deficit, similar in kind to some of Schneider's symptoms. This is important to note, as the impact that our surroundings have upon our body does not condemn us to an unthinking subordination to whatever they solicit. A compromise exists between experienced solicitations and our implicit awareness of our ability to interact with them, alongside our capacity to decide *not to* engage them.[25] In fact, this 'over-affording' is precisely observable in *disruptions* of spatial experience, not normative spatial experience (see Rietveld, 2008, 2012). When encountering an unstructured mass of spatial potentiality, the schizophrenic individual or lesion patient engages their spatial horizon with a kind of vertigo, unable to establish any stable equilibrium ('spatial level') between body and environment. The mode of spatial embodiment that typically affords structure to one's spatial surroundings is this disrupted:

> If the world falls to pieces or is broken apart, this is because one's own body has ceased to be a knowing body and has ceased to envelop all of the objects in a single hold; this degradation… must be related to the collapse of time, which no longer rises toward a future, but rather falls back upon itself; (334/295).

This means that lived space can be considered as *spatio-temporal*. However, unlike a physical account of spatio-temporality (Rovelli, 2006), the 'temporal' component to the "quasi-synthesis" of space-time is informed by Husserl's phenomenology of temporality

[25] See Cappuccio (2023) for a recent account of how pre-reflective, skilful engagement is not akin to being 'mindless'.

(1921/2001). Just as the present moment is divided into a retention-impression-protention structure (Zahavi, 2003), Merleau-Ponty posits that a here-there spatial division is conjoined as a “passage”. Again, analogous with physics, time and space are not two discrete phenomena combined in synthesis but a continuum. As Viljoen (2010) points out, every ‘there’ (outside of PPS) is presented also as a ‘potential-here’. Lived space is thus always temporally inflected. Generally speaking, as (Viljoen, 2010) emphasises, the phenomenon of ‘there’ is also that of a ‘could-be-here’. And as both Talero (2005) and Viljoen (2010) show, through in-*habiting* the world, I ‘have’ a circumscribed dimension of the phenomenal world by bringing it out and making it somehow ‘mine’. When engaged in tasks, my body automatically uses its practical know-how while I may simultaneously view another area of space as a zone of future interaction. Out of an undifferentiated spatial grid emerges a place suitable for life, structured on the basis of possible actions (future) and past habits (past).

Finally, we have gathered further phenomenological evidence that this world with which we practically reckon is understood not just by thematising it abstractly or even directing our gaze toward it, but by exploring and interacting with it. When assessing the famous epistemological dilemma presented by the difference between illusions and true perception, Merleau-Ponty notes that it is actually *through* perception and interaction - not reflection - that perceptual errors are rectified. One route for this rectification is that, with an unreal, illusory object, I am prohibited from exploring it further with my body (moving around it, touching it, grasping it, relocating it in space). As Merleau-Ponty notes (350/310), the man lost in the desert cannot cognise his way out of the illusory oasis. Rather, it dissolves away when he tries to scoop water and takes only sand; that is, when he tries to engage it with his body in space. As such, we need not (always) rely on the knowing *Cogito* to understand our spatial surroundings but rather our ability to update our knowledge of the world through further sensorimotor investigation.

2.6 Overview

Above, we have discovered with Merleau-Ponty’s assistance that the interrelation between agent and world emerges in the form of a spatial level, optimising the coherence between the body and its surroundings to confer a mode of grounded orientation that, even if disrupted, eventually reconfigures itself following directed bodily action in the world. Thereafter, we saw how the body schema includes not just its *own* body parts but also intentional-objects and the practical knowledge regarding how to use them, which feature as the reference points for one's motor-intentionality, enabling skilled, pre-reflective interactions between body and objects. Over time, these motor-intentional ways of acting in space become sedimented in the form of habits (Viljoen, 2010), which can thereafter be deployed without the need for reflective cognition whenever a situation demands it. Habit is thus the mechanism by which practical know-how becomes stored in one's permanent modality of being-in-the-world. In addition to action, aspects of spatial perception, such as depth and motion perception, highlight how being an organism embedded in the spatial world with concern for its own existence structures the content of its perception. Consequently, the depth, distance, movement, and trajectory of things in space are presented to the agent on the basis of having lesser or greater saliency and relevance for the organism. Finally, we saw how 'lived space' aligns with the notion of 'lived time' in that one's surroundings are structured by mutually implicating events that beckon one toward future action.

In summary, Merleau-Ponty conceives of embodied human existence in space as a constant dialogue between perception and action, the concrete and abstract, between actuality and potentiality. The entirety of Merleau-Ponty's account of embodied spatiality might exemplified in the aforementioned notion of the 'I can'. On the basis of 'I can', one's spatial surroundings are structured as a nexus of possibilities constituted by the contextual actions that *could be* taken up, structuring one's projective mode of spatial embeddedness. My lived body *in-habits* space by actualising bodily tasks presented to me insofar as I bring them from the 'abstract' into the 'concrete', oftentimes recruiting external objects into my space of action as if they were my own body parts. Thus, lived space is determined by the skills, habits and tools that one has at one's disposal and the kind of material and cultural environment into which one has been acculturated, presenting itself as an ever-present background that bestows familiarity, orientation and fluidity to one's actions. We should emphasise that these spatial concepts help us further differentiate 'lived' from 'objective' space as inaugurated by Heidegger. However, Merleau-Ponty enriches our discourse by showcasing a greater role for the body in space and by frequently supporting his claims with scientific evidence, a strategy that we shall continue below.

As the later Merleau-Ponty showcased with the notion of 'flesh' [*la chair*], our bodily space merges with 'objective' space that, while certainly never departing from objective space in some transcendental sense, is nevertheless not fully expressible with the concepts used to measure objective space (see Marratto, 2012). However, despite the impressive utility of phenomenological accounts of lived space, the meaningful relation between agent and environment, often known as the *Umwelt*, can still be disclosed in much further detail. To do so requires the assistance of another discipline devoted to the disclosure of meaning.

Chapter 1, Part B: Semiotics of Spatiality.

Introduction

After inaugurating our enactive account of bodily space by drawing upon the phenomenological resources listed above, we can now aim for further depth in our account of lived space by incorporating the field of semiotics, a discipline also designed to reveal, describe and catalogue meaning in its various guises. Indeed, corresponding to our own methods and aims, Zlatev et al. (2018, p.1) describe (cognitive) semiotics as "a truly transdisciplinary science of meaning". As identified previously, it is primarily the presence of meaning that pre-reflectively structures the agent's spatial embeddedness in their surrounding space. Biosemiotics in particular has important things to say here, because it originally furnished us with key spatial concepts such as the *Umwelt*. Moreover, Peirce is closely linked with the original development of philosophical pragmatism (Dewey, 2016; Johnson, 2016) a philosophical current that, along with phenomenology, has strong influenced the conceptual purview of ECS (Gallagher, 2023).[26]

Indeed, central to our current embodied-enactivist reading of spatiality is the assertion that PPS is an enactive interface that unifies the 'worlded' brain-body with the *Umwelt* in which it is embedded, facilitating embodied interactions between agent and other entities on pragmatic grounds in the form of a 'dynamic structural coupling' (Varela et al., 1991). Furthermore, for an analysis such as ours that freely combines resources from the sciences and humanities, the tools of biosemiotics feature particular importance because PPS sits at the intersection between both biological and cultural factors. Accordingly, an account aiming for comprehensiveness on human spatiality must simultaneously account for the interplay of both within a unified framework. Thus, both biological and physiological evidence (e.g., neuroimaging data, clinical literature) and cultural analyses of the social world (e.g., social signifiers, language) are necessary to showcase how agents experience space in pragmatic, meaningful and sociocultural terms.

Crucial to any semiotic analysis is the postulate that a given object might be encoded with a variety of different meanings in accordance with the person, group or organism that

[26] For this reason, Uexküll shall be the first major semiotic figure we cover in this chapter and Peirce the second.

engages it. The sign studied by semiotics is an inherently contextual phenomenon (Eco, 1975; Paolucci, 2018; Zlatev et al., 2018). From the standpoint of a semiotic account of spatiality, it is from out of the dynamic, contextual and meaning-making relationship existent between *people*, *object*(s) and *space* that a kind of global sense-making emerges, known as 'semiosis', that fuses together each of these elements into a *meaningful* whole. Accordingly, the agent perceives their surrounding 'world' as a field populated by meaningful signs relevant to their life: nourishment for sustenance, traffic lights that implore them to go, and words which evoke certain feelings, etc. The presence of contextual and pragmatic meaning thus continuously modulates the agent's primary engagement of their surrounding space and figures heavily into how they respond to the various entities that are dispersed within it. Once more, this key factor differentiates lived space *qua Gestalt* phenomenon from the kinds of divisible and/or quantifiable spatial systems that are studied by (some fields of) mathematics and the physical sciences.

Moreover, since this thesis deals heavily with evidence deriving from disciplines that frequently bear the label of 'biological' or 'cognitive', the sub-disciplines of semiotics that we will use for our account of lived space are those of 'biosemiotics' and 'cognitive semiotics'. Emmeche (2001) indicates that the three central figures of biosemiotics are: C.S Peirce, J. von Uexküll and Thomas Sebeok. Additionally, these figures are of equal centrality to the more recent semiotic subfield known as Cognitive Semiotics (esp. Peirce), particularly in regard to recent embodied-enactivist interpretations (e.g., Violi 2008; Paolucci 2021), which will be discussed in further detail below. Thus, in what follows, we will primarily engage the work of two of the three central figures highlighted by Emmeche (2001) – von Uexküll and Peirce – before concluding our analysis by turning to the sub-discipline known as cognitive semiotics. Thus, in the foregoing analysis, we aim to better understand lived space by discovering how it manifests in the form of semiosis.

1b.1. Von Uexküll

1.1 Uexküll's Umwelt

A spatial concept of foremost importance to our analysis is undoubtedly that of the '*Umwelt*', introduced into semiotics (and scholarship generally) by Jakob von Uexküll's masterful *Foray Into The Worlds of Animals and Humans* (1934/2010) and *Theory of Meaning* (1940/2010). In the field of biosemiotics, which Uexküll pioneered, an *Umwelt* designates a meaningful environment comprised of objects *qua* signs or 'meaning-carriers' that are infused with signification relevant to the organism's needs or general mode of living. For this reason, an *Umwelt's* terrain is not interchangeable from species to species, nor even those occupying the same 'objective' location. Indeed, as Sebeok (2001, p.xv) explains: "animals with widely divergent anatomies do not live in the same kind of world". Furthermore, while they are technically transliterations, the terms 'environment' and '*Umwelt*' as employed today are not completely interchangeable; as Lotman (2002) explains, we might readily say that an atom exists in an environment, we cannot say it exists in an *Umwelt*.[27] Only a living being can exist in an *Umwelt* which, in Uexküll's analyses, encompass amoebas to humans. By implication, any *Umwelt* that fails to foreground the perspective of the perceiving agent(s) cannot be an *Umwelt* and is closer to the homogenous environment occupied by the atom.

First, let's discuss the clearest analogues with the previous section's conclusions. In parallel with phenomenology, semiotic investigations into the spatiality of *living* beings inevitably press upon the limits of quantification when articulating the kinds of relationships existent between living beings and surrounding entities, whether alive or inanimate. As Sharov (2001, p.211) cogently describes it:

> Umwelt is not an ecological niche because niches are assumed to be objective units of an ecosystem which can be quantified using external measuring devices. On the contrary, Umwelt is subjective and is not accessible for direct measurement.

Unlike in classical phenomenology (e.g., Husserl, Heidegger), however, scientific inquiry has traditionally been included at the forefront of biosemiotic research, rather than as something to be bracketed; von Uexküll himself was a practising biologist who remained in dialogue both with the philosophical currents and major theoretical debates in the biological sciences of his era. Above all, Uexküll wished to liberate his discipline from the then-dominant (and arguably still dominant) mechanist worldview, which he thought was entirely proper to physiology, yet failed to capture the domain of biology. He argued that mechanistic modelling was largely incompatible with the larger scope required to make progress in the biological sciences because, in contrast to the physiologist who studies *processes* that are *internal* to the organism, "the biologist takes into account that each and every living thing is a subject that lives in its own world, of which it is the centre" (p.45). This emphasis on the lived nature of the relationship between living things and their surroundings places Uexküll's aims firmly in conjunction with our own.

[27] However, in the PPS literature, neuroscientists use 'environment' in place of what might otherwise be called an *Umwelt*. However, there are exceptions to this rule (Gallese & Sinigaglia 2010; 2011; Gallese, 2018).

For Uexküll, 'objects' encountered by organisms are best defined as 'carriers of meaning' and are vital constitutive elements of the *Umwelt*: "We begin with a subject located in its environment and research its harmonious relationships to individual objects that present themselves to the subject as carriers of meaning" (172). Uexküll employs 'meaning' as a technical term to define the qualitative nature of the relationships between entities within an *Umwelt* and a living organism that is receptive to them: "*The question of meaning must therefore have priority in all living beings* [original emphasis] (151). As Emmeche (2001, p.655) summarises: "the subject is the constructor of its own *Umwelt*, as everything in it is labelled with the perceptual cues and effector cues of the subject".[28]

Once more, then, we are confronted with the idea that the space proper to a living organism - 'lived space' - only becomes intelligible when underscoring that a living being serves as its own nucleus, as its ultimate ordering principle from which its surrounding space acquires structure and intelligibility (Gaines, 2006). Importantly, however, despite Emmeche's above-quoted passage, such 'meaning-carriers' do not derive *ex nihilo* from the individual; this would amount to a reincarnation of Cartesianism. As such, further articulating the *Umwelt*, of which the living, enactive organism is the centre from a semiotic perspective in which it partakes, shall be the focus of the next section.

1.2 Action, Sensation and Perception

'Meaning' is at least neither *fully* objective nor subjective since "Meaning bridges the gap between physical and non-physical processes" (157). If meaning represents such a link between organisms and their world, how do organisms practically recognise and partake in meaning? Pre-empting contemporary 4E approaches to cognition, Uexküll emphasises the fundamental importance of both perception and action ('effect') in meaning apprehension, despite articulating their relationship in terms which might strike the contemporary enactivist as somewhat dualist. Indeed, Uexküll divides brain cells into 'perception' and 'effect' cells, articulating the co-dependency between action and perception thusly:

> All our human actions, which represent specific perception signs, join together to form the qualities of the external things which serve us as perception marks for our actions… the effectors activated by the muscles impress their effect mark ['*Wirkmal*']" on the objects that lie outside their subject (48).

[28] One will note that a subject-object metaphysics is here much more prominent than in the other thinkers discussed in this chapter. This is appropriate when discussing Uexküll for reasons that will later be discussed. However, with the semiotic work of Peirce discussed hereafter, we shall receive a model of semiotics that, like Heidegger and Merleau-Ponty, attempts to more explicitly overcomes the traditional subject-object dichotomy.

If indeed “every carrier of meaning is utilised through perception and action” (150), then the organism is inherently an enactive entity that understands its world as a place comprised of numerous interactive opportunities, as a junction between sensory perception, bodily movement and interactable meaning-carriers, whereby each influences the other in a continuous cycle. These context-dependent ‘meaning-carriers’ thus elicit equally context-dependent responses from the organism. Uexküll clarifies that the most salient qualities of such meaning-carriers frequently depend upon the temporally-contingent needs of the organism, who, by automatically eliciting these qualities from the perceived objects, in some sense brings them into concrete reality. This process is labelled the ‘functional cycle’.

The functional cycle thus draws the agent into a participatory role alongside relevant meaning-carriers in the *Umwelt*. The functional cycle is perhaps one of Uexküll’s central theoretical achievements and remains informative for enactive cognitive science (Froese, 2010; Feiten, 2020). It is worth quoting Uexküll’s key passage at length:

> Since every action begins with the production of a perception mark and ends with the impression of an effect mark on the same carrier of meaning, one can speak of a functional cycle, which connects the carrier of meaning with the subject. The functional cycles that are of most importance are the cycles of the medium, of nourishment, of the enemy and of sex (145).

These 4 categories seemingly apply to all biological organisms and serve as a kind of global context that modulates inner-Umwelt meaning-carriers according to the global context’s internal logic. Uexküll’s language here is self-consciously Kantian because he sought to synthesise scientific biology with Kantian philosophy at a meta-theoretical level. Nevertheless, Uexküll clearly subordinates perception and action to mutually dependent elements co-constitutive of a holistic, environmentally-situated organism and not that of a knowing and ontologically-separate *Cogito*. And, more importantly, while this organism is intrinsically defined *as* that being which exists in relation to an environment, contra Emmeche (2001), it is not said to completely ‘construct’ this environment according to its own independent mental constitution. Rather, in Uexküll’s words, it *connects* the organism to *Umwelt*.[29] Indeed, each organism is co-constituted by its biological capacities for perception and action *in response to* the environment’s demands.

Moreover, we should visualise something of a hierarchy of graded feature-carriers in the things that an organism encounters, since “some individual properties play a leading role

[29] Corresponding to this philosophical idea, Uexkull elsewhere writes that a “Spatial schema only exists if there are organisms to enact them” and “A perception mark ‘activates’ a functional cycle“ (88).

as carriers of perception marks or of effect marks while others only play a supporting role" (146). He also tells us that "Perception marks entering distinct sensory modalities might contradict one another (91) and that "If it serves more than one kind of act, the same object can have multiple effect images" (95). That is, some properties are more salient than others (such as the firmness or colour of a fruit that signifies its edibility).[30] Thus, several competing 'marks' that all elicit action may compete for the organism's attention, with the most salient or appropriate subordinating the rest. But it is important to remember that these ideas do not imply epistemic nihilism whereby every interpretation is of equal value; functionality, appropriateness and the organism's biological needs always determine the dominant meaning found in any given object. The organism thus connects to its environment via the functional cycle in a manner that is both meaningful and situated.

While von Uexküll might disagree with the phenomenologist in that the object is seen *as* its use, he seems to believe that an object's utility ('effect image') is processed *simultaneously* to its appearance ('perception image'), claiming that "stimuli are then transformed into nerve excitations in order to be conducted to the central perception organs" (147) while "we alloy this effect image so effectively with the perception images we receive from our sense organs that the two acquire a new characteristic, which announces its meaning to us" (95). This fully illustrates how Uexküll understands organisms from a proto-enactivist perspective (e.g., Noe 2004); we 'see' certain objects within our sensory field when we can perform actions upon them, and their objective properties are given to perception and integrated extremely quickly with their use-value, thereby conferring the object's meaning to us via a pragmatic and instantaneous integration of perception images and effect images without any role for conscious decision-making.

Thus, all syntheses of perception and action - as concretised through the perceived meaning-carrier – are classifiable as functional cycles. These cycles permeate the organism's existence in the *Umwelt* at multiple scales and levels. For Uexküll, even blinking cannot be considered a mechanistic response but rather a simple and easy-to-model instance of the functional cycle:

> Even the simple reflex of blinking at the approach of a foreign body to the eye is no more progression of a chain of physical and effects, a simplified functional cycle, which begins with perception and ends with effect (147).

[30] This line of thought may be thought of as a precusor to Cisek's (2007) 'Affordance Competition Hypothesis'.

What, then, of more complex functional cycles? Uexküll's strikingly pragmatic and proto-enactivist position is that: "We may say that an animal is able to distinguish as many objects as it can carry out actions on them" (96). Thus, the existence of objects *qua* meaning-carriers multiply to the extent that organisms can actively incorporate them into their life-world. Let's take a singular object and a singular species: a rock and a chimpanzee. The chimpanzee *sees* the rock as a tool for opening nuts when it feels hungry and as a projectile when it feels threatened. These qualities remain latent until they are 'activated' by the situationally-contingent needs of the organism. The primate *sees* the rock as a weapon when an enemy appears, which permits allows it to act on it accordingly. Elements of the subject's world 'light up' and align themselves to its body and from this alignment emerges the spatial structure of the *Umwelt* emerges, enabled by functional cycles. The 'external world' is therefore coloured by the 'subject' who both *produces* and *elicits* the dominant meaning of the spatial region through the functional cycle.

As Uexküll repeatedly highlights, if our treatment of the biological organism necessitates viewing it as a holistic entity, we must include within our definition of it that to which it responds as an integral part of said definition. The whale or tropical frog cannot be biologically understood if we have no concept of the ocean or rainforest, for example. The most complete model of any organism would thus necessarily include its *Umwelt*; separating the organism from its environment will only give us a mere simulacrum of its complete being. If a Martian were to come to Earth and be presented with a worm, it would have a far worse grasp of what kind of organism a worm is if it were not also shown the soil. Uexküll's distinction between organism and world is, therefore, arguably less clear-cut than its traditional formulation in Cartesian-Kantian philosophy, whereby a subject filters the world according to its own *a priori* categories. This is because the semiotic 'subject' (as Peirce often emphasised) is always-already part of and shaped by the greater network of meaning-relations that exist prior to it. In evocative words strongly pre-emptive of Merleau-Ponty's later interpretation of the biological sciences, Uexküll here claims:

> Subject and object are interconnected with each other and form an orderly whole… Every subject spins out, like the spider's threads, its relations to certain qualities of things and weaves them into a solid web, which carries its existence (pp.49/53).

The organism's existence is 'carried' by the sum of these relations because they fundamentally define how it exists in relation to everything else. The bird's relation to tree branches for resting and rearing young, the soil which contains nutrition and the sky as a backdrop for airborne motility define its existence *qua* bird. We should imagine the space surrounding the organism as one connecting it to its environment via a network of interlapping, bidirectional arrows or circuits, each representing a functional cycle that brings the organism into alignment with its world and forming a species-specific *Gestalt*. Above all, this ecologically-situated sensorimotor network defines the spatiality of living organisms. As Uexküll poetically puts it: "The dwelling world of an animal, *which we see spread out all around it*, transforms itself which observed by the animal subject into the latter's environment, whose space is teeming with the most varied carriers of meaning" (150) [emphasis added].

Additionally, Uexküll highlights three further concepts essential to revealing the spatiality of the organism, each of which serves as a kind of spatial filter: "the search image, the tracing of the most familiar path and the demarcation of territory" (119). The search image is one instantiation of what Uexküll calls a 'spatial schema',[31] the structure of which hinges upon what he terms 'tone'. Tones are expressed by verbs or adjectives (e.g., search, avoid, edibile, repulsive) that represent the primary function that a dynamic object serves for the organism that essentially binds the organism and the external entity. Tones are often species-specific and a single tone can encompass several diverse objects. In the case of the anemone, Uexküll provides examples of a 'protective tone', 'dwelling tone', and 'feeding tone'. With canines (119), Uexküll highlights how a dog understands a generalised 'object-for-sitting' upon hearing the human word 'chair' spoken. The dog searches for anything that fulfils this function, whether or not it resembles what a human adult would call a chair. To give another example, a dog understands a lamp-post as 'object-to-mark-territory' even if (we hope) a human does not! Accordingly, functionality determines both the type and token of the search image. Disparate objects are thus grouped together if serving an identical function, thus rendering 'tone' as essentially a kind of enactive template through which spatial entities in the *Umwelt* are filtered.

Uexküll adds that "the subject's mood is crucial for which effect image gives a tone to the perception image" (95). But here, the semantic meaning of 'mood' seems closer to 'intention' than to 'feeling': the dominant intention currently inhabiting an organism determines the object's tone. A mood thus subordinates perceptual input according to its own schema, reconfiguring entities in accordance with the organism's situated and needs-based orientation. Uexküll cites empirical evidence that a toad will look for food most closely resembling what it had recently eaten, including items which do not actually

[31] As we shall see, the notion of 'schema' is essential to a semiotic spatiality.

constitute food for it (117). Correspondingly, the human will search for an object which fulfils a certain task (e.g., cutting or hammering), and objects will suddenly manifest to perception on this basis. Indeed, Uexküll attributes great importance to the organism's tone regarding the structure of lived space. When the organism is transfixed to a 'Search template', it orients the organism in a 'finding-mode' that restructures the surroundings to prioritise the sought object, allowing their context-appropriate tone to manifest. Other times, "the search image wipes out the perception image" such as when we cannot find an object useful for a task because we are searching for something slightly more specific. The perception of our surrounding space is thus highly dependent on the dominant intention which reconfigures the *Umwelt's* global quality.

Pivoting again to human beings, Uexküll (1940/2010) writes tellingly of an immigrant to Europe who, when asked to climb a ladder, claimed he was only able to see "bars and holes" (p.141). However, upon witnessing somebody use the ladder a single time, its 'for-climbing tone' became immediately apparent to him; the perceived object was transfigured from 'bars and holes' into a useable, task-specific object. Thus, some meaning-carriers are culture-dependent, even if witnessing them in use by other humans is sufficient for them to show themselves as tools.[32] The 'climbing tone' did not emanate from the object until it was witnessed in use as something-to-climb, transforming the visual object (ladder) from a collection of shapes ('bars and holes') into a tool ('meaning-carrier') included within a perceptual-action cycle. Thereafter, for that individual, *all* ladders acquired a 'climbing-tone' after witnessing a single ladder in use. Thus it is in this format of a type-token distinction that a meaning-carrier permanently enters the *Umwelt* and becomes part of a functional cycle.

And what, then, can the so-called 'tracing of the familiar path' tell us? When describing the temporally-extended intentional structure typical of many advanced organisms, Uexküll insists on the superiority of the term 'plan' over 'instinct'. Why? Because a plan, according to Uexküll, is neither "a force nor a material substance" (92) and thus escapes the mechanist framework of physics. This distinction is crucial when discussing certain cases of purposeful action in the *Umwelt,* as the organism's spatial activity may exist on a grander scale than can be located within the immediate surroundings ('*Um*') that it inhabits, if taken as equivalent to what it can immediately interact with or perceive. Yet

[32] Mirror neurons may have a role to play here. Their relation to peripersonal space while be discussed at various points in this thesis.

though the organism is technically required to depart from its immediate location in order to activate this meaning, it rather travels through a succession of 'heres' and 'nows'. This is exemplified in flocks of birds that follow a migratory route, an example Uexküll uses that perhaps provides a visual image of the core idea. Accordingly, the 'potential-here' that implictly structures the birds' 'actual-here' is not physically present yet still continously influences the real, moment-to-moment physical presence of the flock.[33]

As such, the space lying *beyond* what is reachable and perceivable nonetheless impacts the organism's situated 'here and now' spatial experiences, guiding its behaviour and allowing it to act meaningfully upon a large spatial scale. Uexküll perhaps unhelpfully refers to this phenomenon as 'magic', as he believes that no clearly identifiable perception or effect signs guide purposeful behaviour on such a large scale. Perhaps a better term employed by him is 'supersensory', as spatial experience can transcend that which is immediately given to the senses yet still impacts their immediate sensorimotor spatial capacities, sculpting their capacity to achieve a long-term goal. Indeed, during the migratory flight, the entire flight path of migratory birds is not immediately evident outside of the experiences of the birds themselves. Thus, if 'instinct' merely draws us from one point to the next, 'plan' encapsulates the entirety of a journey from the outset in a more global, holistic and ultimately human-like sense. Lived space is thus always co-constituted by such plans.

A similar idea is at play in the concept of the "demarcation of territory", the last of our 3 concepts adressed in this subsection. A territory is distinct from a home, as Uexküll notes, with some animals defending both while others defending only their home *proper*. A territory recalls prior discussions of tone and mood, which cloak entities according to a certain function. Sometimes, a spatial region will encode all entities within it as 'prey' or 'enemy', hence explaining why some animals strictly segregate the spaces in which their children are, lest they acquire a 'eating-tone' and be mistaken for prey. Tones and schemas such as 'territory' thereby confer a global qualitative status upon a wide region of space, which, once again, is not necessarily marked in accordance with strict, metric boundaries but instead speaks to the qualitative structure of lived space.

1.3 Species and Societies

[33] This is, of course, highly evocative of and parallel to Merleau-Ponty's discussion of lived space and time (**1a.2.5**).

Another key issue in this project that we will repeatedly return to is the status of, or dynamic between, private and public space(s).[34] Indeed, several individuals, cultures and species can all co-exist within a single bounded space, yet experience aspects of it quite differently. Does each thus only contain the meaning of the space in their respective heads? Or is there one big homogenous space in which all creatures are uniformly contained within? Uexküll would say neither and thus disparages the illusion that all spatial experiences necessarily:

> play out in the same space and time as the relations that link us to the things of the human environment… This illusion is fed by the belief in the existence of only one world, in which all living things are encased (pp. 52-54).

Seemingly, this anti-reductivist sentiment implies that no space can never be exhaustively describable with a singular terminology or conceptual framework. This is evidenced by the enormous variety of organisms whose surrounding worlds are constructed from their species-specific perceptual-effector capacities which render them receptive to relevant environmental signs but not to other ones. However, extreme caution is required regarding the word 'construct'. Isolating an individual subject from the wider meaning-giving community that they are part of seemingly leads to a conceptual impasse. This is because the subject cannot *construct* a world by itself apropos of nothing by projecting an otherwise non-existent meaning onto an undifferentiated, objective spatial grid. Sign-systems are far too complex and archaic for this. That is, the signs constitutive of a system of meaning must be recognisable as meaningful by a system's members and likely were developed long before the births of any individual adopter of said system. Each new generation does not construct a language, rule system (e.g., highway code or restaurant etiquette) or academic discipline completely from scratch. Even if we radically innovate, it is always more accurate to say that we are *introduced* to such sign-systems rather than construct them.

At the very least, then, the *Umwelt* is imminently *inter*-subjective. In most cases, individuals (of any species) are introduced into said meaning systems by natural instinct or by socialisation. The waggle dances of bee species, the howls of wolves or the mating rituals of human beings at nightclubs are neither solely produced nor maintained by

[34] Indeed, for Uexküll, the term *Umwelt* encompasses the (qualitative) surrounding world in its entirety, inclusive of others whereas Heidegger speaks of both *Umwelt* and *Mitwelt,* though they are mentioned separately only for practical academic purposes. Treating these two *Welten* separately is a tactic also pursued here but, again, only at the level of structure of the thesis. For Heidegger also, the use of two terms is not in any way to imply that the worlds of objects and others are in any way ontologically separate.

isolated individuals, even if skill and proficiency may vary among its individual members. It would therefore be incoherent for an *Umwelt* to exist solely as the product of an individual organism solipsistically interpreting a domain of objects. By contrast, an *Umwelt* is optimally conceptualised as that which *belongs to* a community of organisms, structuring their daily interactions and providing a stable source of meaning and an implicit orientation that scaffolds their activities. The signs shared by a community shape and give character to the organism's *Umwelt* and, just like a physical habitat, formally characterise a culture or species. To stretch this idea further still, in the animal world the existence and impact engendered by other species within an *Umwelt* also provides it its structure in the form of a complex ecosystem.

However, as discussed, hard limits exist as to the kind of meaning-relationship that any one individual might be attuned to. One obvious limit is found in the biological and anatomical endowment of a species. A species will perceive an object *qua* meaning-carrier according to its role in their survival or form of life.[35] For instance, a terrestrial animal will never perceive a high, thin tree branch with a sitting-tone, while a bird cannot view a bicycle as a means of exploring a new city. Some compatibility must exist at the bodily-sensory realm (most likely visual but also possibly tactile, gustatory or olfactory too) between organism and object for a true meaning-relationship (e.g., tone) to emerge. Uexküll elaborates this alignment between body and world thusly:

> As soon as the object appears as a carrier of meaning on the stage of life of an animal subject, each component of an object is brought into connection with, let us say, a 'complement' in the body of the subject, which serves as a consumer of meaning (143).

'Complement' speaks to the philosophical heart of Uexküll's theoretical biology. We already saw how acquiring cultural knowledge of the ladder's use-value allows it to register to the perceiver with a 'for-climbing' tone. However, on a more fundamental plane, the biological or psychological constitution of the species must be compatible with some of the object's qualities as a necessary condition for the emergence of meaning. Ideally, the organism's physiology and the object's use-value should fit together like pieces of a three-dimensional jigsaw puzzle, i.e: "A coffee cup with a handle shows immediately the contrapuntal relation to coffee, on the one hand, and the human hand, one the other"

[35] With the caveat, of course, that this would be a reductive if applied to human beings. We interact with all kinds of entities that do not have any direct relationship to our survival (e.g., poetry).

(191).[36] Thus, the physiological needs, anatomical odily constitution and intellectual capacity of a species and/or organism all determine how objects enter into their respective lifeworlds and functional cycles, ensuring that the 'same' object might serve a variety of functions by 'complementing' a variety of minds and bodies.

Take the humble flower as an example. On Uexküll's account, the 'same' flower carries a different meaning according to its place within the *Umwelten* of the ant, the cow and the young girl: as building material, nutrition and decoration, respectively (144). In each case, the same physical entity assumes a divergent functional role. Alternatively, a phone on an outside dinner table may not manifest as meaningful to an overhead bird, but the bread on that same table certainly will. Moreover, Uexküll emphasises that the meaning *receptor* does not always align with a highly individuated example of the meaning-*carrier* that is compatible with it. Recalling the concept of the template, we remember that the organism can have an approximately non-specific orientation, whereby several distinctive might objects align to this template insofar as they fulfil a specified function, and this categorisation process also depends on biological concerns, for instance, what is edible for the species or what could realistically function as shelter. But this never means that these aspects of the *Umwelt* are less 'real' simply due to their functional role for organisms. Uexküll would surely nod in agreement with Fuchs' (2018, p.25) enactive interpretation of a biological study (Ehrlich & Raven, 1964) published subsequent to his death:

> It can be shown that the development of color patterns in flowering plants took place in constant interaction with the development of color vision in insects. The property and its perception arose in various species co-evolutionarily in the context of a comprehensive ecological system.

Furthermore, to better understand the spatiality of an organism, we must also consider that its core 'being' has absorbed external elements into itself. Uexküll returns to his prized example of the tick, which, he claims, is always and inherently attuned to a kind of Platonic form of a mammal. That is, at the most fundamental level, all of the tick's sensory apparatuses and entire bodily constitution must be in line with the warm-blooded mammal that it takes as its sustenance. We thus circle back to the concept of complementarity: the tick's very anatomical form is incomprehensible unless we account for another entity which serves as its 'complement' within space. Or, pivoting to another

[36] Interestingly, similar to micro-affordances, some experimental research making great use of the dynamic between the cup handle and the human hand (Buccino et al., 2009; Costantini et al. 2010; 2011). This will be covered in greater detail in the following chapter.

species: “the spider’s web is configured in a fly-like way, because the spider is also fly-like. To be fly-like means that the spider has taken up certain elements of the fly in its constitution” (190). To apply this same notion to humans might net the idea that we are inherently tool-using and civilisation-building beings and thus to understand any historical culture, contemporary or ancient, we must include the tools it uses and societies it builds into our models. Thus, pre-empting contemporary accounts of extended cognition (Clark, 2008; Kiverstein, 2018), we should remain cognisant that ‘external’ objects or other animals are, in some way, extensions of that organism itself.

These biosemiotic insights permit a rich model of biological life whereby complex interconnections between organism, objects, and other organisms are found everywhere, in contrast to the linear cause-and-effect models preferred by some of von Uexküll’s contemporaries and their modern-day analogues. Indeed, even in PPS research, there have been attempts to define it as solely an approach-avoid system.[37] On this point, Uexküll deserves quotation at length, whereby he critiques the notion that:

> Whatever complicated action an animal might perform, the animal will always either approach or move away from the effectuating object. Leob declared these simple spatial components of each action to be the action itself and therefore divided all actions into actions turning toward and actions turning away from. The place of actions by tropisms. By this means, he transformed all living animal subjects into dead machines, which must thus confront each other spatially; (162).

Indeed, the fact that living beings’ spatial existences are inherently interdependent with one another brings us to one of the more abstract aspects of Uexküll’s philosophical biology, which speaks to the way in which diverse species within environments, and individuals within communities, stand connected via semiotic systems. Uexküll wants to convince us that we are not encased in one homogenous kind of substance called ‘space’ that uniformly encapsulates all inner-spatial entities. Once again, we are dealing with a relational, not absolute, conception of space. Instead of one homogenous, absolute space, there exists a staggering heterogeneity of intersecting, inter-relational spaces which escape description by any singular vocabulary. As stated, Uexküll considers the idea of an “all-encompassing world-space” a “fiction” that exists only because “we can get along with each other more easily with the help of this conventional fable” (70).

As we shall later see, Bufacchi and Iannetti (2018) have made a analogous critique regarding how PPS is often conceived of in the literature.

Here, we encounter a qualitative-quantitative dualism akin to that of Heidegger. On the one hand, all human beings and animals must jointly inhabit a singular objective space (e.g., the Earth) so that their spatial lives can fluidly overlap with one another as part of this greater, interconnected whole. But one conceptual 'world-space' cannot apply uniformly to the disciplines of geometry, physics, biology, etc., let alone to direct, pre-theoretical spatial experience. Consider an open field of 10 square kilometres. Within this space, we might find cats and dogs, human beings, the insects and birds in the trees, the worms underneath the soil, etc., all occupying the 'same' objective, geographical location. On the other hand, no singular 'world-space' could do justice to the heterogeneity of *Umwelten* thriving between these organisms, which are all rich with unique meaning carriers, perception-action marks and functional cycles, all overlapping or bypassing each other at different levels. For instance, humans are not attuned to the soil as '*for-living-in*' like worms are, which themselves strongly feature as *'food'* within the *Umwelt* of birds, but far less so for human beings.

At this juncture, we see a further convergence with Heidegger's philosophy.[38] If world-space is homogenous insofar as it is a space in which every entity exists *in the same sense as* every other entity, the logic governing spatial relations between such entities should be equally valid and uniform across all forms of space. That is, we cannot distinguish between the spatial distance between person *A* and object *B* as quantitatively measurable, and the relationship between a person and the affording-object as one of meaning. Furthermore, we could not meaningfully distinguish between 'space' as a container of solar systems and galaxies and 'space' as the world of a perceiving being aside from that of an order of scale, in which an *Umwelt* is simply 'smaller' than the space taken up by galaxies.[39] Indeed, the relations governing the logic of *Umwelten* do not exist *only* in numerical terms.

On this note, while Uexküll develops a predominately qualitative understanding of space, it should be noted that some form of *quantitative* analysis, if properly wielded, also proves revelatory regarding the kind of meaningful space that interested him. Namely, I refer to the amount of signs that are conceivably present within an *Umwelt*, which, for Uexküll, indexes a species' complexity. Uexküll writes that "[space and time] can only become meaningful when numerous perception marks (features) must be distinguished" (73) and "we may say that an animal is able to distinguish as many objects as it can carry out actions

[38] See also Storey (2016) for a rich, alternative comparison of the philosophies of Heidegger and von Uexküll.
[39] Heidegger outlined an analogous difference in reference to world-time. This shall be dealt with in greater detail later.

on them" (96). Thus, one way that the complexity of an *Umwelt* can be ascertained is through reference to *how many* signs or sign-systems constitute it. Unlike the amoeba or the tick, human *Umwelten* are comprised of innumerable, interconnected perception-action marks that relate to technology, art, science and other cultural forms. We might then infer that the complexity of a species, group, or even individual may be partially represented by the number of perception-marks and effect tones that make up their environment, as well as by their quality.

Therefore, a greater number of sign-systems speaks to the relative complexity of a given species or individual organism. Indeed, to reiterate a previous point, a community provides its members more sign-systems (i.e., linguistic, visual, artistic) than could be constructed *ex nihilo* by any autonomous Cartesian subject. It is in this way, then, that culture intersects with 'biological' spatiality. Thus, in a manner unarticulated in Heidegger (Storey, 2016), Uexküll shows via biosemiotics that biology plays a distinct role in revealing the complexity of the *Umwelt*. Some species are equipped to comprehend a greater number of signs; consider higher mammals such as gorillas or dolphins compared to a snake or beetle. Regarding humans, it is also quite evident that several sign-systems are lost to the currents of history, while a magnitude of other cultural sign-systems will develop in the future. 'Capturing' these sign systems would certainly increase the scope of one's world, were such a feat possible.

Finally, an intriguing convergence point with modern PPS research is found in Uexküll's reliance on the metaphor of a 'bubble' when articulating the spatiality of living beings. Indeed, if we take modern definitions of PPS in mind (in which 'bubble' is frequently employed; e.g., Cardinali et al., 2009; de Vignemont & Iannetti, 2015; Buffachi & Iannetti, 2018), Uexküll's words now seem remarkably prescient:

> We must therefore imagine all the animals that animate Nature… as having a soap bubble around them… in which everything visible for the subject is also enclosed. [In each bubble] are found the directional planes of effective space (69).

'Effective space' designates the space in which organisms can interact. Directional planes of effective space pertain to the efferent motor orientations the organism has to different entities, which has obvious analogs with Merleau-Ponty's motor-intentionality. However, the notion of a bubble might unfortunately invoke connotations of impermeability. To conceive of spatiality as a bubble of which I serve as the nucleus might again creep into a kind of solipsism or subjective idealism whereby my world is self-contained and remote from the 'bubbles' of others. However, as a pre-emptive antidote to this questionable ontology, Uexküll adds a qualifier: "Each of our fellow human beings [are] enclosed in bubbles that effortlessly overlap one another because they are made up of subjective perception signs." Taken thusly, we can reflect that socially interconnected human agents are nodes in a single, overlapping spatial network of meaning that, owing to shared signs, is mutually comprehensible and intrinsically interconnected. Our spatial bubbles effortlessly overlap with each other's because they are not sequestered and independent 'mini-worlds' but parts of a greater, meaningful whole which is threaded together by shared and overlapping perception and action signs and functional cycles. A clear method for understanding the lived space of human communities is therefore to give voice to what these signs are and how they bring together different human individuals into a shared lifeworld ('*Mitwelt*') of sense-makers at the level of meaning.

1.4 Overview

Detailing von Uexküll's rich philosophical biology has gotten us closer to understanding the structure of lived space, which he rightly notes cannot be subsituted with a mechanical account if discussing the spaces of living beings To summarise Jakob von Uexküll's position on lived space, one might claim the following: an objective model of space that exorcises the experiential domain ultimately remains incompatible with the spatial models necessary in life sciences such as biology. And to fully account for how biological organisms engage their worlds in their own experientially unique way, a biosemiotic model that accounts for meaning from an embodied-enactive standpoint is required. The honest biologist must therefore reorient towards the first-person perspective of the spatially embedded organism's web of relations with other entities to get a grip as to how the *Umwelt's* internal spatial relations fit together, because purely physical relations between matter (e.g., gravity, inertia) cannot hope to encompass the totality of spatial relationships. Instead, the perception-action marks, functional cycles, tones, plans, moods and schemas that constitute an *Umwelt* as disclosed by biosemiotics depend wholly on their perceiver's mutual existence along with them, alongside the organism's ability to concretely enact them, thus bringing them into being. Yet these qualitative relationships prove to be just as real as the animal's height, weight or general anatomy. Poetically, Uexküll provides a summation of this position (and one which will guide the forthcoming analyses of empirical evidence) thusly:

> In individual cases, it is sufficient to search out the meaning utilizers belonging to the carriers of meaning in order to gain insight into the tissue of the environment. Meaning is the pole star

> by which biology must orient itself, not the impoverished rules of causality which can only see one step in front or behind and to which the great connections remain completely hidden (162).

However, semiotics has not yet exhausted its utility in helping us build a comprehensive account of lived space. The work of C.S Peirce and the secondary literature that it has inspired (esp. philosophical pragmatism and cognitive semiotics) shall be our final stop in this conceptual account of lived space before we turn toward the mutually illuminating empirical data in succeeding chapters.

Semiotics of Spatiality II: Peirce and Pragmatism

Introduction

Aside from von Uexküll, the other central figures highlighted above by Emmeche (2001) were Charles S. Peirce and Thomas Sebeok. However, as Peirce inaugurated the disciplinary approach today characterising most semiotic investigations, that also influenced subsequent semioticians (including Sebeok) as well as ECS (Chemero, 2009; Kiverstein, 2018; Gallagher, 2023) he shall act as the figurehead for this closing section on the philosophy of lived space. Indeed, Peirce's semiotic and pragmatic insights are perhaps the biggest foundation-stone for the subdiscipline of cognitive semiotics (Daddessio, 1995; Eco, 1999; Brandt, 2020; Paolucci, 2021). We might thus view Uexküll as the figurehead of biosemiotics and Peirce as the figurehead of cognitive semiotics, each of which is essential for understanding lived space. Though Peirce's semiotic work preceded biosemiotics as an established sub-discipline, a clear convergence point between Peircean semiotics and biosemiotics exists via a focus on communities as producers of ascertainable meaning. As living members of a social *Umwelt*, the meanings that are fixed onto objects (concrete or abstract) are, more often than not, pre-established by the community (and sub-communities) of which members are part.[40] As Peirce often highlighted, we are *introduced* to systems of meaning; rarely do we individually create them (Paolucci, 2021).[41]

For his part, it must be said, Peirce apparently did not pay major thematic attention to spatiality itself. Nonetheless, several principles of his philosophy are conceptually indispensable to the interdisciplinary account of spatiality developed here. Moreover, the longstanding tradition of philosophical pragmatism also owes a great debt to Peirce (Dewey, 1916; Mounce, 2002), as does the recent field of 'cognitive semiotics', which

[40] An analogous Heideggerian notion would be that of 'thrownness', which likewise emphasises the pre-existence of meaning-structures into which one is absorbed.
[41] The pre-existence and open-endedness of sign-systems pertains to another of Peirce's central concepts - 'infinite semiosis' - that we do not have space to deal with here. See Paolucci (2018).

explicitly bridges semiotics with the cognitive sciences first and foremost through the philosophical and semiotic framework developed by Peirce (Eco, 1997; Paolucci, 2021). Indeed, Peirce was instrumental in developing the philosophical school of pragmatism, an approach that, alongside phenomenology, is most influential to the Enactive approach (Chemero, 2009; Kiverstein, 2018; Paolucci, 2021; Gallagher, 2023). With this in mind, in this section I identify three conceptual aides to this project that are salient in Peirce's work: *Synechism* (1), P*ragmatism and Habit (2)* and *Semiosis and Cognitive Semiotics* (3).

2.1 Synechism

The first major concept relevant to our current purposes pertains to what Peirce labelled 'synechism', a type of continuum proposed to replace sharp metaphysical dualities (Paolucci, 2021). Indeed, lived space *qua s*emiotic space of a Peircean variety can be potentially located among several types of continua, which we will recount here.

One of the most salient and well-established of these is that between culture and nature, a recurrent theme in semiotics (Eco, 1997/1999; Paolucci, 2018, 2021). The relevance of this particular synechism here becomes evident whereupon we consider that the brain is an electrochemical organ, which entails that its study often comes under the methodological purview of the hard sciences (Sykes, 2021a). Nonetheless, in contrast to other hard sciences, the functioning of this organ is profoundly influenced, and even materially constituted at the level of neural plasticity (Han et al., 2013; Eagleman, 2020), by factors otherwise classifiable as cultural phenomena. That is, we could not speak of 'language in the brain' or similar notions without introducing sociocultural artefacts into the analysis.[42] Indeed, in many of the experiments assessed later, the 'natural' brain is experimentally investigated within the context of 'sociocultural' circumstances, and it is via the changes induced by such circumstances that researchers can better map the nuances of PPS. These cultural phenomena encompass everything from the rules governing social interaction to the myriad of complicated tools we use as participants in our sociocultural life-world (Kiverstein, 2018).

Moreover, these levels often intersect, such as with the meaning produced by different clothing styles or the ways in which people interact with their technological devices or ingest substances that alter their endocrinal system and, consequently, their bodily spatial

[42] Indeed, an entire subdiscipline has recently developed, entitled Cultural Neuroscience (CN) which, citing analogous reasons, researches these culture-biology intersections experimentally from a cross-cultural perspective (Han et al., 2013).

structure. Indeed, most of the material objects used in experiments are tokens of mankind's technological innovations that the ancient PPS network must contend with. Human beings have access to, among other things, spoken and written languages, the internet, transport such as trains and planes, DIY tools and video games. All of these factors powerfully influence the brain's immediate understanding of space, conferring a myriad of spatial experiences to the agent who uses or engages them. The (in evolutionary terms) recent cultural developments of human beings do not somehow exist *outside* of the brain's more ancient capacity for wielding tools or distinguishing between friend and foe. Rather, they interpenetrate each other as part of semiosis (Violi, 2008). Thus, an experiment that measures the brain's response to interaction with technological devices (**2.2.1**) or to modern social contexts (see **Chpt. 3**) simultaneously measures this confluence between nature and human culture. It is arguable that human developments can never be predicted simply by mapping the brain's functional topology, but that cultural developments nevertheless emerge from the phylogenetic particularities of our brains. As such, the classical semiotic synechism between nature and culture lies at the very forefront of our investigation.

Yet another important synechism for the present analysis is the one that exists between humans and animals, whereby experimental findings on the PPS of non-human primates prove informative regarding the PPS of human beings.[43] Since PPS is a neural system that is shared by humans and several non-human animals alike (di Pellegrino & Ladavas, 2015), evidence obtained from the animal literature would prove useless in building an account of human spatiality were it not that humans and some non-human animals are similar in some capacities. Indeed, like mirror neurons, peripersonal neurons were first discovered in the primate cortex before human beings (Rizzolatti et al., 1988; Graziano, Yap & Gross, 1994; Gallese et al., 1996; Rizzolatti et al., 1996, 1997).

Conversely, the lived spatiality of human beings and animals is nevertheless clearly demarcated in several glaring respects due to humanity's capability of forming complex civilisations and creating sophisticated technological instruments, which profoundly (re)shape human spatial cognition. Whilst noting the continuum that exists between them, we should nonetheless remain attentive both to the ways in which the spatiality of human

[43] By contrast, in the philosophy of Heidegger one sees a vast gulf that separates the human from the animal (Storey, 2016).

beings overlaps with a generalised mammalian peripersonal cognition in addition to the ways in which human spatiality is notably distinct.

In his later years, Peirce even proposed that semiotics would be absorbed into a larger philosophy of continuity that grounded mind in matter and vice versa as part of a united ontological framework, an idea of which Eco was a notable critic (Paolucci, 2017, pp.260-263). This idea, in turn, is contiguous with Peirce's foundational concept of 'thirdness', whereby semiosis occurs on the basis of a triadic relation between sign, meaning and sign-perceiver. As Brier (2003, p.74) puts it: "Triadic semiotics is integrated with a theory of continuity between mind and matter (Synechism) where the basic three categories (Firstness, Secondness and Thirdness) are not only inside the perceiver's mind but also in the nature perceived". Nevertheless, despite its risks, this idea once more has currency in today's academic climate. Recent developments in philosophy of mind and ECS (Froese, 2023; Froese & Sykes, 2023; Westlin et al., 2023) have sought to radically overturn stubborn echoes of a prior Cartesian dualism and there is a noted receptivity to methods and conceptual frameworks capable of doing so. Overcoming a duality between mind and matter with a specific philosophical framework may, therefore, currently have more purchase than it has at any time since Peirce first committed his ideas to paper over a century ago.

Finally, the importance of synechism at the level of methodology also becomes particularly apparent regarding the necessity of synthesising findings from across several disciplines when formulating the present account of bodily space. Resources from the neurosciences, psychology, semiotics, phenomenology and psychiatry are all treated as mutually illuminating pathways for accessing the complex and multilayered phenomenon of bodily space. According to this framework, no clearly defined routes for accessing bodily space are marked 'philosophical' or 'scientific' in absolutist terms. Rather, we aim to disclose bodily space as revealable from across a variety of disciplinary borders and on several interlacing continua. Areas of convergence between these disciplines often require careful attention to the *loci* in which they can be most profitably exploited. As such, we should avoid the temptation of viewing the discrete methods employed to do so as condemning their obtained results to pertain *only* to the selfsame disciplines which produced them. Instead, while there may exist a strongly philosophical or strongly scientific model of bodily space at either end of a continuum, much of what can be said about bodily space exists in between them. Thus, the spirit of Peirce's synechism strongly informs this project at both the methodological and metatheoretical level.

2.2 Pragmatism and Habit

The second and third principle integral to the present account is 'philosophical pragmatism', one of Peirce's most important contributions to philosophy. Indeed, while pragmatism is a (primarily American) philosophical movement famously expanded by James (1884) and Dewey (1916), it was essentially founded by Peirce in his celebrated 1878 essay 'How to Make Our Ideas Clear' (Mounce, 2002). In essence, Pragmatism emphasises that 'meaning' is to be located in an action's consequences or by its capacity to solicit further relevant action (Dewey, 1916).[44] Pragmatism synthesises especially well with our other driving notion of 'pre-reflectivity' since, as a general rule, we pragmatically engage our environments and experience things as soliciting context-relevant action before deliberation takes hold.[45] In Peirce's (1903/1998, p.241) own words: "our logically controlled thoughts compose a small part of the mind, the mere blossom of a vast complexus which we may call the instinctive mind", which is so integral to life he compares its activity to the "natural growth of hair". As such, if this 'complexus' denotes the sedimentation of previously learned and/or established skills, beliefs and dispositions, then its smaller, surface-level 'blossom' (i.e., reflective cognition) is merely a smaller, comparatively insignificant domain of consciousness that, while sometimes under our logical control, must already be rooted in pre-reflective habits. Lived space's primary residence is thus in this 'vast complexus', which is an interestingly independent manifestation of the concept of pre-reflectivity.

As with phenomenological spatiality, the sedimentation of habits renders pragmatic engagement into an on-hand ability that sits in the background of one's mode of world-embeddedness. While agents can, of course, always *choose* to thematise space, question their habits or control specific movements: "This scope of deliberate control may be usefully thought of as a "foreground" which is set against a "background" of habits which fall outside of deliberate self-control at any given time" (Legg and Black, 2022, p.2275). Colapietro (2021, p.13) adds that: "From a Peircean perspective, at any rate, the mind is first and foremost a more or less integrated network of various types of habits, though each of these habits, being semiotic in character, are illative in operation". Core to a Peircean reading of habit can thus be summarised as one's capacity "to act in a certain way under

[44] While we have already provided a brief overview of pragmatism and habit, these themes will be dealt with in greater detail in the next section as they profoundly inform the purview of contemporary cognitive semiotics.

[45] For related reasons, Peirce attributed importance to surprise, as surprise yanks us away from our pre-established patterns of established behaviours (West, 2021). This will be dealt with in greater detail later.

given circumstances and when and when actuated by a given motive" (5.480). In many instances, however, it is more accurate to refer to such abilities as skills, competencies, or capabilities than as habits or dispositions (Colapietro, 2009). This is because, from a semiotic perspective, the most interesting or important kinds of habit are not biting one's nails or smoking, but the meaningful ways that one navigates one's world on the basis of pragmatic, skilful engagement alongside automatic expectation and prediction that informs one's experience (Paolucci, 2021). Peirce also notes that, if these embodied habits come under conscious awareness and control, they can also be considered 'beliefs' (5.480).

Thus, intimately connected to pragmatism is the notion of 'habits', each of which plays an equally pivotal – and mutually enforcing - role in Peirce's wider philosophy (Colapietro, 2021; Paolucci, 2021). This is because pragmatism of a Peircean variety holds that concepts, objects and others are understood by the actions one can perform on them and the results one obtains; their meaning is thus automatically suggested to us as derived by past experiences and their prior consequences. Peirce cogently summarises his pragmatic view of meaning and habit thusly:

> To develop the meaning of something, we have, therefore, simply to determine what habits it produces, for what a thing means is simply what habits it involves. Now, the identity of a habit depends on how it might lead us to act, not merely under such circumstances as are likely to arise, but under such as might possibly occur, no matter how improbable they may be (CP: 5.399-400).[46]

The idea that past experiences automatically sculpt the present situation is especially important for our analysis because 'meaning', taken as synonymous with 'habit of action', applies to how agents engage both objects and others in space (Määttänen, 2007), which are the main structural elements in our relational account of space. Indeed, our enactive conception of spatiality that emphasises the meaningful and practical character of lived space certainly finds its antecedent in Peircean pragmatism insofar as Peirce (1903/1998, p.218) succinctly states that "[in Pragmatism] the idea of *meaning* is such as to involve some reference to a *purpose"*.

As noted by Legg and Black (2020), a habituated act is not homogenously repeated each time but rather strengthened through repetition: its stability increases following each enactment. Habit thus represents a crucial element of semiosis because it stabilises and sediments systems of meaning, allowing particular ways of being to permeate one's semiotic-experiential life as well as (in some cases) become transparent for third-person

[46] Quoted from Paolucci (2021, p.6).

objective analysis. A habit is neither a by-product of reasoning nor a thought-out, deliberate action but my body's grounding in the world via a network of integrated habits (Colapietro, 2021). On Violi's (2008) account, this enactive interpretation of habit was already dormant in Peirce's work:

> For [Peirce] concepts (and representations) are always correlated with actions: while concepts, seen as habits of mind, have a regulative function in relation to the internal world, stabilizing the process of unlimited semiosis; on the other hand, when operative as beliefs, they also constitute the basis for behavioral and communicative habits, which are nothing but regularities in actions. In this way the very same semiotic structures regulate both the internal world of concepts and beliefs and the external world of actions, acting as a bridging system between the two, (p.255).

Applying this logic to spatiality, pragmatism informs us that agents experience their surrounding space on the basis of acquired habits of thought and action, which predict, inform and facilitate pragmatic spatial interactions with the entities located around them (see Paolucci, 2021). Put simply, our spatial surroundings elicit us to act in particular ways in meaningful alignment with the objects found there and the type of setting in which they are found. Signs are thus the means by which agents can perceive, act upon and even manipulate the world, fundamentally grounding the way in which that agents spatially exist in relation to their environments. Prior engagements with a sign entrain context-dependent pragmatic habits that allow automatic understanding and/or interaction during all of its subsequent encounters. We must also remember that a sign acquires its meaning through an intuitive understanding of the wider context in which it is encountered (Violi, 2017), elicting a context-dependent 'field of expectations' (Eco, 1997/1999). Thus, when a sign is removed from its context, the power of habit may suddenly cease to pragmatically orient us in space. To employ quite a literal example, a STOP traffic sign encountered in its correct context in the road will not have the same meaning and trigger the same cognitive, autonomic and neurological responses as if it were encountered in a random location.[47]

This proposition circles back to the aforementioned synechism between mind and matter. Specifically, these sign-systems need not be taken only as semantic representations of truth value but also as ways of engaging the world that render it intelligible by presenting agents with means for direct engagement with the world (Violi, 2008; Paolucci, 2018). The holistic interconnectivity of semiotic network of habits is strikingly reminiscent of the role

[47] I did, in fact, encounter someone who took such a STOP sign to their room as an undergraduate, and so personally experienced the uncanny effect of seeing such a sign stripped of its typical signification due to its circumstantial placing.

played by the ‘referential totality’ in Heidegger’s phenomenology of equipmental praxis. Peirce’s greater emphasis on belief perhaps fleshes out the phenomenon of ‘worldhood’, allowing us to recognise that the Marxist’s belief in dialectical materialism or the capitalist’s belief in the free market are as co-constitutive for consciousness as practical engagement, which is supported by, and manifests through, our behavioural, intellectual and artistic ‘habits’, which in turn cement the semiotic agent into their world.[48]

The final central figure noted by Emmeche (2001) is Thomas Sebeok, another thinker profoundly influenced by Peirce (Jappy, 2023). Sebeok’s contributions to semiotics are manifold but perhaps one of the most useful for our current purposes is his semiotic account of spatiality in terms of social role and place (Sebeok, 2001, p.22). Indeed, consider how even across a single day, both the type and quantity of diverse places – all with their own layout, associated sensations and rules of conduct - that one inhabits will vary greatly, and this variety is strongly reflected in one’s corresponding spatial experiences (and their neurophysiological correlates).

Furthermore, there exists a pronounced and mutually reinforcing connection between the rules that govern interaction in the format of social roles and the type of place that one inhabits. For instance, consider the differences in custom that differentially govern acceptable comportment at a library, hospital, bar, aeroplane or friend’s house. These implicit rule systems entail that there is at least partial homogeneity in the experiences of lived space in individuals who occupy such places.[49] And in another interesting semiotic parallel with the phenomenological notion of pre-reflectivity, Sebeok and Danesi (2001, pp.174-180) note how factors like communication, making tools and symbolic thought not only form the basis of group life but can be relegated to automatic “motor programmes” which can be initiated ‘unconsciously’.

Importantly, however, two individuals can occupy a singular objective place yet undergo vastly different bodily spatial experiences. One major way in which this occurs is on the basis of social roles. Take a prison cell as an example. The roles of the prisoner and the warden regulate how their spatial surroundings appear and what possibilities (or lack thereof) manifest to each. In some sense, the prisoner and warden occupy one unitary

[48] Indeed, one may argue that the Peircean emphasis on belief, compared to phenomenology, stands to enrich some discourses in the cognitive sciences which tend towards so-called ’higher-order’ cognition.
[49] We can compare this sentiment with Heidegger’s account of everyday, inauthentic Dasein in *Being and Time* in which one ‘does *what one* does’, i.e., at the restaurant one does not sit on the table and read as in a library.

objective space, and both have an equal 'objective' possibility of exiting;[50] both could *technically* walk through the cell door. In a qualitative sense, however, each occupies a vastly distinctive space. The prisoner's bodily knowledge of his own confinement differs enormously from the warden's knowledge that the exit is an always-existing possibility for him that can be taken up freely. Different patterns of neurophysiological activation likely correspond to these diverse spatial situations, a testament to the synechism between nature and culture described above, in which 'matter' (i.e., the electrochemical brain) produces measurable responses in line with 'sociocultural' phenomena such as role and place. And, as Peirce foresaw, these domains interface with each other via habits that also correspond with implicit beliefs (e.g., I can/cannot leave), thus co-constituting the spatial reality of the situation (e.g., as Warden vs. Prisoner).

Furthermore, the divergent roles of warden and prisoner modulate which kinds of meaningful behaviours, postures, tones and verbal expressions each employs in the space. How each person speaks, dresses or acts within the cell is wholly dependent on whether they are in the 'prisoner' or 'warden' role. Thus, spatial experience is heavily modulated by factors such as place, context and social role and the norms governing their interaction (all of which have been demonstrated as influential to the peripersonal system) yet these factors structure lived space without requiring constant recollection. The prisoner's confinement is immanent in his fundamental spatial experience and not something deduced; it belongs to pre-reflective cognition or what Peirce termed the 'instinctual mind'.

Social roles are, of course, reliant upon a semiotic community insofar as the rules of social engagement are semiotic systems that feature publicly accessible meaning that governs conduct. Even when the nature of the social dynamics is not as clearcut as prisoner and warden, an observer might also glean pertinent data regarding social role of the actors from watching several people interact. This brings us to the idea that people interacting in space *itself* produces semiotic meaning:

> The study of spatial and temporal bodily arrangements (sometimes called proxemics) in personal rapport, the proper dimensions of a cage in the zoo or a prison cell, the layout of offices, classrooms, hospital wards, exhibitions in museums and galleries, and myriad other architectural designs all involve the axiology of volume and duration, (Sebeok, 2001, p.21)

Taken thusly, intersubjective bodily arrangements (proxemics) themselves feature as signs which convey meaningful information to the astute observer. As a prototypical version of a

[50] That is to say, the laws of physics do not prevent the prisoner from physically walking through the door, even if he would indeed eventually be restrained. Habit, in true Peircean style, has thus informed the prisoner's bodily space as well as his preconscious beliefs (i.e., that he cannot leave).

sign system, if read correctly, proxemics conveys vital information regarding the quality of social relationship and the intentionality and/or emotional states of individual actors or the meaning of the overall scene. Moreover, such information is also empirically observable and measurable and has been the focus of several empirical investigations in experimental and clinical psychology. Valuable information such as how one person evaluates another, the quality of their relationship, or their positions within a hierarchy may all be gleamed by applying a proxemic lens. Even metric distance, then, *signifies* something other than *mere* distance; that is, when we treat interpersonal proxemics as a semiotic system, we can better understand qualitative relationships between agents. Analysing third-person behavioural data, supplemented with a more in-depth semiotic analysis, can thus greatly inform our understanding of social spatiality in a way that pertains to recent debates on interpersonal (IPS) and peripersonal space (PPS) (Bogdanova et al., 2021).

Thus, the conceptual resources provided by Peirce and his followers offer a suitably non-Cartesian antidote to Uexküll's illuminating biological metaphysics, which, arguably, was already dormant in Uexküll's work yet solicited a fuller articulation. As Kull and Favareau (2022) note, accounts of learning and individual development are also underemphasised in Uexküll, whereas Peirce showcases their utmost importance for fluid, pragmatic engagement in the world. Therefore, semiotic investigations of place, habit, pragmatics and proxemics all help us achieve a fuller understanding of the various ways that meaning, context and normativity shape the distinct structure of lived space. Combining Uexküll's rich biosemiotic account of organism-world interactions with Peirce's emphasis on synechism, pragmatism and anti-Cartesianism, in addition to Sebeok's discussions of social role and proxemics, prove informative to transcribing peripersonal space's pre-reflective cognitive correlate. Indeed, Peirce's application of semiotic analyses to the human mind has birthed the field of cognitive semiotics (Daddesio, 1995; Eco, 1997/1999; Brandt, 2020; Paolucci, 2021). We might thus view Peirce's philosophy as characterising the basic premises of semiotic approaches to cognitive science. Accordingly, th final section turns to contributions by scholars explictly working under the largely Peirce-inspired Cognitive Semiotic approach to see how this contributes to our model of lived space.

2.3. Semiosis and Cognitive Semiotics

Our final subsection shall deal with the field of cognitive semiotics and the term ‘semiosis’, which sometimes stands in for ‘cognition’ itself in semiotic-based versions of cognitive science. (Daddesio, 1995; Eco, 1997/1999; Paolucci, 2021; Kull and Favareau, 2022). Cognitive semiotics (CS) shows us that sign-systems are not only their own domain of study; they are themselves deeply implicated in the workings of what we term ‘mind’, ‘consciousness’ or ‘cognition’. Borrowing from Peirce, the term ‘semiosis’, which denotes the sense-making activity that integrates several discrete items into a cohesive and meaningful whole, provides a fitting alternative for the arguably oversaturated term ‘mind’. Semiosis designates the integration of several sources of meaning into a coherent (but potentially decomposable: see Champagne, 2018) whole that is not *only* a cultural, biological or cognitive endeavour but rather all three simultaneously (Eco, 1997/1999). This aligns the notion of semiosis with the interdisciplinary thrust of the cognitive sciences. Indeed, as Paolucci explains in *Cognitive Semiotics* (2021, p.2), cognitive science often deals with classically semiotic problems yet without correctly designating them as such. Accordingly, our philosophical account of lived space shall culminate with an analysis of semiosis alongside the Peirce-inspired subdiscipline of cognitive semiotics, particularly in its contemporary, Enactivist-friendly instantiation.

In CS, we encounter a direct application of the kind of synechism discussed previously, reapplied at a methodological level. Indeed, cognitive semiotics aims to overcome sharp dualisms created by a ‘purist’ biosemiotics and an equally ‘purist’ semiotics of culture (Eco 1997/1999; Paolucci, 2021, p.5) in an interdisciplinary fashion that aligns neatly with our current aims. Aiming to bridge the gap between culture and nature, Eco (1999, p.9) first laid out a methodological foundation appropriate for this endeavour as follows: “a cognitive semiotics ought to consider again the role of nature in culture, at least as much as it advocated the role of culture in nature.” Indeed, as Paolucci (2021, p.10) elaborates, “from a cognitive semiotics’ point of view, this environment is not a “natural” one, but a semiotic environment crowded with objects, norms, habits, institutions, and artefacts that shape our minds”. This definition unifies our prior discussion of synechism with habit to showcase that semiosis is something that develops and emerges across a developmental trajectory, in contrast to preformed, cognitivist categories that organise all input.

Applying these insights to our present goal enables us to posit that spatial sense-making retains a biological and neurological instantiation, yet its particular manifestation(s) are cemented by acculturation processes (‘semiosis’) that themselves act as signs within other meaning-systems. For example, learning the correct way to sit at the dinner table and use cutlery undoutedly recruits discrete neural pathways but these neural pathways are not hard-coded into our DNA. Semiotic space is thus not a pre-existing category fully formed in the human mind because:

> [The mind] is not transcendental in the Kantian sense, it does not come before but after the semiosic process; it is not the structure of human mind that produces the interpretation but the reality that the semiosis builds up (Eco, 197/1999, p.12).

Subsequent cognitive semiotic accounts have sought to align Peirce's and Eco's insights with those of situated/4E cognitive science (e.g., Violi, 2008, 2017; Zlatev, 2018; Paolucci, 2021; Jappy, 2023), highlighting their conceptual compatibility. Indeed, owing to Peirce's emphasis on the public quality of meaning as existent outside of the individual's head, this compatibility was already latent throughout Peirce's work a century earlier (Paolucci, 2021; Jappy, 2023). Indeed, even in the earliest cognitive semiotic accounts, one finds a protracted emphasis on action and situatedness. As Kull (1998) highlights, organisms maintain the semiosphere's existence through committing recognisably meaningful actions there, so that functional cycles and space reciprocally define each other. Furthermore, as noted by Violi (2017), Eco's (1979) central concept of 'encyclopaedia', one's stored knowledge of culture-specific pragmatic meaning - as juxtaposed to the stable, semantic meaning found in a dictionary - is profoundly situated. On this topic, Violi (2017, p.227) writes that "the situatedness of meaning is always contextualised and locally determined", especially as the 'thirdness' definitive of semiosis always allows a sign to reobtain fresh meaning or to be deceptively shown as something other than it is.

Additionally, Violi (2008, p.242) echoes a classical phenomenological argument that remains pivotal to contemporary embodied-enactive approaches to cognition; namely, that the body is not necessarily "something easily accessible, objective and physically defined". Violi adds that this embodied version of semiotics inherits a clear Peircean legacy because "although Peirce does not thematize in an explicit way the role of the body in semiosis, it is quite evident that for him, the body plays an important role" (p.244). Reminding us of Peirce's skepticism towards classical Cartesian dualisms, Violi offers up another pertinent example:

> [In Peircean semiotics] the classical dualistic relationship between mind and matter is overcome, as well as that between the internal and the external world, which are no longer seen as being dramatically and irreducibly separate from one another. There is mutual interpenetration in all directions, (p.245).

Both Violi's arguments regarding 'mutual interpenetration in all directions' and Peirce's overcoming of a proposed dualism between mind and matter apply readily to bodily space. Bodily space, I argue, is best conceived as an (enactive) interface surpassing any sharp categorical distinction between an inner mind and outer space because 'mind' *qua* semiosis extends further than the 'material' boundaries of the body. Indeed, Jappy (2023) notes that Peirce explicitly claims that semiosis is not restricted to the brain and can even be encountered in the discipline of logic,[51] in animals and even in plants, as well as, we should imagine, the possible interactions between these different species of sign-producers. Another parallel lies in the fact that any prolonged discussion of bodily space necessitates the inclusion of other sources of meaning which are "not only issues related to action and movement, but also those related to affect and emotion, [and] the crucial issues of subjectivity and intersubjectivity" (Violi, 2008 p.246). As shall be further demonstrated, bodily space certainly exemplifies this 'interpenetration' between body, action, intersubjectivity and emotion because the body *qua* semiotic device (Stjernfelt, 2006) engaged in meaningful action extends beyond its material boundaries to *in-corporate* surrounding space and the objects relevant to its projects in an act of embodied semiosis.

Indeed, we shall encounter these core themes repeatedly in the ensuing chapters, which shall further showcase bodily space as an instance of semiosis whose way of understanding the world is not limited to the rational, 'inner' mind but an extended incorporation of 'external' signs. Once more, the importance of action appears paramount; the lived body is only realistically 'lived' insofar as it is not a stationary object or passive observer but actively enmeshed in worldly projects that co-constitute its definitive capacity for sense-making. Indeed, the interpretant's capacity to understand signs encountered during semiosis is not passive reception but an *activity*, a "reaction in the interpreter-analyst" (Jappy, 2023, p.156), akin to both Heidegger's account of perception as well as, according to Jappy, that of Alva Noe (2009). As such, the body's capacity for motion in space is a precondition of action and sensation, which, in turn, are preconditions for semiosis. In support of Violi's (2008) contention, semiosis is, therefore, inescapably embodied. Furthermore, as also noted by Violi (2008), the way in which semiosis is concretised in the body hinges upon our affective state and an immersion in social context, conferring a kind

[51] Peirce thus here converges again with the phenomenological tradition; more specifically, with Husserl's (1900/2001) arguments against psychologism in logic in *Logical Investigations*.

of multilayered, global attunement of bodily space to the surrounding world that can be approached from a number of angles.

These insights thus bring us directly to more recent, explicitly 4E accounts of cognitive semiotics. Paolucci (2021, p.6) outlines three core principles foundational for a truly 4E cognitive semiotics: *Radical Enactivism*, *Pragmatism* and *Material Engagement Theory* (MET). Applying these criteria to spatiality, we uncover that spatiality is radically enactive (it facilitates direct action upon surrounding space), pragmatic (the spatial relation to the world is composed of habits and enables active sense-making) and MET (bodily space is co-constituted by material objects and enactive signs present in the environment). Recalling our driving principle that lived space is relational, we thus arrive at the conclusion the semiotic or autopoietic agent engages its world an interconnected system of meaning or 'semiosphere' (Lotman, 2002, 2005) in accordance with 4E principles.

In addition to embodied cognition, contemporary accounts of extended cognition (e.g., Clark, 2008; Kiverstein, 2018) likewise have clear antecedents in Peircean semiotics, which further showcase the anti-subjectivist footing of Peircean semiosis. One striking example is that of the pen, inkstand and notebook used in writing, an example employed by Peirce himself (Paolucci, 2021). On Paolucci's account, we see that the act of communicating one's ideas is constitutively dependent on the artefacts used for its execution. Drawing on Hjelmslev's (1959) so-called 'commutation test', Paolucci (pp.78-80) illustrates how the necessary inclusion of a tool for the completion of some otherwise 'cognitive' task renders that tool as constitutive and thus as indispensable as the body part or even brain itself. This allows us to see how an embodied act, even a paradigmatically intellectual one such as writing, requires every component for its concrete actualisation in the world.

In opposition to a cognitivist model in which, broadly speaking, ideas arise fully formed in the human mind before being iconically transposed onto the paper, it is instead the situated event of writing with the pen itself that *enacts* the ideas communicated, determining both form and content. And if the *act of writing* shapes the ideas communicated, then it follows that pen, book, and inkstand are all equally ineliminable components of the written content and thus equally constitutive as the ideas 'in the mind' that one transcribes. The purposeful action of writing thus encompasses the agent, pen, notebook and inkstand into a temporary spatial unity, whereby the act of writing and the content of ideas are enveloped into a situated and extended spatial *event,* anticipating recent arguments of the same species (Clark, 2008; Kiverstein, 2018).

If the lived and objective body and lived and objective space can be considered a unitary phenomenon with a dual aspect (Fuchs, 2018), and if bodily space designates the way in which the brain-body perceives and engages it spatial surroundings, then certain systems of signification can be activated *only* by action. However, a meaningful action is never a self-encapsulated moment. As noted by Eco (1997/1999, p.206), a subject needs prior familiarity with an object (e.g., a car) so that it may automatically elicit a field of expectations (Nessier, 1976). Thus, even perception is grounded upon an embodied knowledge of sign-systems, as Peirce often emphasised (see Paolucci 2021, pp. 145-153). Indeed, as Kull (1998, p.303) rightly points out, "an important property of semiosis, which makes it different from physical processes, is its historicity together with the ability for learning." Expectations of objects in space, which pre-reflectively prepare the body for appropriate action, are thus wholly dependent on prior familiarity ('historicity') with said object. We thus arrive at the temporal dimension underlying semiosis, another clear parallel with phenomenology. Following Eco's (1979; 1997/1999) reasoning, the most prominent meaning that an object offers us is not defined by its *conceivable* use but its *most likely* use. If this is the case, then bodily space *qua* semiosis should reflect this state of affairs, so that the directly perceived utility of objects is a spatio-temporal event grounded upon habit (see Peirce, 1903/1998, p.223).

Our account of semiosis enables us to understand that conceptual 'knowledge-that', active perception and motoricity can unite in a single semiotic event, producing an appropriate response in the interpretant (Jappy, 2023, p.157). Furthermore, we again see how something approximating 'belief' supports a direct perceptual account (see Kreuger, 2018). For instance, it is not until I grasp or perhaps bounce a basketball does the hoop show up as something to be thrown towards. Without the ball, I may perceive the hoop, but it will not solicit the same intensity of appropriate motor-possibility. In turn, this motor-possibility rests upon my familiarity with the game of basketball and the rules that govern it (for instance, that the ball is to be thrown and not kicked). Had I never seen a basketball court before and never been introduced to the game's rules, the key objects (i.e., the ball and the hoop) would not offer affording-possibilities that, in turn, are scaffolded by an implicit awareness of the know-how of basketball. A system of significance may always 'have' meaning, yet this meaning may lay dormant until the enactive agent himself picks up the ball and initiates the semiosic process that aligns motor-capacities (know-how) with rules (know-that), uniting both in the spatial situation which, to reiterate, as semiosis, does not just occur ‘in the head’.

As such, we might consider both context and individual circumstance as triggering conditions for individual cases of embodied-enactive semiosis (Violi, 2017). How the brain might react to *unfamiliar* situations, places, and habits will be considered later.[52] Thus, following Wittgenstein, we can agree that use defines meaning but, importantly, this meaning also always showcases something’s *potential* use when one faces it (Kiverstein & Rietveld, 2014). Because, as enactive sense-makers, we always perceive our world in projective terms: “for an artist a canvas is never empty [and] for a writer a page is never blank” (Paolucci 2021, p.15). While we have already discussed how bodily space is characterised by an ever-ready openness to potential action, pragmatic philosophy astutely emphasises that it is not only possibility but rather *probability* that significantly determines perception. Indeed, when faced with an object, all of its possible uses are not laid out uniformly before the agent (Batencourt, 2005). The watercolour painter does not project a pencil drawing onto the canvas when holding her paints, nor does she see them as projectiles or decorative items. Instead, it is typically the case that the use most pertinent to one’s spatial situation, the action of most contextual relevance, determines the immediately apparent meaning of an object:

> Meaning consists in the conceivable practical effects, in other words (in Eco’s semantic terminology), in *the coding of contexts and circumstances*, and thus in the concepts of the possible uses of a sign that are culturally and conventionally considered *more probable* (Paolucci 2021b, p.296; Emphasis added)

Recalling the importance of place and habit as detailed previously, we can further state that familiar objects and places work alongside motor habits to constitute a background of intelligibility that characterises lived space.[53] Semiosis is thus one prominent means by which the brain-body exists in a nexus of implicitly understood ‘context and circumstance’. Since brains are not *only* organic entities determined by physical processes but themselves active elements in broader socio-cultural sign-systems: “brains cannot wait, they act before they know what to do and what they are doing is not to construct a correct image of the stimulus. What they are doing is trying to act efficaciously” (Paolucci, 2021, p.152). Good

[52] Eco devotes a great deal of attention to cases where agents are faced with decidedly unfamiliar and/or confusing objects. A paradigm case of this is the titular ‘Platypus’ – this gave the title to Eco’s book *Kant and the Platypus*.

[53] We might here find informative Casey’s (1997, p.164) “what defines place as something separate from the space taken up by a body is the relations of that body with other entities” as applicable to our own account of relational, meaningful bodily space.

pragmatists that they are, our brains always have one metaphorical foot in the future, attempting to predict what the world will throw to us in order to meet that future occurrence optimally. Indeed, the classically semiotic notion of narrativity (Greimas, 1971) also confers a temporal grounding to sensory experience and cognition, bridging expectation with veridical perception and the sedimentation of habits with skilful action (Paolucci, 2019, 2021). Narratively-structured actions conceal a past, present and future so that we again see that when dissecting spatiality, 'temporality' seemingly arises quite near to the surface (Popova & Cuffari, 2018). Meaning from a cognitive semiotic viewpoint thus appears to emerge from the interpenetration between affect, action, mind, body, time, space and community as outlined above, making the world intelligible on the basis of habit and expectation, in which meaning becomes fixed and enters the background of our capacity to know the world.

Finally, it is important to highlight how the concept of spatiality developed here, despite being clearly bounded in several important ways (e.g., to one's physical location or cultural milieu), must be viewed as always open to as-yet-undetermined configurations and as-yet-unseen instantiations of self-world relationships that social and technological developments impose upon us. The dynamic, open-ended and evolutionary nature of semiosis, repeatedly highlighted by Peirce and Eco, provides food for thought here. That is, there always remains the possibility of updating our working notion of lived space because human spatiality is intimately connected with ever-shifting cultural phenomena such as technological artefacts and political organisation (Eco, 1975, 1989, 1997/1999). In some sense, the PPS network's properties are relatively fixed due to its phenotypic, biological instantiation. However, as long as human beings exist, new objects will be invented, new environments shall emerge and new models of societal organisation shall form, all of which will bring with them new modes of being spatially embedded. Accordingly, our peripersonal spatial system shall adapt to all these as-yet-undetermined changes (as it already has to universities, nightclubs, airports, guns, cars, video games, ovens and smartphones), contributing to new forms of semiosis while still remaining anchored to its biological (albeit plastic) instantiation.

Following Eco (1975, 1989), this 'openness' should remain on the periphery of – if not baked directly into - our concept of bodily space. Bodily space is thus a system which is profoundly and even constituively *open* to currently unforeseen spatial forms and is, therefore, still (and forever?) an unfinished project. By implication, then, human creativity emerges as one final factor that sharply distinguishes 'lived' from ‘objective’ spatiality. Thus, the recent field of cognitive semiotics, heavily indebted to Peirce and now increasingly incorporating corroborating evidence from 4E cognitive science, showcases how mind is itself an instance of semiosis and fundamentally constituted by the sign-systems of which it is also a co-constitutive part. By incorporating recent research in cognitive semiotics, we further saw how the type of semiosis exemplified in the interpretant is concretely embodied while simultaneously extending beyond the body’s material boundaries in the act of semiosis, connecting semiotics with the prior analysis of phenomenology.

2. Chapter Summary

Several key themes have emerged from the phenomenological and semiotic analyses of spatiality provided here, which combined have helped us formulate a robust blueprint of lived space that, in addition to serving as a standalone theory, should prove useful for interpreting and explicating the empirical evidence analysed in the succeeding chapters. Broadly, we have arrived at an account of lived space which prioritises the lived body in active engagement with its surroundings at multiple levels, whereby from this organism-environment dynamic coupling, emerges a qualitative, relational and non-dualist kind of space that is structurally grounded upon meaning.

More specifically, the convergence of perception and action in bodily space emerged as an overarching theme throughout this thematic analysis. Indeed, it was noted several times that bodily space arises at the intersection between one’s motor capacities and sensory perception. Uexküll shows us that the surrounding world is constituted by perception-action cues that together form functional cycles, which are emphasised or deemphasised based on the organism’s current goals and intentions. Peirce (1998, p.223) likewise tells us that “there are no conceptions which are not given to us in perceptual judgements”, and it is these judgments that allow us to pragmatically act in the world. The importance of action for perception is likewise a central theme in both Heidegger and Merleau-Ponty, informing some of their most famous concepts: ‘ready-to-hand’, ‘motor-intentionality’ and ‘optimal grip’ (Dreyfus, 1990, 2000, 2002), to name but some.

In essence, all of these concepts emphasise that the fundamental spatial relationship existent between agent and environment is forged by concrete engagement with the qualitative aspects of one’s spatial environment which form the background against which the embodied agent is always immersed. A dynamic relationship between agent and environment that fuses bodily-motor capacities, multisensory perception and their meaningful intentional-objects thus lies at the heart of our model of lived – and by extension bodily - space. Seen thusly, the surrounding world is synonymous with a zone of contextual opportunities for interaction which ground one's sensorimotor capacities at the most fundamental level; i.e., as embedded in a space of meaning.

We can draw from this that we do not engage objects as isolated entities 'by themselves' but rather as things embedded within complex networks of meaning-relations that determine the automatic way in which objects manifest perceptually. Moreover, both Heidegger and Uexküll persuasively argue that the surrounding world is filtered according to an affective logic that imbues itself to things encountered. Specifically, Heidegger's account of the world-disclosive power of Mood (*Stimmung*) is strikingly similar to Uexküll's biological account of moods and tones, such as the 'search tone' or the multiple roles of the flower, which guide appropriate action with the help of their affective impact. Mood encompasses the entirety of the *Umwelt* so that our surrounding space itself has a different global character depending on when one or one's group is excited, depressed, confident or apprehensive. In understanding that surrounding space is profoundly structured by affectivity (Colombetti, 2018), we understand that a metric model can never exhaustively capture its nature.

Another such factor jointly present in the phenomenological and semiotic literature is the role of 'place'. Like Uexküll's 'territory', place denotes a kind of global context without strict metric borders which impinges directly upon our bodily space. Consider a safe or hostile place, a nostalgic setting of fond memories or a working environment rife with either fierce competition or easy-going relaxation; such factors converge with mood to modulate bodily space. Moreover, Heidegger showcased how *Zeug* or *pragmata* are functionally encountered in accordance with this logic of place: tools of carpentry characterise the workshop, and when encountered there they are more 'at-hand' as parts of a holistic 'referential totality' than if those same tools were encountered at the rubbish tip. In semiotics also, it is place that provides some of the contextuality that immediately determines how a sign is interpreted. Thus, placial context also grounds the agent in a particular mode of spatial embeddedness which naturally extends to how surrounding objects co-present there are encountered (see Casey, 1997). Importantly, the recognition of this 'context' is not an intellectual add-on (Dreyfus, 2007), but part and parcel of one's spatial semiosis or spatial being-in-the-world.

While our methodological focus remains fixed on a 'near space' which features the embodied agent as its nucleus, we frequently saw how factors located *outside* this agent-centred spatial zone (or alternatively: exogenous to the 'here' and 'now') nonetheless sculpt presently-situated bodily space. Notably, Uexküll labels such abilities as 'supersensory'. Prominent examples here again include Uexküll's concepts of 'territory' and 'plan', spatial phenomena which, while superseding our immediate sensory capacities, continuously impact our immediate and bounded experience of the space surrounding us and our place within it, enabling sensorimotor interactions on a grander scale in accordance with this plan or, alternatively, with others with whom we share spaces with via our mutual immersion in meaning-systems. Merleau-Ponty adds to this picture by combining a Husserlian-Heideggerian analysis of lived time with his own embodied account of lived space, showcasing how the body moves through space not as discrete points but as meaningfully-connected 'passages'. Thus, one's spatial 'here and now' is always called to by a projected or anticipated future that immediately influences the present, which is never fully a demarcated instance. The phenomenological literature provides convergent evidence here, as this clearly dovetails with a Heideggerian interpretation of time, in which a future state constantly and pre-reflectively informs and 'calls out to' the present moment.[54]

Closely linked to sensorimotor cognition and the temporal nature of lived space are 'habits'. Habit is explicitly central to the philosophies of both Peirce and Merleau-Ponty and implicit in Heidegger's. In semiotics, a habit renders finite and stable a world that is otherwise open and infinite (i.e., unlimited semiosis), grounding consciousness within a network of signification-systems that constitute a culture and/or individual identity (Eco 1975; 1979; Jones, 2002; Paolucci, 2015). Merleau-Ponty likewise suggests that habit enables one's surroundings to manifest as a qualitative place soliciting specific, bodily opportunities for interaction that structure the 'background' of one's bodily embeddedness in space. This is because, when concretely enacting a habituated action, I need not execute it step-by-step as I did when I first learned it (Cappuccio, 2023). Rather, the action is rendered 'on-hand' whenever the right moment arises, such as when I spot a useful object. Tool-use itself can become habituated (thus entering the body schema as a constitutive component) to the extent that it becomes a permanent fixture of the lived body. Subsequently, this enduring incorporation of the tool into the schema enables surrounding

[54] Later, we shall encounter experimental evidence that necessitates a more detailed exposition of lived time than was appropriate to this chapter dedicated to space.

space to show up a particular way, e.g., the soldier on the battlefield experiences their surroundings on the basis of the weapon with which they are proficient.

Additionally, at a meta-theoretical level, Peirce's semiotics lends conceptual fortification to how we conceptualise human spatiality by dismantling strong ontological dichotomies. Applied here, Peirce's notion of synechism lends theoretical credence both to the relevance of animal studies in PPS research as well as reminding us to view human spatiality as something that is simultaneously and irreducibly both natural and cultural (Eco 1997/1999). Since distinctions between man and animal and/or nature and culture exist on a continuum (not as sequestered categories), this allows our project to draw freely on animal studies, cultural analyses, experimental data and theoretical philosophy whenever such resources augment our analysis. Indeed, with Uexküll, we receive a plausible account of the continuity between animals and human understanding of the world as networks of meaningful, intractable sign-systems, a nice example of the kind of synechism that intrigued Peirce. Consequently, 'synechism' forms the conceptual backbone of this thesis: there are recognisable continua between nature and culture and animal and human life that permit the biological and neurophysiological system of peripersonal space to fluidly interface with cultural *and* evolutionary factors that determine it.

Moreover, Peirce's anti-Cartesianism and emphasis on the public accessibility of signs serve as a conceptual curative to Uexküll's neo-Kantian approach, reminding us that even the mind itself, as an instance of semiosis, is classifiable as an external phenomenon. Taken thusly, semiotics smoothly intersects with phenomenological philosophy and enactivism, facilitating their joint inclusion into our ecclectic account. Indeed, the juncture at which all the thinkers discussed in this chapter converge is in the proposition that science cannot account for all manifestations of space. But this did not mean that science and philosophy could not communicate with each other to mutually reveal bodily space. On the contrary, Merleau-Ponty and Uexküll were deeply engaged with empirical and clinical psychology, neuroscience or the biology of their era and Peirce, a trained chemist, regularly drew upon scientific examples when expounding the nature of semiosis. Indeed, Merleau-Ponty provided an exemplary blueprint for interpreting experimental findings through the lens of phenomenology particularly regarding the difference between body image and body schema (Gallagher, 1986, 2005), which has found widespread adoption in mainstream psychology (Cole, 2008; Sykes, 2021a). As such, studying what these thinkers had to say on both meaning and on space has provided us with a template to follow regarding cross-disciplinary integration, even if the studies in question were published many decades after their deaths.

The other commonality worth brief mention is Heidegger's criticism of mind as substance. Heidegger addressed this (purportedly) erroneous substantilisaiton of mind by replacing the term *Bewusstein* ('conscious*ness*' or 'aware*ness*') with *Dasein* ('there*ness*'). While in traditional metaphysics, consciousness was treated as a self-sustaining substance, 'Dasein' emphasises its fundamental interconnectedness with 'external' phenomena such as objects, language and culture (Dreyfus, 1990, 1996; Blattner, 1999). This distinction found further support in application to AI where it seemingly explained the failures of early attempts to artificially replicate human intelligence due to their lack of world-embeddedness; this became known as the frame problem (Dreyfus, 2007; Froese, 2007; Cappuccio et al., 2021). Cognition *qua res cogitans* need not exist as substantially independent from the spatially extended container it is somehow located in but is fundamentally a part of and formed by the spatial contexts it is embedded in. Our notion of bodily space is thus as a 'framed', process entity. The relation between agent and world is thus best defined as one of 'embeddedness', which will be a key piece of terminology used to contextualise the vast array of empirical discoveries discussed below.

To reiterate, bodily space's primordially qualitative nature does not imply that it has no discernible structure amenable to thorough conceptual analysis nor demands of experimental validity and reliability. While the embodied mind in space follows a logic, it engages the world in ways far more multivariate than, say, as an uncompromising analytic philosopher. The mind's semiotic logic and phenomeno-logic (Martin, 2005) thus confer a structure to bodily space that operates completely behind the scenes as far as the agent-interpretant is concerned, structurally uniting brain-body with surrounding space before reflective analysis manages to interpret the world. Nonetheless, while it is evident that cognising space explicitly (e.g., calculating width, doing geometry, studying astrophysics) is non-identical to the pre-reflective, 'ready-to-hand' immersion in space, the agent can occasionally objectify space as part of their worldly projects (Heidegger, 1927/2010). Thus, while our account of lived space does not serve to deny objective space, in-keeping with the principles of ECS, it is this former kind of pre-reflective immersion in the *Umwelt* that permits the reflective and conscious thoughts, actions and feelings that take place there.

To recap, the numerous qualitative factors found to structure lived space, as detailed with the help of four key thinkers above, essentially reveal spatiality's pre-reflective and embodied dimensions, whereby the dominant mode of relationship connecting organism to environment is one of embeddedness and not one of computation or representation. This is because spatially embedded agents do not, for the most part, engage surrounding space by abstractly ratio scaling or mentally rotating shapes (e.g., Cipolotti et al., 2021) when engaging the world but are rather actively immersed in meaningful zones that are structured by useable tools, contextual anchorage points, and solicitations for interaction. Lived space is, therefore, a relational phenomenon that is structured according to intersecting planes of meaning, for which the lived body serves as its nucleus. As such, this chapter has essentially expounded upon, using several examples from across phenomenology and semiotics, Fuchs' (2018, p.60) astute summary of the embodied agent's relation to space: "the integration of the living being's sensorimotor interactions with the environment [become] an *intermodal action space* (*'sensus communis'*), allowing for skilled coping with environmental affordances and opening up possibilities for action".

In conclusion, if the thinkers discussed in this chapter contribute to a genuine understanding of how living, embodied beings are qualitatively embedded in space, we might expect to see that experimental accounts of embodied spatiality can simultaneously support, and be supported by, these conceptual analyses, even if (or perhaps especially) no prior knowledge exists on the experimenter's part of any such similarity.[55] While we will often emphasise particular convergence points (with quotations) where they arise, this chapter has conferred to us a general framework which will guide all subsequent analyses of the empirical evidence so that its general principles are always themselves 'in the background'. Thus, in the following two chapters, we shall investigate how this qualitative, situational and pre-reflective model of bodily spatiality is uniquely positioned to shed light on empirical data regarding peripersonal space as regards both *Objects* in the *Umwelt* (**Chpt. 1**) and *Others* in the *Mitwelt* (**Chpt. 2**). In doing so, we aim to simultaneously reveal *1)* how novel scientific evidence can inform prior philosophical accounts of space; *2)* how scientific evidence is itself illuminated by conceptual resources provided by philosophy and, finally, *3)* how we can arrive at a more well-informed and comprehensive definition of the construct known as peripersonal space through an interdisciplinary investigation.

[55] That is to say, while interdisciplinary accounts are highly valuable, we will see that some studies conducted independently of philosophical knowledge support those conclusions. This mutual convergence of evidence is strengthened if there is no chance of bias or preconceived in the experimenters due to a lack of awareness of the philosophical material.

Chapter 2: Bodily Space and Objects – The *Umwelt*

Chapter Overview

This chapter aims to explicate how bodily space is embedded in its *Umwelt*. This goal can be accomplished by understanding how bodily space exists in relation to the objects present there by recruiting both theoretical and empirical resources. According to the present account of embodied-enactive spatiality, objects encountered within the agent's *Umwelt* are not taken to be object*ive* but rather useful equipment meaningfully enmeshed in a form of life (see Kiverstein & Rietveld, 2015). This is why Heidegger referred to tools as *pragmata*: useful equipment is ontologically defined by its *pragmatic* utility (Dreyfus, 1990).[56] *Pragmata* are essential to the constitution of any *Umwelt* an agent is embedded in because they manifest the various action-possibilities that one can take up within it (Gallese & Sinigaglia, 2010, 2011). Moreover, the tradition of philosophical pragmatism initiated by Peirce broadly concurs (Johnson, 2016; Paolucci, 2021; Gallagher, 2023, p.4). We will thus flesh out this notion theoretically before turning to the corresponding experimental literature.

Most prominently, the agent-object pragmatic relationship that structures the *Umwelt* speaks directly to the relational character of world-embedded, multisensory-motor bodily space (Serino, 2019).[57] From an enactivist standpoint, the brain-body does not observe objects first as neutral, three-dimensional entities and then sequentially infer their various use-values on top of their more enduring, objective properties (Kelly, 2000). Rather, objects in the *Umwelt* are directly perceived *as* their uses just as directly as are their geometric forms (Noe, 2004, 2009; Gallagher, 2023). On this account, a dynamic coupling between agent and environment (Varela et al., 1991) scaffolds what we label cognition and/or sense-making (Weber & Varela, 2002), so that even 'passive' sensory perception is co-constituted by an ability (potential or actual) to interact with things perceived. Moreover, these meanings are usually individual or culture-dependent insofar as they

[56] 'Object' here denotes an inorganic, concrete and materially bounded entity. An atom, horizon or a galaxy would not count under this particular definition.

[57] It seems that Merleau-Ponty, quite remarkably, also pre-empted- the importance of multisensory integration *and* context for PPS when he writes that: "'Visual givens' only appear here through their tactile sense, and tactile givens only through their visual sense, each local movement only against the background of a global position, each bodily event only against a significative background where the furthest repercussions are at least indicated and the possibility of an inter-sensory equivalence is immediately provided." (*PoP*, 187/151).

obtain said meaning according to our current needs, wider goals, and/or general form of life (Rietveld & Kiverstein, 2014).

Accordingly, tools feature an inherently functional connection with respect to delineated tasks one can engage. We might even entertain the stronger, Heideggerian-inspired claim that the brain engages (most) objects *primarily* as useful tools, so that their objective properties are only reflectively inferred *after the fact*, disclosed in a detached, theoretical stance (Dreyfus, 1999). Thus, we will briefly confer further depth to our previous discussion of Heidegger and tool-use to set the stage for an analysis of tool-use in the PPS literature. Here, 'primarily' entails a two-fold meaning. The first meaning is temporal: the brain-body first perceives an object as a tool *before* it sees it as an objectively present entity. That is, while I may see my laptop as *for-typing* and as a rectangle simultaneously, I don't see its atomic weight (at least not in precise terms) as immediately. The second meaning of 'primarily' designates that of priority. One compatible neuroscientific dimension to this story would be that, at each stage, the brain-body perceives affordances ('*to-open*'; '*to-switch-on*') as solicitations toward action (Gibson, 1979; Chemero, 2009; Gallese & Sinigaglia, 2010). That is, the brain-body devotes a larger amount of its processing power to the receptivity of an object's utility, so that its pragmatic qualities occupy a greater influence over correlative neural activity compared to, say, its Euclidian dimensions.[58] Put simply, the brain-body is more immediately interested in a knife as '*for-cutting*' or '*as-dangerous*' than in its metric width.

Heidegger's introduction of 'ready-to-hand' (see **1a.1.1**) into the discourse is pivotal because he persuasively argues that much of human existence occurs in such a modality, despite the comparative salience of 'present-to-hand' phenomena (which potentially misleads us as to its importance) (Dreyfus, 2000). Applying this notion to the cognitive sciences, we can propose that computational and/or reflective modes of cognition ('present-to-hand') are more salient to consciousness, thereby resulting in fallacious inflation of their role in everyday functioning (Dreyfus, 1990). Spatial cognition is thus more often ready-to-hand than present-to-hand. In a now-classic example, Heidegger claims that the carpenter hammering a nail does not experience his hammer as a three-dimensional entity comprised of the materials of wood and metal; instead, the carpenter experientially merges with the tool via engaging it via the skill of carpentry, with the

[58] While Heidegger might object to such a naturalist interpretation, this proposition seems easy to nest within a Darwinian framework because the organism's survival depends far more on the impact that an object will have than anything pertaining to its objective properties.

hammer slipping seamlessly into the background. The tool as ready-to-hand thus becomes part of the way something other than the hammer is engaged, caught up in the web of context-driven action and earning its role as part of the larger world of carpentry, all of which provide meaning and coherence to the series of movements that the carpenter undertakes.

In rarer cases, we might undergo what secondary scholarship terms 'breakdown' (Dreyfus, 1990, 1996): the hammer is too light or heavy, the carpenter hits his thumb, or he must 'de-world' the hammer to investigate its objective properties for reasons of science or engineering. At this point, the hammer has broken its connection with the engaged flow of the task and partially detached itself from the situational *Gestalt*. The tool becomes a 'presently occurrent' entity defined by its objective properties (**1a.1.1**). However, these properties are now more clearly demarcated compared to when everything was functioning smoothly; the tool can be viewed objectively 'in itself' when not caught up within a wider relational network of meaningful activity. Now, as 'broken down', the hammer is no longer a transparent, constituent component of one's intentional-directedness, which temporarily restructures one's embeddedness in the *Umwelt*.

Furthermore, when not merely perceiving but literally using a tool, the brain in some sense minimizes any substantive distinction between the tool-user and the tool used. Indeed, the collapse of a sharp subject/object distinction between agents and tools during skilled activity is key to Heidegger's phenomenology of tool-use and, as will become clear, to the present account of *Umwelt*-embedded spatiality also. Moreover, using a tool fundamentally alters the way in which surrounding space manifests to the agent; via habit, this modulation can also become longitudinally instantiated due to a learning process that makes it a permanent fixture of the way that the agent understands and engages the spatial world. The tool thus modulates the agent's spatial consciousness or spatial being-in-the-world so that specific ways of acting in space always remain as latent background possibilities to be taken up at will and thereby structure peripersonal space and the *Umwelt* at the most fundamental level. This is one way in which *meaningful* objects constitute bodily space's relationship with the *Umwelt*.

Can we go further in defining how the brain-body cognizes objects as 'meaning-carriers' (Uexküll, 1934/2010)? 'Meaning' exists on both a cultural and individual plane or often as a complex entanglement between the two (Deely, 2015). We can here recall Uexküll's many rich examples of how organisms with different biological constitutions divergently perceive objects in an *Umwelt* due to a difference in 'effectors' and 'tones' as grounded upon their physiology, anatomy and psychology. Due to their different biological constitutions, the human cannot directly see the soil as *home* just as the mole cannot see a penthouse apartment as *home*. A type of organism which could not interact with objects as we do would therefore likely not *see* them in the same way that we do (Noe, 2004; Froese & Di Paolo, 2011).

Cognition of objects, then, is not just what is provided by brute visual perception of objective matter alone nor the passive reception and transduction of incoming sensory data. As any good enactivist would be happy to tell you, the possibility of using or in some way integrating the tool into one's activities feeds into how that same object is intuitively presented and this process will be shown to form the backbone of *Umwelt*-embeddedness. This 'seeing-as-functionality' component of object perception entails that meaning is always present as a co-constitutive element of perception at both a semiotic and phenomenological level (Zlatev, 2018). Of course, the object's contextual appropriateness must also be intuitively present to the situated brain-body outside of any conscious decision-making processes.

If space is relational and 'world-involving' (see Froese & Sykes, 2023), then meaningful objects are irreducible constituents of worldhood and, by extension, of spatial embeddedness too. The cultural function that tools hold within the agent's lifeworld, as well as what the object may mean for them personally, produces a powerful effect upon the brain's response to it, which is not always interchangeable between individual cultures. Ontologically, the uses of objects have a public, external meaning, in a way somewhat analogous with Peirce's notion of sign-systems (Paolucci, 2021). That is, I do not decide what function these tools have, nor do I decide to perceive them as such; the same goes like others inhabiting the same lifeworld. In most cases we do not deliberately *choose* to see a jug as something to pour with. Rather, its utility is perceived concomitant in perceiving the jug itself. In the 21st century, I can navigate through hallways, swipe keycards, pull out chairs and turn on computers as part of what Dreyfus (1990; 1996) termed 'absorbed coping'. Due to a difference in world-involvement, not intelligence, an Ancient Athenian could not accomplish my daily tasks fluidly, just as I could not smoothly navigate around the ancient agora and use the objects found in an ancient Greek *Umwelt*. Simultaneously, at the individual level, I might perceive the computer screen as a harbinger of despair or as a pathway to fulfilment, depending on how I feel about my work (Colapietro, 2009).

Stjernfelt (2006, p.21) argues that the *Umwelt*-embedded body is a semiotic device in itself because our bodies are always adjusting to the environment, sometimes with impressive success, other times as a miserable failure. As discussed, the body both enables semiosis and is part of semiotic activity. This bodily-semiotic variability complements Merleau-Ponty's 'optimal grip' and 'spatial level', notions which speak to the constant need for the body to adapt and readjust to situational demands. Following Stjernfelt and Merleau-Ponty, we can keep in mind that while we *can* fail to harmonise with our spatial situation, we *tend to* try to harmonise with it at the pre-reflective level. However, neither are we slavishly condemned to interaction. Not only are we not slaves to every whimsical invitation but, because not every part of our surroundings is equally distributed in terms of worth, we are never pulled equally in each direction by every affordance available. Indeed, the qualitative heterogeneity of space is what distinguishes it from a uniformly-distributed quantitative space. Our transient motor-intentional attunement to the changing world constantly modulates and mediates which kinds of actions we respond to, which in turn co-constitutes the qualitative structure of the spatial layout before us as it lies at the intersection of our perception and motoricity (Rietveld, 2008). As Gallese (2018, p.33) cogently summarises this phenomenon: "the functionality of the motor system literally carves out a pragmatic Umwelt, dynamically surrounding our body.

In the prior chapter, both Peirce and Merleau-Ponty helped us realise that particular modes of *Umwelt*-attunement frequently become sedimented into habits. Habits and the presence of tools that we act upon thus jointly give character to the immediate appearance of the agent's *Umwelt* (e.g., workshop, home, gym, shopping mall). Merleau-Ponty (1945/2012) emphasised that, through habituation, the merger between tool and agent develops into a long-lasting fixture of the agent's body schema. In fact, as Peirce (1903/1998) also demonstrated, habit can be viewed as the stabilization of self-world dynamics that follows from several repeated interactions of the same kind until said action has sedimented into part of the agent's long-term being-in-the-world (see **2.3,** Colapietro, 2021). We should remember, then, that an object's use can be relearned and, through this relearning, novel (but not infinite; see Eco 1979) worlds can be opened up. We increase our ledger of encyclopaedic items on-hand for sense-making, as the concept of 'infinite semiosis' means that, in principle, humans have relatively few hard constraints regarding how many semantic or pragmatic meanings they could learn (see Eco, 1981; 1989; Deely, 2015).

From an enactive perspective, we should expect to see bodily space reflect the power of habitude insofar as interactions with familiar vs. non-familiar objects in space will be found to be diverse in some way. Perhaps this is why Peirce gave such prominence to surprise, habit's opposite. Surprise forces us to recognize the holistic background in which one's habitual action is embedded and to question our prior beliefs that lead to the error that generated the surprise and broke that habit (West, 2021). The consequences of surprise enables a creative response to affordances, which is analogous as to how 'breakdown' helps reveal a normative phenomenological structure (Dreyfus 1996; 1999; Cappuccio & Wheeler, 2010).

1. Tool-interaction and Affordances

1.1 Spatial Alignment and Affordances

We will begin our interdisciplinary exposition of the *Umwelt* by first examining the most practical mode in which agents engage objects (e.g., functional interactions with tools).[59] Critical to any account of peripersonal space, moreover, is a centring of the agent's capacity for interaction with nearby entities (e.g., Brozzoli et al., 2012; Graziano, 2018, de Vignemont & Iannetti, 2015, Serino, 2019). Moreover, as discussed above, the ruling logic of these body-object interactions is often intimately tied to the utility that the object serves in relation to the context in which it is encountered. If lived space is, like objective space, an inherently relational phenomenon, then relationships to objects profoundly constitute the way in which organisms are spatially embedded in the *Umwelt*. This proposition coincides with the foundationally enactive idea that cognition (or rather: 'sense-making') is more than the passive reception of information but constituted by a future-directed capacity to act upon that information whereby it is incorporated into one's greater projects. Our peripersonal spatial network must reflect this reality if we are able to have fluid, meaningful engagements with tool-like objects (Costantini & Sinigaglia, 2011). Indeed, one the most striking and well-replicated modulations of PPS is that the utility or affordance of

[59] I have used several sections from this chapter in my paper*: 'Sykes, J. J. (2023). Tools and peripersonal space: an enactive account of bodily space. Phenomenology and the Cognitive Sciences, 1-21'*. Some (but not all) of the sections used in that paper have subsequently been re-edited in this thesis. Several elements of this section were reused for my publication (Sykes, 2023). That article mainly incorporates elements from this chapter, (esp. 1.2 and 1.3) but other aspects of the thesis may also have been used.

the perceived tool determines the brain's observable response to it (Serino et al., 2007; Buccino et al., 2009, 2012; Costantini et al., 2010, 2011; Martel et al., 2016).[60]

As revealed in **Chapter 1**, the spatial relationship between agents and objects developed here hinges on the characterization of objects as tools, in turn defined by the tasks that they facilitate. Because the type of spatial cognition we aim to illuminate here is of the pre-reflective variety, our strategy entails that we are relatively uninterested in how the brain-body understands the world as a bearer of objective spatial properties. Abstract or Euclidian properties like width, volume or distance – if devoid of any relationship to meaningful tasks and projects - do not *ipso facto* figure into the primordial way in which agents are pre-reflectively spatially embedded (Jackson, 2014; Gallagher, Martínez & Gastelum, 2017). To understand this difference, simply recall that calculating a tool's objective length or the height of a doorframe requires a secondary, reflective mode of reasoning as its condition of access which stands in contrast to the automaticity of directly perceiving its utility or passing through it. Thus, instead of an agent-world spatial relationship defined predominately as a computational brain contained within its surroundings understood in terms of calculated properties, the situated brain-body understands space as a place of situated *meaning*.

That some tools became transparent constituents of action will be shown to be of great importance later. For now, however, we should introduce the pivotal concept of 'affordances' (Gibson, 1979), which helps bridges our theoretical and experimental analyses. The much-studied concept of affordances aptly demonstrates this bi-directionality between agent and environment emphasised in enactive cognitive science (ECS) (Thompson 2007; Chemero 2009; Costantini & Sinigaglia, 2011; Kiverstein, 2018). Objects are *afforded* to us via their task-paired function (e.g., scissors are *for-cutting*) as ready-to-hand entities. Introduced by Gibson (1979) following his development of ecological psychology, affordances have birthed an enormous literature, spanning an immense number of disciplines (see Kiverstein & Rietveld, 2014 and Chemero, 2009).

Echoing Heidegger, Uexküll and Merleau-Ponty, Gibson's (1979/2015, p.119) famous definition is that "the affordances of the environment are what it *offers* to the animal, what

[60] This is not to say that factors such as size, volume or material count for nothing. Certainly not. However, I would like to argue that these factors are subordinated to the meaning they have for the agent; e.g., is the object a real football that I can kick or a stone statue of a football that would break my toes? It is in this way that the materiality or weight of the object is understood in relation to interaction-possibilities, instead of as properties 'in themselves'.

it provides or furnishes, either for good or ill… it implies the complementarity of the animal and the environment". In Gibson's ecological psychology, we face the now-familiar notion that a living being's 'environment' is best conceived as a relational and situational phenomenon emerging from local interactions between agent and object(s), forging connections of mutual compatibility that in turn defines the very ecological nature of this agent-environment coupling (Thompson, 2007). Gibson's ecological psychology thus sits well with Heidegger's phenomenological ontology, Uexküll's theoretical biology and Merleau-Ponty's phenomenological metapsychology. In each account, one's dynamic spatial coupling with surrounding objects that arise into salience is characterized by meaning, context and utility.

Suppose, then, that affordances in space are indeed tantamount to what the environment "offers, provides or furnishes". In this case, every tool can offer a variety of meanings in accordance with the contextual environment (or 'place') in which it is encountered.[61] Affordances in the *Umwelt* are thus constitutively situated (Rietveld 2008, 2012). Moreover, depending on the context, an affordance might have a meaning *for* everyone, for *us* or even for *me,* privately.[62] Examples here may include the sound of a nearby car which signifies danger (and *my* possible death if I don't get out of the way but not the man nearby) or the title of a book I happen to see in a shop window that reminds me of something that I should include in *my* PhD thesis. Simultaneously, objects likewise feature shared, cultural meanings that constitute the background of our public being-in-the-world, or the cultural encyclopedia of shared, situated knowledge (Eco, 1979; Paolucci, 2015). In my apartment block, everyone's brain presumably registers a fork as a utensil *for-eating* because it has this function in our culture. On a more local scale, another example would be that, for a group of three people, a heavy object appears moveable solely because the group enjoys a combined power to lift it.[63] In sum, how an object affords use is powerfully culturally, functionally and situationally determined and pertains and shaped by the context in which one encounters it (Eco, 1979; Paolucci, 2015; Violi 2017; Deely, 2015).

[61] It is worth reiterating that a significant difference between phenomenal qualities and objective properties are the former's adaptability and the latter's uniformity. If an ant, a cow and a schoolgirl engage the same flower, this flower will retain the same objective properties throughout. See also the discussion of Heidegger and place (**1a.1.2**)

[62] But not ontologically private. That is, if only I can read a secret message hidden in a text, this does not mean that its meaning (or language itself) derives only from me.

[63] How surrounding space manifests on this cooperative basis will be discussed in **Chapter 3**.

Thus, in the context of a particular lifeworld, if one is acclimatised to its intra-cultural logic, one experiences certain artefacts as pregnant with meaning even if they do not feature as explicit intentional-objects of focused interpretation (see Blattner, 1999). For instance, as a member of a technological society, a SmartScreen used to order food in a restaurant will automatically afford me action-potentials, whereas a member of a 'primitive' agricultural society may encounter only a flat surface. In turn, these objects belong to a wider network of meaning; for example, the SmartScreen used to order food I recognise which I expect to arrive in a certain way.

Furthermore, if the SmartScreen is located in a restaurant, I navigate it as a familiar setting that features doors, stairs and corridors that I know how to navigate, staff I know how to interact with, scents and noises I have come to expect from a restaurant and contextual social norms that give shape to my actions inside. In parallel, members of that aforementioned agricultural society may experience particular hunting, crafting and decorative utensils and objects belonging to their lifeworld as inherently featuring affordances whereas to me they perhaps more closely resemble spatially extended entities devoid of any affordances that I must interpret to understand (see Dreyfus, 1990). Thus, the logic of place, alongside the availability of accessible objects confers a kind of spatial orientation or 'level' that links me to my environment and (certain) objects therein.

Taking all these factors into consideration, what does the recent empirical literature have to say regarding the role of the body's spatial position in affordance perception? Mirroring the above theoretical discussions, Ferri et al. (2011, p.3523) note that "artefacts activate manipulation as well as functional information". Iani et al. (2019, p.1363) further note that it has been consistently demonstrated that "observation of graspable [i.e., intra-PPS] objects is accompanied by activation in brain areas implicated in object manipulation [and is] modulated by objects' features [and] the physical and social context". Like Iani et al., several noteworthy studies have focused on the interplay between bodily posture and affordance orientation as mutually influential factors upon affordance-perception, typically finding faster reaction times when the position of the tool and position of the body are spatially aligned (e.g., a right-handed utensil displayed on the right side of the body). Indeed, Ellis and Tucker (2000) showcase that the agent's motor abilities and bodily position reciprocally determine how an affordance is perceived. The coherence (or rather: 'spatial level') between the position of the object and the aligned position of body parts required for successful interaction is termed the 'spatial alignment effect', coined by

Tucker and Ellis (1998) who first found that response times to objects were faster when the position of a cup handle was ipsilateral to the subject's grasping hand. As De Stefani et al. (2014, p.2432) quite succinctly characterise this relationship: "extrinsic (spatial position) and intrinsic (size and shape) object features contribute to affordance instantiation".

In a TMS study on affordances, Buccino et al. (2009) measured MEPs in participants' right hands and primary motor cortex (PMC) excitability. Participants would look at familiar tools (e.g., a mug) in different conditions of usability, such as with an intact or broken handle (so-called 'broken affordances'). Buccino and colleagues demonstrated that the strength of motor-evoked potentials (MEP) was higher when subjects viewed mugs that had intact handles instead of broken ones. Costantini et al. (2010, 2011) likewise found that misaligned tools produced slower reaction times (RTs) when participants were instructed to grasp them. Costantini et al. (2010) also found that successful affordance processing increases when the tool is presented *within* the peripersonal space.

Accordingly, the topographical location of two tools may be identical, but if one affords less usability than the other, then participants are less automatically fluid in reaching for it, culminating in the object having a less pronounced presence within their experience and correlated neural activity. This essentially aligns with our aforementioned notion of 'breakdown', whereby fluid interaction with tools is impaired when an unusual or disruptive element is introduced (Dreyfus, 1990, 1996). Usability is thus a continuum: the *more* useable an object is, the *greater* is the MEP and/or PMC activity. Put simply, if a cup's handle and usability is spatially aligned with one's anatomy, the brain-body is more geared to interact with it and the affordance is thus more constitutive of the situational *Umwelt*, thus becoming more definitive of the spatial situation.

Interact-able objects (i.e., tools) thus elicit appropriate motor responses when their spatial position and orientation coheres with one's body, i.e., when there is a well-oriented spatial level within PPS. Accordingly, objects in space are not *just* encountered as three-dimensional entities located in a particular geometric position but as affordances intrinsically connected to bodily space and the body schema. This is why PPS must be responsive to contextuality. Action-readiness (or what we might call 'object-readiness') determines how the brain-body pre-reflectively anticipates engagement with an object in near-space.

Thus, as Costantini et al. (2010, p.95) explain: "An affordance is not about a mere physical property, rather it incarnates the action opportunities that the environment may offer to any individual which is able to perceive and use them". From this neuroscientific standpoint, then, an object *is* its utility: the pen *is* something to write with and the dial *is* something to turn, and both are directly encountered as such when oriented towards the body in the form of the 'spatial level' (Merleau-Ponty, 1945/2012). Importantly, a breakdown can occur in this relationship (highlighting its typical structure) whereby the functional aspects of tools produce measurably divergent responses in the subject perceiving it, perhaps reducing their readiness-to-hand (Buccino et al., 2009; Costantini et al., 2010; 2011).

But, even if affordance-perception occurs in the present, the past also has something to say here. It is only because I have already been introduced to the object's utility that it shows up to me as something useful. As von Uexküll's example shows (see **1b.1.2**), a strange object encountered for the first time with no intuitive usage cannot offer the same strength of affordance as an object that has been already sedimented in my 'situational encyclopaedia' (Eco, 1979; Violi, 2017) and that I know how to use proficiently. Uexküll offers a pertinent, real-life example of this phenomenon when he speaks of the immigrant who only saw "bars and holes" upon seeing a ladder, until he saw the ladder in use, at which point it became what it really was: a '*for-climbing'* tool. When its utility is known, and its presentation is coherent with body and task (e.g., not laying on the ground), a successful affordance-reaction bypasses a conscious initiation of a sequence of planned actions directed at the object (Sinigaglia & Costantini, 2011). Perception of the tool and corresponding motor preparation are largely simultaneous and automatic, so that one encounters objects *through* their affordances, which furnishes a meaningful character to the *Umwelt* in which we are sense-making.

In sum, across almost every situation, the meaning and structure of one's bodily space is greatly co-constituted by the useable objects or 'affordances' that one is surrounded by, which reciprocally confer meaning to a place.[64] More importantly, the compatibility and orientation of these objects correlate to the impact they have on the Umwelt's manifestation. We see this fact reflected in the heavy emphasis given to object-interaction in both the scientific and philosophical literature on bodily space. However, there exists a widespread lack of differentiation between what, on examination, appear to be vastly different species of object-interaction that shall require further clarification. In addition,

[64] This is essentially Heidegger's conclusion when discussing how Dasein engages its world as ready-to-hand, a structure that he labels the: "*Umhafte der Umwelt*", (p.102/99): 'the surrounding character of the surrounding world'.

specifying these different modes of tool-interaction shall augment our understanding of how peripersonal space is embedded in the *Umwelt*. In what follows, I intend to highlight and sharpen the important distinctions between tool-*perception* and tool-*use*, showcasing their discrete neurophysiological and cognitive-experiential profiles.

1.2 Tool-perception and Hold

The perception of objects or 'tools' in space is thus heavily informed by what possibilities these tools present to us (affordances), which, in turn, temporarily shapes the dominant meaning of surrounding space itself, directly impacting the motor system (Gallese, 2018). Before, we saw how the shape and position of a tool influences affordance-perception. Of course, in real life, the objects typically surrounding us on a daily basis are rarely laid out equidistantly. Typically, useful objects are dispersed at various locations and distances from the spatially embedded brain-body, and their position *relative to* the agent further imbues them with specific, contextual meanings. Accordingly, 'distance' stands out as one crucial factor for better understanding the dynamic between agents and objects in the *Umwelt*. However, 'distance' seems fitting to, even exemplary of, a quantitative account of space, as it is traditionally seen as something best understood in terms of the metric amount of space (e.g., 0.8cm, 12ft, 300.5km) existent between entities *X* and *Y*. Nonetheless, distance has been usefully operationalized in numerous seminal PPS experiments. How, then, can we make quantifiable and positional distance fit with the qualitative and situational account of space attempted here?

A revelatory but frequently unmentioned phenomenological notion developed by Merleau-Ponty (1945/2012) appears highly informative regarding the role of distance in affordance perception and bodily space generally. Namely, the phenomenon that Merleau-Ponty labels 'hold'(see **1a.2.4**). The notion of hold first appears in Merleau-Ponty's discussion of depth perception in *Phenomenology of Perception*, making its inaugural appearance in the following passage: "the man at two hundred paces away is a less articulated figure, he offers my gaze fewer and less precise 'holds' [and] is less strictly geared into my exploratory power" (*PoP,* p.310/272). By clear implication, this closer man exerts an *increased* presence over my current spatial situation by pre-reflectively drawing my attention while soliciting my lived body to anticipate an imminent interaction with him according to the contextual demands of the setting. Being closer, he thus enjoys a greater *influence* over my lived spatial situation than an otherwise identical, but further-away man.

Switching from persons to tools, the potential interaction that is perceptually presented via the further tool has a diminished presence in my 'exploratory power' and thus the spatial situation. The 'content' of a situated agent's motor-intentionality is equivalent to whichever task that specific tool is useful for. As the tool's distance increases, its phenomenal presence diminishes, and alternative action-potentials can come into focus; their 'holds' may increase. But this dynamic does not imply an immutable boundary. As Bufacchi and Iannetti (2018) have recently argued, proposing a strict, 'in-out' PPS dichotomy is inadequate and PPS is more accurately conceived of as a gradient, one which also emphasises particular task-related body parts. Indeed, as Merleau-Ponty already intuited, we can still 'hold' something located further away in EPS, albeit in a diminished way:

> We 'have' the object that is moving away, we do not cease 'to hold' it and to keep a hold on it… the increasing distance merely expresses that the thing begins to slip away from the hold of our gaze and that it joins with it less strictly (311/273).

Nonetheless, physically nearer objects are usually more 'geared into our exploratory power' by co-determining the overall meaning of our spatial situation more pronouncedly. Because the brain-body is spatially embedded in the world via PPS, when an object comes within reaching distance it solicits the body toward task-appropriate action without need of reflective cognition (Dreyfus, 2000; Cappuccio, 2023). Interestingly, Merleau-Ponty adds that the transition from perception to grasping – even if resembling a decision - mostly takes place in a manner today described as 'pre-reflective':

> No sooner have I formed the desire to take hold of an object than already, at a point in space that I was not thinking about, my hand as that power for grasping rises up toward the object (181/147).

What can the empirical literature add to this topic? Cardellicchio et al. (2011) measured motor-evoked potentials (MEPs) in the hand muscles of participants who were presented with tools (e.g., mugs) both inside and outside of their PPS and found that hand-muscle produced MEPs were higher in amplitude for the tools placed *inside* of participants' PPS. That is, the closer the tool to the agent's reach, the greater the motoric activation of interaction-relevant muscles.

Crucially, this indicates that, even non-volitionally and below awareness, tool-relevant body parts are motorically prepared for interaction whenever such tools are realistically reachable. This 'interaction-preparation' effect substantially diminished when non-functional, non-tool-like objects (such as cubes) were presented. Thus, participants' hand muscles produced higher amplitude MEPs (indexing increased action-preparation) when tools were presented *within* PPS. These higher-amplitude MEPs can be viewed as consequential to the occupation or 'hold' that the nearby tool possesses over the situated sensorimotor system, whereby the body is pre-reflectively solicited towards physical engagement with the presented tool *if* it lies within reach. The PrCC here is that of an agent perceiving contextual action possibilities *in* the direct perception of a tool. Pre-reflectively, one's body is occupied by the specific task that the tool offers, and this influence extends to the very muscles in our hands, indexing task-related motor preparation.

To reiterate, tools inside PPS occupy a greater 'hold' over the sensorimotor system as compared to those outside PPS. Should the computer mouse currently next to my right hand be moved further away at a distance of three metres, my phenomenological relationship to it changes insofar as it does not literally offer a *for-navigating* opportunity during that precise moment in the spatial situation, since I cannot actually wield it. As I walk away from the computer, typing-relevant body parts are less actuated by the possibility of typing and thus the availability of the tasks it presents to me are experienced as increasingly dimmer on the horizon of possibility (Gallese, 2016). Thus, a *quantitative increase* in distance has its experiential correlate in a *qualitative decrease* in hold. And such a decrease in hold means that the object enjoys a diminished presence in the situation, whereby the agent is offered fewer or more coarse-grained interaction-potentials.

There is further neuroscientific evidence, utilising alternative measures, that demonstrates how tool-perception is qualitatively modulated by distance. Using a virtual reality and EEG set-up to test neural responses to objects placed both inside and outside of PPS during a reachability judgement and object identification task, Waimain et al. (2016, p.26) found greater EEG-measured *Mu* [μ] desynchronization for objects inside of PPS compared with those outside. They thus found that there was greater *Mu* rhythm desynchronsiation for the objects within PPS; i.e., those which were realistically graspable. This effect was particularly pronounced when subjects were asked to judge an object's reachability of objects, while "desynchronization reduced progressively when objects approached extrapersonal space". This modulation was task-dependent, as when subjects were only asked to *identify* manipulable objects in PPS, the effect was diminished: "the greatest *mu* desynchronization was observed when participants judged the reachability of prototypical objects presented in peripersonal space" (p.26).

Thus, during reachability judgement tasks, the strongest *Mu* desynchronization occurred during the confluence of two factors: 1) prototypical objects that were 2) presented inside peripersonal space.[65] Intra-PPS tools contribute to this neurological effect, I claim, due to the above-described 'hold' phenomenon, an integral part of tool-perception in space. Prototypical objects offer the body greater 'holds' because they are automatically registered as items belonging to one's lifeworld, soliciting one towards action, while nontypical objects require greater processing, thus reducing the automaticity of the perception of their affording-features and thus a diminished phenomenal presence. And since *Mu* desynchronisation positively correlates with affordance-perception (Llanos et al., 2013), these data further support the claim that agent-object proximity in space is neurologically mapped in qualitative, interactive terms. If tasks acquire a greater presence due to their increased hold over agents when placed nearby, it is expected that this is cashed out in measures of motor stimulation triggered by visual perception, thus triggering *Mu* desynchronization. Such desynchronization "reduced progressively when objects approached extrapersonal space" (p.26) precisel y because their multiscalar hold over the agent continued to weaken as they left the agent's 'horizon of possibilities' (Gallese & Sinigaglia, 2011).

We have found that closer objects are not *just* processed metrically but provide the situated brain-body with specific opportunities for contextual interaction, the strength of which are negatively correlated with distance. Graspable objects *within* peripersonal space evoke muscle activity in the hands and greater affordance-related neural activity as a consequence of 'hold'. But what if one's hands – our major powers of interaction - are immobilised? Iachini et al. (2014) introduced an experimental condition that involved tying the hands of participants behind their backs while usable objects were presented both inside and outside of PPS. Iachini and colleagues found that participants with their arms tied were slower and less accurate in an object recognition task only for the objects presented *inside* of PPS. The authors claimed (p.24) that their results "confirmed that spatial localization of both manipulable and non-manipulable stimuli was facilitated by having free than blocked arms in peripersonal space".[66] The inability to generate affordances for objects with strong 'hold' interferes with the regular perception of objects, which has an 'enactive' dimension (Noe, 2004, 2009, Gallagher, 2023 Jappy, 2023).

[65] The importance of 'protoyipical objects' to this finding was covered in the prior section on 'breakdown'.
[66] It appears that also here non-tool objects produced the same effect as tools did. The authors concluded that motor resources only interfere with object localisation if the object is outside of reaching range.

Thus, the metric distance between participants and objects remained identical throughout all conditions, yet their perception of objects was modulated by their (in)capacity to grasp them. It follows that the close affiliation between perception and action (through which 'hold' manifests) entails that blocking one's arms renders reachable objects more difficult to localise and recognise. Interestingly, when non-manipulable objects were presented in *extrapersonal* space for the blocked-arm group, localisation accuracy *increased*. The authors (p.79) suggested that reducing the subject's capacity for task-related movement increases localisation accuracy, suggesting that "extrapersonal space could instead primarily rely on visuo-spatial ventral processes" in which the enactive, bodily component of perception is comparatively diminished.[67] This implies that motor resources are comparatively less important when objects are not realistically graspable, that is, those with diminished hold, in which we may see them as more present-to-hand (see also Martel et al., 2016).[68]

Closer tools can, therefore, be represented not only by a quantifiable decrease in measurable distance but by a qualitative increase in their temporary 'occupation' of the situated sensorimotor system via automatically simulated action-potentials, which registers experientially, neurophysiologically and anatomically (Cardelecchio et al., 2011; Iachini et al., 2014; Wamain et al., 2016). When the brain-body perceives a nearby tool (i.e., 'affordance'), its task-relevance (or 'the activation of motor programmes' in computational terms), signifies that the brain-body currently views that object as something '*for-handling*'. This phenomenological 'for-' structure is either absent or significantly diminished, as the experimental evidence indicates, if we cannot *really* reach out and use the tool. Reachable objects thus confer a greater bodily, experiential and neural 'imprint' by automatically presenting agents with more strongly suggestive action-possibilities (Gallese & Sinigaglia, 2010). Furthermore, it also appears that this 'imprint' is sufficiently powerful to interfere with the recognition of objects in far-space (Iachini et al.,

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[67] As suggested by the authors, this result coheres with evidence that reaching-to-grasp actions are accomplished by the dorsal stream (see also Goodale, 2011).

[68] It is interesting to speculate how subjects may adapt after prolonged time periods. Merleau-Ponty writes on phantom limb phenomena and experiments involving immobilizing the legs of insects, that the "the tied limb is not replaced by the free one because the tied one continues to count in the animal's being and the impulse of activity that goes toward the world still passes through that limb" (107/80). However, such 'ecological' instances are outside of timespan typical of laboratory settings used in human subjects research. Nonetheless it is interesting to speculate whether the effect found would diminish on a larger timescale, as in the case of amputees. I thank an anonymous reviewer for Sykes (2023) for drawing my attention to this point.

2014), perhaps as a consequence of the lived body struggling to get a hold over an object which offers less to one's spatial situation.

We have seen that the position and serviceability of an object 'holds' the agent as a function of subject-object integration. At this juncture, two more of Merleau-Ponty's notions can further explicate tool-perception: *1)* 'Intentional threads' and *2)* 'Optimal grip'. 'Intentional threads' designates the temporary phenomenological connection occurrent between an organism and another entity, emphasizing a bidirectional connectedness unobservable with the naked eye.[69] Regarding *2)*, Merleau-Ponty emphasises that our conjoined sensory, postural and motor capacities always tend towards the functional maximisation of our orientation to our environment (Bruineberg, Kiverstein and Rietveld, 2018), labelling this phenomenon: 'optimal grip'.

In some sense, all perceptual experience attests to this pre-reflective 'optimising' tendency. If I intend to cross a busy road, my perceived spatial surroundings are innately structured to optimise this goal. Instead of receiving a mess of undifferentiated sensory stimuli, the combination of one's bodily abilities, immediate goal-directedness, and higher-order purpose(s) generates a cross-modal stabilisation of perceptual input on pragmatic grounds, globally directed towards successful engagement in the *Umwelt*. This determines how motor-intentionality contends with proximal and distal entities in both peripersonal and extrapersonal space (Gallese, 2018): I see a gap in the flow of cars in the road *as* a place to cross, subordinated to my local goal of crossing the road for the higher-order purpose of reaching the supermarket. Again, all of this pre-reflectively structures my sensorimotor opening onto the *Umwelt* rather than featuring as any reflective content of my thought.

To further develop upon (1), we also saw how perceiving certain affordances brings task-relevant body parts into salience (Cardelecchio et al., 2011). This evokes Merleau-Ponty's (1945/2012, pp.127-212) celebrated insights into the body schema,[70] in that its schematic is conceptually impoverished if it only includes the body parts themselves (see Gallagher, 1986). As seen, for Merleau-Ponty, our body schema develops relationally, through tools and tasks that certain body parts are appropriate for. The body *qua* situated motor-intentional entity is inconceivable if we exclude the objects *of* motor-intentionality from

[69] Even if this bidirectional relation is typically asymmetrical; see Zahavi (2003).
[70] Relevant for our purposes is the fact that the chapter in *PoP* in which Merleau-Ponty examines the body schema in *Phenomenology of Perception* is entitled: 'The Spatiality of One's Own Body and Motoricity'.

our account, which ‘bring to life’ the body parts used to engage them (Sykes, 2021a). Merleau-Ponty provides a rather topical example (for our purposes) regarding how bodily space is shaped by nearby tools:

> The subject placed *in front of* his scissors, his needle, and his familiar tasks has no need to look for his hands or fingers, for they are not objects to be found in objective space, but rather powers that are already mobilized by the perception [of them], they are the centre-point of *intentional threads* (p.136/108); [emphasis added].

‘Intentional threads’ thus complements the notion of ‘hold’ by emphasising the bidirectional link existent between agents and tools. This motor-intentional thread can be broken whenever tools drop out of salience or accessibility. Should I turn away from the keyboard, or should my arms be immobilised by (hopefully) an experimenter, the ‘thread’ linking me to the tool becomes weakened or obliterated (Iachini et al., 2014). These ‘[motor-]intentional threads’ link the situated agent to surrounding objects (and the tasks they present) at every moment. But we should note that one’s motor-intentional directedness is rarely dispersed to all surrounding things equally; attention, valence, salience, proficiency, etc., all co-determine which objects in our *Umwelt* are most prominent, as bodily space always attempts to form an optimal grip over what is most important in its surroundings.

Spatial distance is one prominent factor, determining the potency (‘hold’) of the intentional thread linking agent with tool. Indeed, nearer objects produce more pronounced responses in experimental settings (e.g., quicker RTs, stronger MEPs, stronger *Mu* desynchronisation) because we are phenomenologically more integrated with the intentional-object in question. As Heidegger writes in the section of *Being and Time* (1927/2010) devoted to space, Dasein cannot help but ‘make room’ for things that are near us or seize our attention (see De Preester, 2012). We are not necessarily always conscious of this nearness, nor need we thematise it in reflective cognition for it to perform its role. Instead, nearness fundamentally co-constitutes how our surrounding space, and the entities within it, show up at the fundamental level. With Merleau-Ponty, we further see that this relationship always tends towards an optimal grip over the environment (Rietveld & Brouwers, 2017; Bruineberg, Kiverstein and Rietveld, 2018).

The core takeaway here is that bodily space profoundly co-constitutes sensorimotor cognition so that action and perception are not discrete modules, but jointly imminent in how we understand our surroundings (Chemero, 2009). This dynamic fundamentally co-constitutes how one’s *Umwelt* appears. The phenomenological notions of ‘ready-to-hand’, ‘hold’, ‘optimal grip’ and ‘intentional thread’ enrich the empirical PPS and affordance literature by disclosing the PrCC and MiP in a manner complementary with the behavioural and neurophysiological evidence. Moreover, it brings to focus the centrality of the spatial concept of ‘distance’ in the affordance literature, a factor which was not always sufficiently acknowledged. Thus, while the brain-body certainly perceives objective distance, and can make quantifiable estimates by thematically objectifying it, agent-object proximity also features a more immediate, qualitative profile as described here. This profile highlights how, owing to the presence of useable objects, the brain-body is pragmatically embedded in its surrounding space as a “horizon of action possibilities” (Gallese & Sinigaglia, 2011, p.130) that co-constitute bodily space as it transitions through innumerable spatial situations, making certain aspects of the *Umwelt* drop in and out of salience and determining the dominant meaning of the spatial situation.

But this finding begs the further question: what then if just *one of these* action-possibilities is chosen and acted upon? Acknowledging such a distinction thus takes us away from tool-*perception* onto tool-*use*.

1.3 Tool-transparency

Let us now analyse what happens in bodily space when the agent stops merely perceiving the tool and decides to make use of their ability to interact with it concretely. Important to keep in mind here is that tool-*use* often features a greater decisive element compared with tool-*perception*. As discussed earlier, agents do not decide to view ladders as *for-climbing*: after gaining familiarity with it, a ladder simply manifests to perception as such. This also entails that, during tool-use, the task-at-hand is more definitive for the agent’s spatial situation since the tool’s importance is more pronounced when using it than perceiving it. As spatially embedded beings, we often perceive several affordances within our perceptual field yet, typically, we can only act upon one at a time (Rietveld & Kiverstein, 2014). While, at least in most cases, using a tool implies a greater executive control over the entire process, even agents electing to use a particular tool exercise little-to-no control over the cascade of changes in bodily space that tool-use engenders. The person who actually climbs the ladder undergoes a shift in the way that they are embedded in the *Umwelt* because the ladder causes bodily space to manifest in alignment with the task of climbing. Because tools become so seamlessly integrated into bodily space while in use, we will henceforth refer to tool-use as ‘tool-transparency’, which reflects a phenomenological heritage (De

Preester, 2012).[71] The precise way in which tools are 'transparent' shall be clarified in this section, where we will first briefly examine the neurophysiological underpinnings to this phenomenon before fleshing it out in further detail at the cognitive-experiential level.

A necessary first port-of-call here is a seminal neuroscientific study on the impact of tool-use on PPS conducted by Iriki et al. (1996); the experimental design they used to demonstrate this effect would subsequently become a staple of PPS research (Serino, 2019). Using a then-novel experimental set-up, Iriki and his team discovered that when a monkey purposefully wields an elongated tool, this action engenders temporary alterations in the shape and size of its peripersonal space. The experimental set-up involved a monkey in possession of a rake (of approximately 20cm in length) and a food source located outside of its normal reaching ability. As monkeys are quite clearly motivated to reach the food, after some training on how to use the rake,[72] the monkeys learned how to obtain their desired intentional-object by using the tool to bring it towards them. This deceptively simple sequence of events conceals a cascade of profound phenomenological-semiotic and neurophysiological changes regarding bodily space. In acquiring the food, the stick-as-object became phenomenologically transformed into a tool because it served the higher-order goal with which it was functionally paired. Corresponding to the stick's in-corporation, the brain treated the area of space near the end of the tool as the outer boundary of its peripersonal space, replacing and surpassing the physical body's extremities. This was indexed by the extension of visual receptive fields in the brain.

Neurophysiological measures indicated that the visual receptive fields (vRFs) located around the tip of the fingers shifted outwards from the monkeys' hands to the tool's tip. The monkeys' tool-enabled motor-intentional act of obtaining the food precipitated an expansion of their PPS to (literally) in-corporate the tool into their expanded sense of bodily space. Accordingly, the tool-using primate's PPS boundary stretched outwards,

[71] After writing this section, I encountered a book chapter by De Preester (2012) that cogently deals with ready-to-handness, peripersonal space, tool-use and embodiment from within a Heideggerian framework. For a comparable but alternative perspective on the themes covered in this article, in which she also examines prosthetics and technics, I refer the reader to her work. Jackson (2014) also provides a compatible account that compares phenomenological accounts bodily space with peripersonal space, questioning whether it is bodily space or the lived body itself that expands during tool-use. I refer the reader to her work for a comparable yet distinctive account.

[72] Unlike higher primates, monkeys are rarely observed to wield tools in naturalistic settings. However, long-tailed macaques have been observed to use stones as tools (Koops et al., 2021). This entails that human and monkey tool-use, while non-identical, can occupy a single continuum. On an Uexküllian account, humanity's comparatively greater number of tools and action-possibilities entail that the human *Umwelt* is composed of far more perception-action cycles.

including the tool within its outermost limits. According to this measure, there was no clear demarcation between the stick and the hand; each co-constituted situated bodily space as engaged in a task. Gallese and Sinigaglia (2010, p.2) cogently sum up the experiment as follows:

> Iriki and colleagues showed that the visual receptive fields (vRFs) of monkey's bimodal visuo-tactile parietal neurons were modified by tool actions. Indeed, after few minutes of tool-using the vRFs anchored to the paw extended to encompass the tool, as if the latter were incorporated into the former. *When the monkey stopped using the tool the vRFs returned to their previous extension, even if the animal continued to hold it;* [Emphasis added].

This ultimate sentence is crucial for the enactive account of spatiality developed here. The monkeys' visual receptive fields returned to their original, body-centered location after they stopped using – but still held - the tool. Moreover, the vRF expansion underlying tool-incorporation also failed to emerge in the condition in which the monkeys simply held the tool passively. What do these results tell us? Interaction with the tool and a *third entity* is seemingly a necessary triggering condition for tool-transparency's emergence. Gripping a lengthy object 'in itself' apparently fails to produce the 'wrap around effect' of PPS (Graziano, 2018) that emerges whenever a tool becomes paired with a task. Bodily space seemingly does not expand to include any item that is simply held; it is the act of using it meaningfully and purposeful that binds body and tool together in the enactive interface of PPS.

It is important to note another foundational study by Berti and Frassinetti (2000) found that a neuropsychological patient 'P.P', suffering from hemispatial neglect localised in near-space, had their deficit's boundary temporarily extended beyond near-space following a session of task-paired tool-use. Hemispatial neglect patients suffer from brain lesions in which there is neglect for the side contralateral to the brain lesion's site (i.e., a lesion in the left side obliterates visual input in the right side). Specifically, the task in question involved bisecting a line on a wall in far-space with a long stick which automatically extended the patient's PPS boundary. Because patient P.P's spatial deficit was localised to near-space, after P.P underwent the temporary 'tool-transparency' effect due to physically interacting with something in far-space, what counted as 'near' had profoundly shifted. Subsequently, what was previously 'near-space' for P.P (and anchored around the body's extremities) expanded outwards to the end of the stick in 'far-space'. As the authors claimed in the title: "near became far" - mediated through bodily space in action.

Subsequent to undergoing the tool-transparency effect, the brain-body's immediate sense of bodily space no longer terminates in the zone around the body but rather at the end of the tool, which withdraws from being an intentional-object of perception and reorients motor-intentionality to facilitate the active task-at-hand. As such, the patient's dominant motor-intentional orientation was directed not towards the stick but at the line on the wall. As withdrawn, that stick could certainly not disappear from the spatial situation, as it was an integral element to enacting the task-at-hand. Rather, it was transparently integrated into P.P's bodily space and MiP, so that, for the brain-body in action, 'near-space' became what was near the *tool*, not near the body itself, bridging extrapersonal with peripersonal space by temporarily incorporating the elongated tool. This finding appears supportive of Merleau-Ponty's claim several decades prior that "Places in space are not defined as objective positions in relation to the objective position of our body, but rather they inscribe around us the variable reach of our intentions and gestures" [*PoP;* 179/144]. Furthermore, in one condition a laser-pointer was implemented as the tool under investigation, and it was found that the tool-transparency effect did not appear.

Let's consider the operative motor-intentional profile (MiP) here in further depth. Before either holding or using the stick, if the organism glances at the stick and/or food, either one may be considered an intentional-object of perception. Indeed, when gripping the tool, the stick acts as an object of tactile perception also. But even if the Macaques in Iriki et al. (1996) could feel the stick, its dominant motor-intentional orientation was directed toward the food, not the rake. Just so, P.P could feel the stick in their palm (meaning that it remained an intentional-object of tactile perception) but without interaction with the wall through the stick, motor-intentional orientation was not redirected. By contrast, the tool-wielder engaging in action suddenly finds their motor-intentionality directed at something *other than* the grasped object itself, enabling the task-at-hand to replace the tool as the most prominent referent of motor-intentional orientation. Pre-empting this finding, Heidegger (1927/2010) already asserted that tools become transparent when in use:

> What is peculiar to what is initially at hand is that it withdraws, so to speak, in its character of handiness in order to be really handy. *What everyday dealings are initially busy with is not the tools themselves, but the work* (69/69), [emphasis added].

Accordingly, the task-at-hand temporarily becomes the most essential determiner of spatial embeddedness, whereby, even though the tool remains an ineliminable element of the event, one's situated spatiality is defined by what one does *with* it. If it is at all possible for Heideggerian phenomenology to be bolstered by neuroscientific evidence, then this experimental effect stands as an optimal candidate. For Heidegger, the act of using a tool was a paradigmatic way of demonstrating the mode of being that he designated 'ready-to-hand' (Harman, 2010). It also demonstrates the importance of what phenomenological scholars call the 'background' (Dreyfus, 1999, 2002), a notion also adopted into cognitive semiotics (Legg & Black, 2022, p.2275). Developing upon Husserl's account of intentionality, Heidegger showcased that objects are not always objects *of* intentionality but can also co-constitute intentional acts themselves, which in turn are directed outwards towards some activity. But for this act to function smoothly, the tool must remain an integral component of bodily engagement whilst still retreating from intentional salience into 'background coping' (Dreyfus, 1999). Thus, during purposeful activity, agents *understand* the tool wielded in a manner distinct from viewing or objectifying them because something *other than* the tool itself is made immediately available; namely, "not the tool, but the work".

By using the tool to engage with the work itself, the tool withdraws into transparency and becomes absorbed into a wider motor-intentional operation. Therefore, when engaged in a task, the brain-body incorporates the tool into one's spatially extended bodily self because its immediate sense of space is determined primarily by the action currently undertaken. The aforementioned "variable reach of our intentions and gestures" (179/144) that Merleau-Ponty speaks of thus reveals the logic of situated spatiality. That is, the task's temporary prominence over the PPS network allows, despite the brain's awareness of the continued usage of an external entity (i.e., it still receives somatosensory and tactile feedback from grasping it) the tool to slip into the background of motor-intentional orientation in the *Umwelt*. As a new addition to this situated 'background', the tool becomes temporarily constitutive *of* one's motor-intentionality instead of acting *as* motor-intentionality's explicit object or referent. If a tool increases the amount of the *Umwelt* available for direct bodily interaction, then the brain-body can 'skip over' the objective boundary between the flesh and the tool to render all the space available to interaction as its own.

Therefore, 'my space' is not equal to the space objectively occupied by my material body *(Korper)* but the space of my actual and potential bodily interaction. Once more, Merleau-Ponty (1945/2012) took up and reapplied this Heideggerian motif with enhanced focus on the phenomenon's 'ontic' and bodily instantiation. Using the classically academic example of a (typing) keyboard to cast light on the interplay between body, space and tool-use, Merleau-Ponty argues that: "The subject who learns to type literally incorporates the space of the keyboard into his bodily space" (180/146). That is, tool-use carries the tool into bodily space because the task-at-hand it facilitates fundamentally remoulds the way in which the agent is spatially embedded in her environment. Thusly, the 'lived body' and 'bodily space' overlap (Sykes 2021b) so that the PPS network extends toward, and wraps around (Graziano, 2018), the tool-in-use, incorporating it into the extended bodily self. Consequently, whenever we 'understand' tools by correctly using them, our bodily space is altered in direct attunement with whichever activities that specific tool facilitates. The task-at-hand thys dictates the form of bodily space.

To take a mundane yet rather ecologically valid example, consider the household chore of hoovering. Imagine that you are wielding a hoover with a long nozzle to clean your floor. With the hoover, areas of the floor that were previously unavailable to your body are suddenly opened up for interaction; through the hoover, an unreachable 'there' becomes a reachable 'here'. Your Merleau-Pontian 'field of gesture' has expanded, and the task has fundamentally altered your spatial relationship with your surroundings. The lived body now automatically experiences a larger area of space as interactable. We can easily visualise the 'bubble' of peripersonal space surrounding the body expanding to include the furthest point of the hoover instead of the body's extremities, as indexed by expanded vRFs. The 'bubble' or 'enactive interface' monitored and modulated via PPS now encircles the body, the tool and the amount of space accessible by the fusion of all three into a singular, situated *Gestalt*. And, again, if we articulate this relationship hierarchically, it is the task-at-hand that sits atop the throne, bringing all the other elements into structured alignment for a limited time-period before they separate once again after the situation dissolves.

Recalling Merleau-Ponty's own example of a typing keyboard, let's consider tool-transparency (i.e., tool-use) in light of the previous discussion of spatial affordances (i.e., tool-perception). If you walk through the aisles of a computer store, you may come very close to a keyboard. Perhaps, if you notice it, it will trigger the affordance of *for-writing*. Should you move away from it, its hold over your situated brain-body (your hands and fingers in particular) gradually weakens as distance increases. However, an alternative agent-object spatial dynamic arises should you decide to *actually use* that keyboard. As Merleau-Ponty claims, "when I take my place before my machine, a motor space stretches out beneath my hands where I will play out what I have read"; (PoP, 179/145). While using it to type, the keyboard becomes incorporated into bodily space so that one's situated spatial embeddedness is determined by the task of typing.

For this to occur, the tool must withdraw as an intentional-object so that the act of typing (not the keyboard) instead determines bodily space's immanent structure and MiP. The dominant motor-intentional reference point is redirected *away from* the tool itself and *toward* the task-at-hand that the keyboard permits. Accordingly, the computer keyboard is rendered transparent so that bodily space can reconfigure itself to incorporate it into itself. We might also think of Peirce's proto-enactivist example of how the pen and inkstand are equally as constitutive of the act of writing and the written content as one's brain (Paolucci, 2021, p.78).

Thus, when the brain-body registers that peripersonal space has expanded in size, along with this expansion comes the immediate recognition that a slightly larger part of the *Umwelt* is automatically presented as interact-able. While we claimed that tool-use is more voluntaristic than tool-perception, this change is, of course, neurophysiologically automatic and experientially pre-reflective; the agent cannot 'turn off' this neurophenomenological profile at will. We should, therefore, avoid imagining an agent whose relationship to space only changes when they move through its sites objectively, like a point transitioning across a grid of co-ordinates. Even whilst occupying the same objective place, the size and shape of one's bodily space rarely remains fixed, because the context-sensitive plasticity of PPS ensures that it is constantly altered as one interacts with all the various entities present there (kettles, knives, brooms, remote controls, etc.). This means that even a prisoner, occupying the same room or rooms every day as their *Umwelt*, may still experience minor alterations in their bodily spatial structure when engaging certain everyday tasks, particularly if using tools.[73]

Another notable study of relevance here is that of Coventry et al. (2008), who investigated participants' usage of spatial demonstratives before and after PPS manipulation. Explicitly building on Berti and Frassinetti (2000), Coventry and colleagues examined the use of the demonstratives 'this' and 'that' (or Spanish-language equivalents) regarding objects both inside and outside of PPS before and after tool-use. Typically, as objects approach the boundary of PPS, usage of 'this' tends to be replaced by 'that'. However, following the tool-use condition, both English-speaking and Spanish-speaking populations were more likely to use 'this' for objects previously outside of PPS. This strongly suggested that participants'

[73] Indeed, many of the experiments using both macaques and humans had them strapped into a chair. Of course, this is not to de-emphasise the distinction between stationary and motional PPS, which is important for an enactive model. Of note here is Noel et al.'s (2015) study on walking and PPS, which observed that PPS can expand to approximately 165cm. To my knowledge, this is the largest recorded expansion of PPS in the literature.

sense of bodily presence in space had expanded due to tool-transparency, again rendering 'far' objects as 'near'.

Not only do these findings tell us something important about body-object interactions, they are also deeply informative as to how the brain-body pre-reflectively perceives surrounding space. When simply gripping a tool ('passive holding condition'), the way in which organisms are spatially embedded in the *Umwelt* does *not* meaningfully alter. Rather, merely using it reconfigures the extent of one's bodily spatial presence. Accordingly, if the brain-body engages space as a place replete with action-possibilities (Gallese & Sinigaglia, 2010), dynamically updating its mode of embeddedness to complement the agent's worldly dealings and activities, then no homogenous model of geometric space can cohere with space as a qualitative place for activity. In heterogenous, qualitative space, certain areas of surrounding space are of greater importance, meaning and significance. Peripersonal space *qua* bodily space is therefore not the objective position occupied by the material body but is rather constituted by a situational *Gestalt* that encompasses one's body, the tool, and the zone of bodily interactability, incorporating each element in accordance with the task-at-hand. Whereas one's situated motor-intentionality terminates at the tool during tool-perception, tool-*use* automatically redirects motor-intentional orientation toward whatever task the tool enables. Simply staring at or even holding tools may not necessarily trigger the tool-transparency effect (Iriki et al. 1996), because only interaction itself brings into play the motor-intentional realignment necessary to spatially fuse the elements of body, tool and task.[74]

As such, there is good theoretical and experimental evidence to suppose that, for the embodied agent spatially embedded in the *Umwelt*, the task-at-hand (and not just the objective measurements of the body) is the most powerful determiner of the enactive interface's size and shape. While spatially uniting self and *Umwelt*, the enactive interface's form is structured by the kinds of tools that one uses alongside the types of tasks that one uses them for. Accordingly, there exists a complex temporal and modal structure to bodily space highlighted by tool-*perception* vs. tool-*use*: if the brain-body does not respect the objective body's objectively delineated material boundaries regarding how it registers its 'own' space - instead claiming the chunk of the *Umwelt* it *could* interact with - then what counts as 'mine' is defined by potential accessibility and inter-actability. Hence, we can

[74] As shall soon be discussed, tool-transparency can be longitudinally instantiated into bodily space by habitual tool-users (Serino et al., 2007; Bassolino et al., 2010). That is, PPS also expands in the *preparation* of future interactions even without any actual tool-use taking place.

now provide further detail to Gallese & Sinigaglia's (2010, p.130) claim that "bodily space is basically and constitutively given to us as the horizon of our own action possibilities". Tool-using spatiality thus constantly shifts between potentiality (perception) to actuality (usage), from the possible to the real. Indeed, when tool-transparency is triggered, what is 'there' and 'inaccessible' can quickly become 'here' and 'accessible'.

On a final note, the hierarchically structured phenomenon in cascading levels of transparency that structures *Umwelt*-embeddedness, governed by motor-intentional orientation toward activities in the world, may be even more deeply rooted than tool-use. Not only are, for instance, one's eyeglasses rendered transparent when directed at a painting as Heidegger (*BT,* p.108/112) tells us, but even the retinal blood vessels in our eyes themselves seemingly withdraw during our normal way of looking upon the world (Eagleman, 2020). We rarely see our retinal blood vessels because our brain has permanently skipped over them and spends no energy in making them salient, except during surprising, sensory 'breakdown' events, "as when a light shines in from a strange angle, [only then] does your brain spend energy on representing the data" (Eagleman, 2020, p.167). Thus, our everyday modality of being in space is to be constantly absorbed in innumerable meaningful and perspectival activities so that a great number of potential intentional-objects are subordinated in reference to the most dominant and fluid way of spatial being-in-the-world (see Ciaunca et al., 2021).

In sum, the pre-reflectivity of contextually-framed tool-interaction in bodily space (perception *and* use) is an important aspect of what we are here defining as spatial embeddedness, which is the dominant type of relationship uniting the agent with the *Umwelt*. Emphasising the transparency of tools is pertinent for an enactive interpretation of tool-use and exemplifies how a descriptive 'motor-intentional profile' and 'pre-reflective cognitive correlate' can be imported from phenomenology into cognitive neuroscience. As entities that modulate the ways in which one is pre-reflectively embedded in an *Umwelt*, tools are things *through which* bodily space assumes its form(s), so that our sense of bodily space is always scaffolded by tools, whether in the modality of perception ('hold') or of concrete usage ('transparency') in all the locations we find ourselves dwelling in. In essence, usable objects structure PPS by allowing agents to pre-reflectively interface with the *Umwelten* in which they are embedded by providing opportunities for meaningful action. As proficiently tool-using beings, we need not always take account of them explicitly and consciously recalibrate our movements. We can feel the 'hold' of a nearby tool when we are drawn to perform the task it presents to us just as when we use it, surrounding space automatically reconfigures itself as disclosed by the tool. These cross-disciplinary insights support the fundamentally enactive notion that tool-perception is profoundly and pre-reflectively modulated by our capacity for embodied interaction.

Despite their importance, however, such a functional utilisation of tools does not exhaust the totality of ways in which the meaningful objects structure our embodied, spatial embeddedness in the *Umwelt*. In the next section, therefore, we shall progress onto the important role that affectivity plays in object interactions and therefore in bodily space.

2. Affectivity

Bodily space is also affectively embedded in its *Umwelt*. Indeed, if pre-reflective spatiality is fundamentally structured by meaning, then our present account must further take affectivity's role into careful consideration, since affectivity is deeply implicated in the transmission of meaning, straddling the traditional border between the cognitive and bodily sense-making (Colombetti, 2018; Campeggiani, 2023). In parallel with tool-use, affectivity stands out as a major theme in the experimental PPS literature. Accordingly, affectivity must be coherently synthesised with an account of practical tool-interaction that further showcases how agents engage an environment replete with objects and tools in a manner structuring their fundamental relation to the *Umwelt*.

In an early formulation of this position, William James (1884/1983, p.191), pre-empting von Uexküll, claimed that emotions have a pragmatic function in that they align the organism, at the level of physiology, toward important, "specific features of the environment in which they are to live" in a dynamic fashion (see also Johnson, 2016). In essence, James argued that physiological changes accompanying the perception of an emotion-arousing thing is tantamount to emotion itself and so emotion's power over the body was evidence for James' naturalistic proto-theory of embodied cognition, since through the bodily consequences of emotion we are forced to consider "how much of our mental life is knit up with our corporeal frame" (p.201).

More recently, several prominent frameworks in cognitive neuroscience have emphasized affectivity's central role in cognition, and this increased centrality has been labelled the 'affective turn' in neuroscience (Panksepp, 2012). Indeed, also citing James' earlier account, Damasio's (1994) own famous (albeit less philosophically radical brand) of anti-Cartesianism persuasively brings into question the expulsion of emotion from scientific models of cognition. For figures like James, Peirce, Damasio, Panksepp and others, affectivity is an irreducible component of what we consider normal cognitive functioning.

From an enactive standpoint, affectivity also pertains to our most basic way of sense-making in spatial environments. As Colombetti (2018, p.575) succinctly puts it: "the constitution of an *Umwelt* is an inherently affective phenomenon". Such evaluations are not based upon any facile or quaint romanticism, nor should affectivity be viewed in opposition to practical functionality. Rather, affectivity can be viewed as disclosing the *relevance* and *importance* of things encountered within our surroundings, which served a vital function for our ancestor's survival and continues to do so for modern, everyday living too. Each of these two factors – 'relevance' and 'importance' - belong firmly to the territory of 'meaning'. As an *Umwelt*-embedded entity, the brain-body must be able to immediately recognize which things dispersed among its surroundings should be prioritised, engaged, ignored or avoided via the emotional tone they impart. A brain devoid of any capacity for emotional experience would belong to the study of neuropsychopathology and such a pathology would indeed extend to practical interaction with objects (Ratcliffe, 2005).

For these reasons, affectivity's importance was (to varying degrees) highlighted by several of the canonical figures of semiotics and phenomenology as an irreducible component of being-in-the-world and/or semiosis (Zlatev, 2018). For Heidegger, emotions co-constitute part of the ever-present background of meaning that modulate the way that we circumspectly engage the world in a pre-theoretical manner. Of the 'canonical' phenomenologists, Merleau-Ponty (1945/2012) provides us with perhaps the mostly explicitly embodied-enactive interpretation of affectivity. In his criticism of empiricism, Merleau-Ponty critiques overreliance on what today is termed 'psycho-physics':

> Perception, impoverished in this way, becomes a pure knowledge operation, a progressive recording of qualities and of their most customary development, and the perceiving subject stands before the world in the same way the scientist stands before his experiments (*PoP*; pp.48/25-26).

Merleau-Ponty subsequently adds that, by contrast, "action, feeling and desire [can] be explored as original ways of intending the object". That is, an intentional-object is not just present in the modality of rational thought (though it certainly can be) but actively intended in a modality dominated by a particular emotion or affective state which can reveal specific qualities. As such, we encounter the *desired* thing, the *hated* thing, the *coveted* thing directly in the fabric of the spatial world. Such an insight was indeed latent in Husserl's (1913/1989) pioneering phenomenological texts *Ideen II*, alongside the original distinction between lived and objective body. Thus, for the embodied agent embedded in the *Umwelt*, affective intentionality (Slaby, 2008) and motor-intentionality are often jointly present in the same intentional gesture, and in many cases equally co-constitutive of it.

Thus, throughout the relevant philosophical literature, we routinely encounter the idea that successful engagement with one's world is facilitated by the emotions. Certainly, then, affectivity must structure pre-reflective cognition. Affectivity assists situated cognition insofar as it both enables the agent to practically get to grips with their current situation and alerts them if something has gone astray in it, allowing them to reorient themselves; this even applies to the 'hard case' of logic, where we encounter another cross-disciplinary convergence. Ratcliffe (2002) published one of the earliest cross-disciplinary accounts integrating a Heideggerian account of attunement with a neuropsychological conception of emotion, eventually arguing that Heidegger finds a role for emotion in a location as seemingly remote as propositional logic. In semiotics, Colapietro (2021, p.12) likewise explains: "Cognition is inextricably bound up with both emotion and conation... Questions regarding cognition are, from a Peircean perspective, tied to questions regarding conduct (the rational comportment of fallible agent)".

Accordingly, both logical reasoning and engaged comportment find practical use for emotion, effectively bypassing a strict higher/lower cognition binary (Rietveld & Brouwers, 2016; Rietveld, Denys & van Western, 2018). One case example is that of 'surprise' which for West (2021, p.13) counts as action-oriented because "surprise entails resultative effects within contexts". Indeed, West (2021, p.13) elaborates that "Surprise is an affirmative agent of change in the beliefs and behaviors of many organisms" and engenders them to adaptively change a course of action. As West shows, surprise thus has a "modal function", modifying the constitutive elements at play within a situation, reorienting us to a new, unfolding aspect of it as disclosed by the surprise. In this way, emotion (surprise) for Peirce even serves logic *proper*, in that it motivates us to question our previous principles which led to the surprise after said principles were violated. The emotion of surprise, while itself not a product of reason, can therefore sometimes reveal important information about the *Umwelt*, facilitating both pre-reflective engagement and reflective reasoning.

Furthermore, the insight that sudden dysfunction in a structure can be informative to said structure displays clear similarities with Heidegger's aforementioned notion of breakdown. Recall that, in breakdown, the constituent parts of one's relationship to the world become suddenly laid bare. If I turn the doorknob while trying to enter my house and find that it does not budge, this discrepancy must enter into reflective consciousness, reconfiguring the relation between bodily space, objects and surrounding space itself. Subsequently, I may then try to abduct the reason why: perhaps it is broken, somebody superglued it shut, etc, which influences my subsequent actions in the *Umwelt*. A more contemporary (albeit slightly different) articulation of this core idea is found in 'prediction error minimisation' (Friston, 2009).

Thus, emotion is always ready to help disclose something in the world or to suddenly grip the steering wheel and ground one within space according to a newly disclosed logic. Affectivity thus co-constitutes the way that *Umwelt* is revealed to the agent at the pre-reflective, sensorimotor level. It is only in cases of surprise (Peirce) or breakdown (Heidegger) that we may have to re-evaluate our instinctual and/or pre-reflective responses to our environment, forging new ways to adapt ourselves via our reflective capacities. However, as Heidegger would point out, an increased conscious awareness of these breakdown occurrences does not serve as evidence for their prominence regarding our modal relationship to the world. Most of the time, our engagement in the world is pre-reflective and non-thematic, even if philosophers frequently err in mistaking the salience of breakdown phenomena as indicators for their ontological priority (Dreyfus, 1999). While reason has a prized position in re-formulating our orientation towards things whenever necessary, it is not always in the pilot's seat and is typically initiated and guided by affective states.

In brief, it has been underlined by the pioneering thinkers foundational to this project, as well as contemporary scholars across several disciplines, that the way in which our surrounding world manifests to us hinges upon its affective coloration. Moreover, our ability to interact effectively with objects within it is almost always assisted by the affective qualities of things encountered therein, appealing directly to pre-reflective cognition and facilitating the practical bodily engagement discussed in the previous subsection. Depraz (1994), nicely summarises the pre-reflectivity of affectivity thusly: "affect is there before being there for me in full consciousness: I am affected before knowing that I am affected".[75] Below, we shall enrich our understanding of how affectivity facilitates and shapes these interactions by again recruiting the experimental literature on PPS. We will, therefore, afford centrality to this cross-disciplinary idea that emotion, rationality and action are profoundly entwined, and that, under optimal circumstances, emotion bolsters

[75] Cited in Fuchs (2018, p.70).

productive sense-making, object-interaction and accurate decision-making instead of hindering it (Slaby, 2008; Violi, 2008; Colombetti, 2018; Campeggiani, 2023).

2.1 Object Valence and Affective Intentionality

Narrowing this broader theme of affectivity to serve our specific purposes here, we may state that affectivity modulates the presentation of specific intentional-objects that agents encounter within the surrounding world. In a more global sense, somewhat akin to tool-transparency, it appears that affectivity co-determines the way that one is embedded within the *Umwelt*. But first we will turn our attention to 'object valence' and the corresponding notion of 'affective intentionality' (Slaby, 2008). Affective intentionality features a pragmatic function insofar as it instantly changes the agent's bodily-spatial attunement to surrounding objects by attuning them to situation-linked meanings that otherwise lay dormant. A door may show up *as* an exit when a fire in the building produces fear or the fly may show up *as* something to swat if it produces annoyance. In each case, the emotion triggers one's adaptive behaviour towards the entity in question. Likewise, if I find myself spatially embedded in a manner characterised by anger, seeing an otherwise pleasant item may suddenly strike me as irritating. Conversely, however, sensorily intending some pleasant item *qua* pleasant may reduce the way in which I am embedded in the mode of irritation, reorienting my affective attunement to my surroundings and the objects therein.

These considerations bring us to the first example we shall use to underscore how object interaction and affectivity are jointly implicated in the PPS network. The first item of evidence to consider is so-called 'object valence'. 'Valence' denotes the emotional value of a stimulus in an experimental context (Tye, 2018). An object that produces a detectable emotional response in the brain is said to possess valence. While some objects may be exceptionally charged with significance (e.g., family heirlooms, life-saving equipment, *momenti mori*), almost all objects feature at least some kind of affective quality, however minor, which emphasises their utility or provides pertinent information as to how (or if) to interact with it. As discussed throughout **Chapter 1**, context plays a major role here. Consider the 'place' of the dinner table: it is not the case that all the items present there feature some undifferentiated, homogenous affective tint. The bottle of wine, for example, may be more attractive than the coaster… at least until I need somewhere to put my cup, at which point it automatically becomes salient whereby its positive valence increases. In turn, the desire to put the cup on the coaster might be to avoid a negatively-valenced sensation of shame or guilt should I ruin my host's table.

Affective intentionality can thus elicit genuine meaning from surrounding objects, jointly sculpting both experience (PrCC) and action (MiP). At the same time, however, as Colapietro (2017) recounts, affectivity also gives rise to, or co-constitutes, a pronounced individuality: the object of my desire is, of course, desired by *me,* perhaps only in a specific situation. Other people might feel differently about the same object. Or at least, this *can be* the case. While we may all be acculturated into viewing diamonds as highly valuable, there is undeniably some interpersonal variance in people's emotional appraisals of objects. Returning to our prior example, perhaps some of the other dinner guests are uninterested or even disgusted by the presence of mayonnaise on their plates while others find it appealing. This ensures that there are intentional relationships at play within a singular shared space which are qualitatively distinct, despite all participants partaking in the light, co-operative mood of a dinner party.

Recalling von Uexküll's rich illustrations of how a singular item produces a multitude of diverse functions depending on the lifeworld of she who perceives it (**1b.1.3**), we can now highlight an affective dimension to this biosemiotic story. For example, consider that a single cigarette placed in an ashtray might differentially produce relief in the smoker, disgust in the non-smoker and longing in the ex-smoker. Furthermore, the ex-smoker who feels the pangs of addiction might overcome them through pride, will-power or the anticipation of shame should they yield to their cravings. Conversely, the ex-smoker who is less receptive to that emotional pull of pride might not have it inhibit their behaviour as they reach towards the object of their addiction and light up. These different types of valence thus present the object in a variety of Uexküllian 'tones', eventually producing different motor-intentional orientations and concrete behaviours (e.g., picking it up or not) depending on how the agent wishes to engage the intentional-object as disclosed affectively.

Yet, while innately structuring one's motor-intentionality and co-constituting a global mode of embeddedness (e.g., the context of social dining) and specific motor-attunements to objects within that environment, valence may never arrive at reflective saliency. Indeed, affect's 'background-ness' attests to the extent to which we can successfully comport ourselves in the *Umwelt* without, or in parallel to, reflective cognition. As already noted, not only should we avoid the trap of thinking that an object's functionality and valence stand in conflict with each another, valence is often inseparably connected with functionality. Consider the relief we might feel at perceiving the comforting red bar of an emergency exit during a fire or instant disgust at a dead animal strewn across the pavement as we swerve around it.[76] These affect-producing qualities of the intentional-object immediately bring forth appropriate behaviors that would be considered 'rational', serving to guide our (re)actions in space, often at a quicker rate than conscious deliberation can manage. The concepts of 'valence' and 'affordance' thus appear to be happy bedfellows: valence modulates an object's affording-features, informing one if, and how, one should take it up or not, which largely depends on the socio-cultural background in which it is encountered (Froese & Di Paolo, 2011).

It would, therefore, perhaps be no exaggeration to claim that all agent-object interactions are affect-laden to some extent, varying only in type and intensity. Equally reasonable is the assumption that objects with little affective 'pull' over us are less conspicuous within surrounding space compared to those that elicit strong emotional impacts. Let's recall that, unlike objective space, lived space is distinct in that it is not laid out equally and uniformly in all directions like a grid;[77] rather, it is populated by zones of meaning and Merleau-Pontian anchorage points (see **1a.2.1**), some of which exhibit greater significance or power compared with others, achieving greater presence or orienting us in our surroundings more pronouncedly. A pool of acid on the floor occupies a greater salience (taking up more 'cognitive-phenomenal space') than a collection of dust, even if both are equally large, as one's entire body will be carefully poised to avoid the acid. In a manner analogous with 'hold', the affective meaning of the acid pool earns a greater presence within our spatial situation compared with the neutral item, sculpting motor-intentionality in alignment with its significance which, phenomenologically, 'de-distances' it to render it phenomenally nearer (De Preester, 2012).

Thus, since phenomenal nearness is non-identical with physical proximity (**1a.1.3**), valence can co-determine an object's apparent proximity. One of the first empirical studies pertinent to this discussion measured the relationship between valence and perceived reachability (Valdés-Conroy et al., 2012). It is important to underscore that the experimental task was a reaching task that simulated purposefully engaging an item, in

[76] As West (2021) recounts, Peirce himself makes a highly similar point using the example of an earthquake.
[77] This is the even the case with the neural mapping of PPS itself, i.e., it is rarely uniformly distributed around the whole body but oriented towards particular body-parts such as the trunk, hand or face (Noel, Bertino & Serino, 2021).

which it was found that objects with positive valence were judged as closer and easier to reach. Specifically, participants were faced with a Negative Item (e.g., a used condom or dead fly), Neutral Item (e.g., a button or paperclip) or Positive Item (e.g., a tasty burger or diamond ring). When asked to judge how distant each object was, participants reliably judged the positive items as both phenomenally nearer and easier to reach, independent of objective location.

The authors (p.7) proposed that "the overestimations [of nearness] produced by positive objects reflect the influence of emotional and motivational states in the representation of object-directed actions in the near/far spatial system". Positively-valenced objects in near-space (i.e., those that engender a kind of pre-reflective compulsion towards further exploration) are literally experienced as closer than items which strike the agent as harmful or noxious. Positively-valenced items thus solicit bodily engagement in stronger terms, entailing that situated agents are pre-reflectively integrated with such items to a greater degree than neutral or negative items, literally reconfiguring the presence and visual appearance of said items within surrounding space.

Interestingly, however, this effect appears reversed for tasks utilising *negatively-valenced* items, in which they also were experienced as closer, not further. Because fear is comparatively simple to replicate in experimental settings, it has been well utilised by experimenters investigating negatively-valenced emotion and PPS.[78] Vangoni, Lourenco and Longo (2012) found that visual presentations of threatening animals were judged by subjects to collide sooner than non-threatening animals. An object's valence (e.g., 'dangerous') therefore elicits an appropriate emotion (fear) which pre-reflectively renders the fear-producing entity as apparently closer to the body. When accounting for individual phobia of the animals (e.g., snakes), this effect increased even further in phonic participants.

The main takeaway here is that perceptually intending intentional-objects in an enactive capacity ('how should I engage this thing?') is fundamentally co-constituted by affective aspects which penetrate affordance perception and thus the corresponding MiP and PrCC.[79] How this occurs is highly situational. In Valdés-Conroy et al. (2012), the presented

[78] However, in what follows, we will also discuss what may be classified as fear's polar opposite to test the parameters of affectivity in peripersonal space.
[79] As Vangoni et al. note, the affective dimensions to affordance perception, in contrast to a merely optical interpretation of visual stimuli, was noted as far back as 1962 by Gibson himself alongside his co-authors (Schiff, Caviness and Gibson, 1962).

objects' visual properties conveyed pertinent information regarding their emotional impact (valence). This helped the agent prepare for appropriate reaction or interaction, thus altering their character as intentional-objects so that positive items seemed closer and negative items further. By contrast, Vangoni, Lourenco & Longo (2012) found that subjects experience more threatening items as closer, reflecting their heightened negatively-valenced impact upon the perceiver's spatial situation.

Affordances and valence thus co-constitute the meaning of objects encountered within the *Umwelt* whereby motor-intentional orientations and attunements towards objects are scaffolded by their affective imprint upon the intending agent. However, because PPS serves as a flexible, enactive, self-world interface that is wholly embedded within such spaces of meaning, discussions of its adaptive functionality must not be limited to visual input alone. Indeed, since PPS is inherently multimodal (e.g., Rizzolatti et al., 1997; Cooke & Graziano, 2004; Serino, 2019), and objects frequently emit sounds which provide equal or even more valuable information regarding their relevance to the situated agent in parallel with, or instead of, visually-conveyed information, we must now turn to the auditory system's role in affective bodily space, where several investigators have approached this question empirically.

How, then, do the spatial and affective properties of sounds modulate affective intentionality? As with visually-intended entities, it was first demonstrated that, if an unpleasant sound is presented as approaching the agent as compared with receding away, negative emotions (measured by EDR, EMG and self-report) are experienced more intensely (Tajadura-Jiménez et al., 2010),[80] an effect that was not replicated for positive or neutral sounds. Thereafter, a study by Taffou and Viaud-Delmon (2014) further investigated this relationship by measuring the PPS of cynophobic participants who were faced with the intentional-object of their phobia (dogs) as compared with non-phobics. The researchers exposed participants to noises of a sheep bleating or a dog growling and discovered that when participants were faced with the fear-producing stimulus, their PPS expanded further outwards compared with the control group. Moreover, the boundary for self-reported feelings of discomfort was likewise located further outward for phobics as compared to non-phobic participants. This finding dovetails with prior evidence that

[80] A follow-up study (Tajadura-Jiménez et al., 2011) found that that listening to positively-valenced music shrank PPS in relation to interpersonal distance, rendering subjects more comfortable with physical proximity to others. The implications of this finding will be discussed in **Chapter 3**.

phobic subjects overestimate the feared entity's collision with their bodies compared with non-phobic subjects (Vagnoni et al., 2012), indicating PPS expansion.[81]

Underscoring this further is a study by Ferri et al. (2015),[82] who presented subjects with neutral, positive and negative looming sounds before measuring subjects' PPS. They found that negatively-valenced sounds elicited an expansion of PPS, supporting prior studies (Vangoni et al., 2012; Canzoneri et al., 2012; Sambo & Iannetti, 2013). By contrast, positively-valenced looming sounds reduced PPS in size. The valence of an auditory intentional-object thus produces pronounced effects upon bodily space. Why is this the case? In their ecological setting, valenced sounds *mean something* to the agent who hears them, serving to spatially reorient the agent's relation to the *Umwelt*. This makes sense for an 'enactive interface' interpretation of PPS, since we can speculate that, as with 'hold' phenomena, meaningful sounds produce associated muscle activity tied to situational requirements. Hearing a rapidly approaching car or growling dog imparts a sense of urgency, calling forth very particular reactions. For instance, if one hears an approaching car, one's legs become poised to get out of its path. PPS expands so that the car 'enters' expanded bodily space 'earlier' and thus contextually-appropriate action-possibilities enter the horizon earlier too. Positive sounds reduce PPS because the brain-body needs less 'reactive space' to exist between itself and the positive item (Vangoni et al., 2012; De Vignemont et al., 2021).

Supporting the idea that PPS is linked with context-appropriate action preparation, Bahadori & Cesari (2021) aimed to extend findings from Park et al. (2019), who discovered that emotional and familiar music influences gait parameters. Bahadori & Cesari aimed to discover whether this effect extended to action preparation also. By manipulating the emotional content (valence) of various sounds, the authors found that the valence of the sensory stimulus (that is: intentional-object) modulates movement preparation with regards to stepping actions. Thus, as with tools (Cardellecchio et al. 2011), the phenomenological *and* physio-anatomical preparation of the body (i.e., both lived and objective body) appear automatically sculpted by valenced sounds in an anticipatory way.

[81] Lourenco et al. (2011) found that claustrophobic subjects have an enlarged PPS. Perhaps importantly, their measure was a line bisection task, which pertains to the functional, sensorimotor-action dimensions of PPS.
[82] Of further note is that Ferri et al. (2015, p.469) explicitly viewed their study as providing evidence for a qualitative, as opposed to a quantitative, model of PPS: "According to the metric hypothesis, all the objects located within a given physical distance (e.g., 50–60 cm) from the body will fall into the PPS. Conversely, if the functional understanding of the PPS holds, PPS boundaries will dynamically change according to contingent factors".

Affective coloration is thus inherent, and possibly simultaneously processed, to the psychophysical properties of auditory stimuli.

Seemingly, then, bodily space's defensive dimensions prioritise negative, looming sounds as these are the most likely to spell danger or death to the agent. However, this difference in intensity was not replicated for neutral or positive sounds. A looming sound thus has more *meaning* for one's situation; it *bodes* forthcoming danger of increasing presence within one's spatial situation. Once more, this 'meaning' is an inherent quality of the auditory stimulus *qua* world-embedded phenomenon encountered that, as such, produces automatic and adaptive sensorimotor responses in PPS.

One sees here a convergence in both the experimental and theoretical recognition that emotional qualities pertain directly to, and do not contradict, a pragmatist reading of bodily space. As discussed, both positive and negative valence of intentional-objects strongly informs a multisensorimotor perception of space; namely, both measurably alter PPS extent and the perceived spatial location or speed of objects.[83] But upon closer inspection lies an important qualitative difference between them. As several studies have found, PPS expands during fear, so that the distance between the extended lived body and fearful object is reduced. This may seem paradoxical when considering that positively-valenced items also appear closer (Valdés-Conroy et al., 2012). But if we view the second skin as a primary defence that prevents noxious stimuli from making contact with the 'real' body (as many experimenters suggest, e.g., Graziano, 2018), we understand the logic to enlarging bodily space so that the 'scope of possible action' (Gallese & Sinigaglia, 2011) that PPS indexes can allow for avoidant countermeasures at an earlier stage, which is the function proposed by several PPS researchers (Vangoni et al., 2012; Taffou & Viaud-Delmon, 2014; Graziano, 2018).[84] Thus, a feared entity both appears nearer whilst drastically reconfiguring PPS in such a way that *Korper* and bodily space are temporarily disaggregated, with the latter (as enactive interface) performing a defensive function for the former.

[83] I refer the reader back to Merleau-Ponty's aforementioned analysis of Movement (**1b.2.4**), in which he explicitly states that the speed and appearance of a moving entity is registered in relation to the embodied agent's situation and self-concern.

[84] Graziano (p.100) writes that PPS is not *solely* for defence but that it is predominately defined by its defensive function. This diverges from the situated interpretation pursued here, which is closer to the approach of the so-called 'Parma School' (e.g., Rizzolatti et al., 1997; Gallese & Sinigaglia, 2010; Gallese, 2018).

As discussed, one of the many reasons that PPS is not best characterized as a uniform bubble is that it is heterogeneously levelled towards particular body-parts (Gentilucci et al., 1988; Serino, 2019; Noel, Bertino & Serino, 2021). The asymmetrical nature of PPS distribution is particularly prominent during tasks that necessitate particular body parts to enact particular goals or reactions, whereby a temporary alignment between task and body-part emerges at the practical convergence point between affectivity and motor-intentionality, as was foreseen by Merleau-Ponty. Intriguingly, it further appears that affective intentionality (at least that characterized by fear) can also emphasise a task-relevant body-part such as the hand when contextually activated. Namely, Zanini et al. (2021) uncovered a situated spatial alignment centred on the hands, scaffolded by a pragmatic alignment between motor-intentionality and affectivity.

First, the experimenters initiated a Pavlovian response between a visual stimulus (light circle) and electric shock. When the stimulus was subsequently redisplayed, skin conductance increased in fearful anticipation of the forthcoming jolt. Importantly, this affective-spatial effect was strongly localised to the hand, where skin conductance displayed the strongest response. Even if the hand moved to a novel position, the associative effect remained; i.e., the "acquired fear responses 'follow' the hand to a new position" (p.869). This effect highlights the nuanced, learned and temporally-contingent interconnectivity between specific parts of the body and the specific zones of the *Umwelt* that they are motor-intentionally aligned with; while typically lying dormant, these semiotic associations emerge into full bloom whenever the situation requires it before receding once more into the background (see Carman, 1999).

This sedimentation of learned associations between otherwise unconnected stimuli pertains to the anticipatory habitual nature of bodily space, which will be treated in the next section. But it also evidently pertains to a Peircean account of mind in which associations are semiotically integrated on the basis of habit and thus instinctually guide subsequent action (Colapietro, 2021). Indeed, an otherwise neutral stimulus (the light circle) became affectively associated with and electric shock. This association was not statically linked to any area of space, but instead to whichever area of space the hand occupied. Thus, the linking together, via semiosis, of otherwise discrete phenomena, body-parts and affective states in a spatial situation showcases the intricate relationality of lived space and the role of habit and affect in sensible (re)action.

How agents perceptually intend objects in the *Umwelt* is therefore deeply structured by their affective 'properties', which in turn follow a pragmatic and semiotic logic, modulating bodily space in attunement with their situational significance. For example, desired items manifest as within reach whereas dangerous animals are rendered as too close: such aspects reflect the meaning that the object enjoys within the agent's world. Furthermore, since 'hold' is tied in with action preparation (Cardellecchio et al., 2011; Iachini et al., 2014; Wamain et al., 2016), a negatively-valenced item may produce a strong affective hold upon the sensorimotor system while nevertheless presenting as phenomenally remote. For instance, a rotten vegetable's undesirability makes it spatially salient while still appearing further away.

By contrast, in approach-based tasks, fearful negative sounds are likewise experienced as nearer and/or faster, as the brain-body is attuned to urgent interaction (specifically: avoidance) in a more intense way if compared with positive stimuli, which do not solicit interaction with the same urgency (Vangoni et al., 2012; Taffou and Viaud-Delmon 2014; Ferri et al., 2015). Depending on context, a negatively *or* positively valenced entity earns itself a larger presence due to its disproportional impact upon one's spatial situation, as something to be engaged or avoided. For our purposes, this showcases that both an intentional-object's functionality and its affective qualities jointly serve as paradigmatic examples of qualitative factors co-constituting spatial embeddedness via motor-intentional orientation toward innerwordly entities. Affectivity thus further demonstrates how one's embeddedness in the *Umwelt* is fundamentally scaffolded by meaning.

Valence has therefore been uncovered as an inseparable dimension of the agent's normative *Umwelt*-embeddedness, with special emphasis on its power over motor-intentionality, whereby the affective significance of intentional-objects are directly perceived via one's sensory modalities, automatically eliciting context-appropriate, motoric actions. The contextual, egocentrically-referenced meaning of a heard sound or visualised entity (which, in lived space, are not reducible to the transduction of airwaves by the cochlea or photons by the retina), produces cascade effects across the entire brain-body that arises specifically in attunement with what these intentional-objects mean for us in our surroundings. Thus, in addition to such affective qualities heavily informing the brain-body's pre-reflective relationship to affordances, the presence of affect-laden objects in turn co-constitutes how surrounding space itself manifests to the situated brain-body (e.g., a sudden fire renders the whole environment as dangerous). Indeed, the presence of meaningful sights and sounds mutually sculpt both the lived and physical body that receives them in preparation for engaging the surrounding word, since bodily space *qua* enactive interface always exists in a dynamic and reciprocal relationship with the *Umwelt* in which it is inseparably embedded. This theme will henceforth be deepened in the following section.

2.2 Affective Openings and States

If valence or affective intentionality mainly designates a dyadic motor-intentional orientation to a circumscribable intentional-object found in surrounding space, then an affective *state* designates a more global way in which the agent himself is spatio-affectively embedded in the *Umwelt*, without necessarily having any discernable intentional-object as its focus. Thus, if we strip spatial affectivity down to its most basic and broadest division, we might claim that it designates a modality of engagement in which agents are either drawn towards things (approach) or repelled away (avoid) from them.[85] This division then maps onto a generalised way of being oriented within an *Umwelt*, as 'open' or 'closed', respectively. This insight is often closely connected with the aforementioned 'second skin' interpretation of PPS whereby bodily space is treated as synonymous with 'defensive space' (Graziano, 2018), as opposed to interactive space (de Vignemont & Iannetti, 2015; Bufacchi & Iannetti, 2018). The skin, or epidermic layer, serves as a protective boundary. In parallel, as an extension of the body that displays protective functions, bodily space earns its 'second skin' moniker (Graziano, 2018). Indeed, an approach-avoid polarity underscores many prominent experimental studies and theories of peripersonal space, as well as the concept of 'valence' (Tye, 2018) even if such interpretations might justifiably be considered somewhat reductionist.[86]

Aiming to avoid such reductionism, Bufacchi and Iannetti (2018) have forwarded the 'action field' model of PPS, adding that their model does not always overlap with the binary 'approach-avoid' model. According to the action field hypothesis, there is a functional difference between approach-avoid (defensive) and task-related (interactive) space, the latter of which is more conducive to our embodied-enactive model of bodily space. Indeed, we can recall that almost a century ago, Uexküll took aim at an analogous kind of reductionism. Uexküll (1934/2010, p.164) noted that however sophisticated an action may be, the organism will nonetheless approach or avoid *something*. Mistaking this aspect for the full picture, Uexküll claims that some scientists "declared these simple spatial

[85] This would be a rather naturalistic version of affectivity.
[86] Perhaps for this reason, 'fear' is one of Damasio's (1994) 'primary emotions'.

components of each action to be the action itself and therefore divided all actions into… tropisms" which served to "all living animal subjects into dead machines, which must thus confront each other spatially", thus obscuring the richness and complexity of biological spatiality (see **1b.1.3**). Heeding Uexküll's warning, we must be careful not to mistake this very real *component* of bodily spatiality for bodily spatiality in its entirety.

Indeed, bodily space is not limited to its defensive functions; several modalities of bodily-affective spatiality encompass a variety of ways of being spatially embedded. Here, we will focus upon how affective states (not the valence of singular objects) co-constitute a kind of omnidirectional spatial embeddedness in which several or all nearby intentional-objects are intended according to univocal affective logic. A helpful metaphor might be to imagine the bubble of space surrounding the body (imagery routinely employed when describing PPS and also by von Uexküll) as coloured in accordance with a delineated affective state: yellow for happy, red for angry, blue for sad, and so forth. This simplistic metaphor aims to invoke that, if PPS *is* an invisible bubble (e.g., de Vignemont & Iannetti, 2015; Fossataro et al., 2023) its affective dimensions penetrate and are thoroughly dispersed throughout it in its entirety, so that entities encountered within this bounded enactive interface are 'tagged' according to the agent's dominant emotion. Accordingly, while defensive space essentially hinges on an approach-avoid axis, task-related space denotes a space of embodied interaction that both facilitates and modulates one's engagement with external entities (Bufacchi & Iannetti, 2018). From a higher vantage point, however, *both* defensive and interactive spaces belong to the 'functional' as opposed to 'metric' model of spatiality (Ferri et al., 2015), as each serve a qualitative role for the enactive interface of PPS. Accordingly, both shall be covered here.

Affective states thus modulate spatial embeddedness in the *Umwelt* through the prism of emotion, whereby disparate innerwordly entities are presented according to a univocal logic, co-determining how the agent finds themselves spatially situated in relation to other entities. A key factor to reiterate is that intentional-objects refracted through an affective state or mood are not localizable to a single cause. In the previous section, we focused on dyadic spatio-affective relations, such as pleasant, disgusting or dangerous entities (e.g., Valdés-Conroy et al., 2012; Vangoni et al., 2012; Ferri et al., 2015). We also saw that an entity which makes no contact with the body still fundamentally modulates the way that bodily space is embedded, such as bringing bodily space into an anticipatory orientation. Going deeper, we can consider how this kind of enduring coloration inhabits an affected individual throughout their daily activities, structuring their relation to other spatial entities, potentially extending across their entire lifespan.

This line of thought suggests that a further avenue for exploring bodily space theoretically and experimentally exists by emphasising a temporal profile of spatial affectivity. Interestingly, there is empirical justification for delineating between the temporary emergence of an emotion and its long-term sedimentation in the individual, sometimes called a 'trait', constituting a person's enduring personality or temperament (Fridhandler, 1986).[87] An affective state that is elongated into a trait (reducing its intensity but increasing its permanence) entails that individuals with that trait homogenously consistently intend several entities/objects/persons through the prism of that trait.[88] Taking the emotion of anxiety, Spaccasassi and Maravita (2020) tested affectivity's influence by differentiating between state and trait anxiety, i.e., anxiety as a limited, temporary event (state) and anxiety as an enduring personality characteristic (trait). Both state and trait anxiety influenced PPS but state anxiety induced more attentional resources to near space, whereas high trait anxiety individuals developed ways of suppressing these same processes.

Previously, Sambo and Iannetti (2013) found that scoring higher on a trait anxiety measure correlated with a permanently larger 'defensive' peripersonal space (DPPS) compared with individuals with lower trait anxiety scores. Measuring face-located defensive peripersonal space ('DPPS'), Sambo & Iannetti (p.14429) found: "in more anxious individuals, the "safety margin" is located at a further distance from the body than in less anxious individuals". As the high-trait anxiety individual goes about their daily routines, it is as if the affective state usually typifying a certain situation has sedimented into their way of being-in-the-world, producing measurable bodily spatial consequences. Higher trait anxiety entails that the world as a whole manifests on a more threatening basis, likely modulating most intentional-objects encountered therein. A trait thus provides an interesting way of viewing an affective state as dispersed across *all* of one's

[87] Further research on the relation between peripersonal space and the so-called 'Big 5' personality traits may be an interesting avenue of experimental investigation. It would be interesting to see if the trait that operationalises a spatial metaphor – 'Openness' - has any imprint on PPS.

[88] However, according to Ferri and Adrizzi (2018), a narrower PPS boundary can also imply adaptability. If novel situations arise, there is more potential variance in action if the PPS boundary is narrower rather than larger; this is perhaps why Ferri & Adrizzi suggest that greater attention to one's feelings and bodily sensations may contribute to a narrower PPS via interoception. Phenomenologically, this may imply that those with greater powers of interoception have their 'centre of gravity' weighted towards themselves, with less input from surrounding entities informing their spatial situation.

spatial situations, instead of being fixed to during a singular situation. That is, all or most of the situations that one enters into are coloured by the affective state *qua* trait that consistently modulates surrounding space and the entities dispersed within it.

At the level of lived space, fear and anxiety label the extent to which the agent pre-reflectively distances herself from the world, erecting barriers that close herself off from surrounding entities. But does there exist any such corresponding affective state equally characterized by a spatial *openness* to the world? In the psychological sciences, numerous scholars have pointed out that, if anxiety has a polar opposite, it is not found in 'calmness' but rather in 'confidence' (van Honk et al. 2005; Masson et al., 2021). Such a distinction maps neatly onto our juxtaposition between spatial openness and closedness, with confidence clearly pertaining to the former. In experiencing a bout of confidence, we remain appreciatively open to the *Umwelt's* possibilities, not closed off from them in self-protection.[89] Our phenomenological orientation to the world via confidence is that of a marked capacity to integrate easily with 'external entities', as juxtaposed to the heightened defensiveness that fear/anxiety engenders, in which entities are hyper-salient but are not ear-marked for integration or exploration. In anxiety, entities around one's body might be both 'close' (defensive), in that they elicit heightened arousal, but simultaneously 'far' (interactive) in that our bodily boundaries are firmly sealed to 'put distance' between ourselves and the feared entity, particularly with a view to rapidly adopting avoidant measures.

It is important, then, to examine a contrasting affective state characterized by positive valence and openness, strategically employing 'confidence', fear's antithesis, as our example. However, compared with fear, confidence is somewhat trickier to authentically replicate in lab settings. Perhaps this speaks to its comparative complexity as an affective state. Nonetheless, one method by which this is experimentally accomplished is via testosterone administration. Using female volunteers, Masson et al. (2021) studied the relationship between PPS and the affective state of high confidence, since increasing testosterone is reliably correlated with increasing confidence and the prevalence of egocentric decision-making (Wright et al., 2012). Masson and co-authors aimed to:

> explore this association between testosterone and bodily representations by indexing whether the former facilitates social dominance in part by modulating not only the

[89] Indeed, testosterone administration can lead to symptom-reduction in anxiety-prone individuals (Hermans et al., 2007).

> perception of one's body… but also the encoding of space immediately surrounding the body; the peripersonal space; (p.1640).

Following testosterone administration, the PPS of the participants indeed expanded outwards, as if the 'second skin' was taking up more space. In this case, the affective state's cause was the testosterone administration, entailing that the affective state derives 'from' the agent's hormonal shift (i.e., not entities or events causing increased confidence), which worked to expand PPS and presumably modulate nearby, innerwordly entities as more 'available' for interaction. Here, the operative notion is again that PPS is an enactive interface which means that its fluid size and shape are tightly bound up with the agent's situated world-embeddedness (see de Vignemont & Iannetti, 2015; Ciuanca et al., 2021).

As Masson and colleagues note, another study by Vergallito et al. (2019) demonstrated that, similarly, when participants are asked to relive past situations in which they felt powerful, their PPS likewise expanded in all directions. Again, this omnidirectional affective shift in world-embeddedness, brought forth by heightened feelings of power, is automatically reflected in bodily space. Thus, how surrounding space as an arena for possible interaction is immediately presented to the agent is co-founded upon their current affective state which, at the motor-intentional level, is omnidirectional. In certain highly positive states, the body's phenomenal presence over the *Umwelt* increases, as if more willing to engage, explore and interact with the things around itself. During confidence, therefore, the world of objects acquires a new, appealing tone. Moreover, we may also witness a feedback loop in which the agent's increased confidence promotes smooth and skilful engagement with surrounding entities, further bolstering the affective state's power over the agent's spatial situation. Over a period of time, this may develop into a trait of confidence that permeates their being-in-the-world, as seen with trait anxiety (Sambo & Iannetti, 2013).

On that note, Masson and colleagues found that PPS expansions following testosterone administration was greatest for those *high* in trait anxiety, implying that one state (confidence) effectively displaced the other (anxiety). They further noted that the same PPS expansion observed in the opposing affective states of anxiety and confidence was a "paradox", speculating that PPS expansion in anxious individuals is "a social coping strategy that anxious individuals employ implicitly to manage feelings of social discomfort and which people with high testosterone utilise instead more proactively as a basic form of empowerment" (p.1646). Broadly, I concur with this assessment. However, extreme care must be taken with the term 'coping strategy', which implies a conscious decision implemented to achieve a delineated goal. However, because bodily space is pre-reflective, this 'strategy' is not enacted on the part of reflective cognition. If this 'coping strategy' is intended to instead denote a pre-reflective adaptation, automatically implemented by a situationally 'smart' enactive interface, then this interpretation holds weight.

Indeed, as Merleau-Ponty (1945/2012) was wont to show, an alteration in situated bodily space is but one reflection of a wider horizon of embodied world-embeddedness, not a top-down choice made by a superordinate *Cogito*. Taken thusly, a PPS expansion, retraction, or shift toward a specific body-part all reflect the broader ways in which the agent is currently situated in-the-world as a *Gestalt* phenomenon. Again, this situatedness is sufficiently pronounced that one may observe metrically homogeneous peripersonal responses underlying markedly heterogenous affective states. That is, an *expanded* peripersonal space can indicate *both* a broadly 'negative' *or* 'positive' state. Defensive PPS expansion reflects the anxious person's disposition to keep the world at bay, while simultaneously reflecting an increased attentional focus and hyper-attunement to surrounding entities, necessary for reacting to perilous situations more quickly (Vangoni et al., 2012; Taffou and Viaud-Delmon, 2014; Ferri et al., 2015).

An expanded PPS also reflects an increased bodily presence and openness towards surrounding entities. Accordingly, what matters most is not the metric alteration but how *Umwelt*-embedded bodily space automatically reconfigures itself to fit the meaning of the situation. And this implies, following the later Merleau-Ponty (1964/2004), that body fits in the world in a chiasmatic relation, not as a separate, thinking substance. This chiasmatic relation (Merleau-Ponty, 1964/2004) can alternatively be labelled an affective-sensorimotor opening onto the world (see **4.3.2**); one is open to a horizon of space that is laid out according to one's motor capacities and current affective colouring. In anxiety, following the second skin model (Graziano, 2018),[90] innerworldly entities are temporarily kept at bay.

By contrast, as Masson et al. (2021) suggest, the openness that is characteristic of confidence lowers one's barriers to reflect and encourage smooth integration with most surrounding entities. Masson and colleagues (p.1646) further refer to the fact that PPS expands following both increased anxiety *and* testosterone administration (a known anxiolytic) as 'paradoxical'. Yet this apparent paradox only holds if one remains fixed to a

[90] Ciauncia et al. (2021) also operationalise the term 'second skin' but instead relate it to the tendency for the body to make other entities transparent during engaged interaction in the world.

quantitative profile of affective PPS and dissolves when re-directing towards its qualitative profile. In each case, a marked heterogeneity qualitatively scaffolds each state. More specifically, as they suggest, the well-known increase in social dominance caused by elevated testosterone may increase the space taken up by the bodily self; that is, confidence renders a greater portion of space as 'mine', reflecting the body's increased feeling of power over the environment, reflecting Ciuanca et al.'s (2021) notion of 'second skin'. This contrasts to the function of fear/anxiety which is to create space between threatening entities and/or respond to them more rapidly, a difference which has no purchase over metric, non-meaningful space.

Finally, we should note how affectivity aligns with a previously introduced concept, that of tool-transparency (**2.1.3**). Tool-transparency denotes that a tool has withdrawn from being an intentional object into co-constituting motor-intentionality itself. The tool subsequently co-constitutes how the agent is spatially embedded, whereby bodily space expands so that previously far items are rendered near, again relating to the 'second skin' model of PPS (Ciaunca et al., 2021). The notion that tool-transparency is fundamentally interlinked with affectivity is bolstered by an experiment by Rossetti et al. (2015) who first triggered the 'tool-transparency' effect before measuring autonomic fear responses as noxious stimuli (e.g., a needle) approached the body. Subsequently, participants exhibited autonomic fear responses at a further distance than occurred in the pre tool-use condition, indicating a PPS expansion induced by tool-transparency that directly modulated an affective state.

In sum, I proposed that while *object valence* and *affective intentionality* (**2.2.1**) pertains to a dyadic, circumscribed agent-object intentional relationship (the agent directly perceives that object's affective significance, eliciting an affective-pragmatic reaction), *affective states* such as fear or confidence manifest in a more all-encompassing agent-world dynamic in which the dominant affective state and/or trait temporarily modulates *all* entities within (and approaching) bodily space, as well as bodily space itself. Importantly, unlike affective intentionality, it appears that an affective state's *cause* need not be localised to any delineated intentional-object. Rather, bodily space's form reflects how an affective state, trait or quality modulates the agent's broader spatial embeddedness. Such contextuality entails that substantially different affective states produce substantially similar (metric) PPS responses. Fear, for instance, lengthens bodily space's borders for the purpose of allowing further away entities to be responded to more quickly, and thus 'tagged' under its avoidant-defensive logic, whereas the expansion engendered by confidence reflects agents' 'opened-up' disposition to loosen their boundaries and 'allow in' external entities. In all cases, the flexible enactive interface of PPS automatically realigns with affectively disclosed situational demands, endowing qualitative individuation to otherwise quantitatively homogenous PPS responses.

2.3. Spatial Mood

To conclude this section, we shall briefly reflect on some theoretical considerations that have come to the fore that will help bring our discussions into fully Enactivist territory. The subtle yet key difference between the affective valence perceived in a singular object and a more pervasive affective state inhabiting the agent might be further explicated via dialogue with Heidegger's *Being and Time* and the secondary literature (Dreyfus, 1991; Ratcliffe, 2002, 2005, 2019). While Heidegger explicitly avoided examining emotion as conceptualized by mainstream psychology, he carefully explored the phenomenon of *Stimmung,* translated as either 'mood' or 'atmosphere', which might be described as a kind of global, affect-laden attunement to the world (see **1a.1.4**). According to Heidegger, common, everyday experience reveals this phenomenon's characteristics. In a bad mood, *everything* irritates, frustrates or depresses me. By contrast, a good mood can render the world as cheerful, promising and profound in its totality. In Heideggerian language, 'Mood' signifies an existential modality of world-disclosure that an agent can become attuned to in particular conditions.[91] Ratcliffe (2002, p.287) succinctly summarises that *Stimmung* "are not merely "subjective" or "psychic" phenomena but an irreducible pre-theoretical background, relative to which the world and the manner in which we are situated within it is disclosed or rendered intelligible".

Ratcliffe (2002, p.298) further claims that Damasio's concept of 'background feeling' shares several similarities with Heidegger's account of mood. Indeed, Mood interested Heidegger precisely for its background-modulating effects. Instead of denoting a noetic relationship between subject and object, for Heidegger, *Stimmung* overcomes traditional subject-object distinctions to dynamically disclose the world 'holistically' to Dasein. Bypassing classic Cartesian dualism, Dasein does not simply project its own mood onto an otherwise abstract Euclidian canvas; rather mood "comes neither from "within" nor from "without", but rises from Being-in-the-world itself, as a mode of that Being" (*BT,* p.137/133). Just so, we saw how the brain-body can be affectively embedded within its *Umwelt* in a comparatively global, 'Mood-like' manner. To the extent that an affective state

[91] Although Dasein is *always* in *some kind* of *Stimmung*, even if just that of banal everydayness.

or trait is not directed at any one specific object, the pervasive, 'global' affectivity studied by PPS researchers is not a far cry from Heidegger's phenomenology of *Stimmung*.

Due to its encompassing, 'global' nature, the phenomenon of mood is not particularly well-suited to the experimental setting. Nonetheless, we saw how affectivity is frequently capable of disclosing more than one intentional-object according to the particular background 'logic' of a dominant affective state, even one intravenously induced.[92] During bouts of anxiety or confidence, we become selectively attuned to the world *qua Gestalt* in a particular fashion, which certainly includes *Umwelt*-embedded material objects (Sambo & Iannetti, 2013; Vergallito et al., 2019; Masson et al., 2021). The fact that more than one of the intentional-objects that one encounters is modulated by the currently dominant emotional state entails that affectivity brings forth an orientation to the *Umwelt* not limited to a dyadic, agent-object relations; instead of fearing or desiring one demarcated thing, *all things* within our *Umwelt* become coloured according to a particular emotional hue. An emotion-induced extension or retraction of PPS incorporates *all* of the entities that might fall within its boundaries.

When feeling confident and powerful, every innerwordly object seems more inviting and less overbearing. When fearful, my PPS juts out ahead of me, extending its boundaries to seemingly keep all entities at a distance, while speeding up my reaction times to said entities, lest they pose some kind of threat (Vangoni et al., 2012; Ferri et al., 2015). In states of openness, my boundaries relax, enabling an event in which both I and other entities are linked together in an atmosphere of smooth integration (Masson et al., 2021; Vergallito et al., 2019).[93] As Heidegger foresaw, affectivity is not (always) a mere subjective feeling but rather a means for the agent to gain access to a world, which then reciprocally reveals our own place in it. We know our own fear, joy, sadness or excitement through the way things in the world manifest themselves to us.

As Dreyfus (1990, p.174) notes, it is how entities automatically affect us that *make our own moods knowable and salient to us*, not our introspective abilities: "If I am in a frightened mood, every particular thing shows up as fearsome. Mood colours the whole world and everything that comes into it". Since bodily space is relational, it follows that, even if affective states permeate it, a spatial mood only concretises in the enactive interface via bodily space's

[92] Even if we view 'Mood' as compatible with Masson et al.'s (2021) findings, Heidegger would have no doubt been somewhat distasteful at the idea that *Stimmung* could manifest on the basis of hormonal manipulation.
[93] There is a particularly noteworthy way in which this occurs in relation to people that will be assessed below (**3.3.3**)

relation to surrounding entities. Furthermore, mood, despite its potentially privative connotations ("I'm not in the right mood for this party"), actually highlights a highly intersubjective instantiation of affectivity. In addition to disclosing the world in a particular way to the individual, moods are frequently generated by a collection of people in relation to a shared, global context. Such moods also seem very adept at drawing in proximal individuals to their sway, qualitatively defining a certain place or event: the upbeat mood emanated by a party or melancholy atmosphere of a funeral will almost certainly modulate our own experience if we are in attendance. Dreyfus (1990) even writes that moods can animate particular epochs, such as a revolutionary era. Clearly, I alone cannot determine my era's mood as revolutionary!

Despite current paucity of empirical data, we may hypothetically extend this logic of mood to whimsy, excitement, sadness, happiness and so forth and posit that all likely have identifiable bodily spatial signatures yet to be unearthed. We should thus venture to contemplate beyond what can be currently studied within laboratory settings. Ratcliffe (2019) provides an interesting phenomenology of grief, whereby the *absence* of the mourned individual creates a *presence* in our world characterized by the sealing-off of certain action-potentials for the bereaved individual in contexts that would have otherwise included the deceased person. Accordingly, the agent's spatial relationship to the world via grief will be altered by the sudden destruction of previously shared affectively-inflected action-potentials. Consider, for instance, the case of someone suddenly realizing they should no longer lay the table for the deceased party: the cutlery encountered in the kitchen have shifted in their meaning. Grief, then, can profoundly alter the way one relates to the *Umwelt* and intends the objects present there. This showcases how tools dispersed around the surrounding world (such as the deceased's favourite mug) are co-constituted by an affective presence, which assumes a completely different quality compared to when they were alive to use it.

Bringing all this back to our current aims, we have found that a mood denotes a means of *Umwelt*-disclosure that individuals can be attuned or dis-attuned to and, as such, leaves an imprint upon the *Umwelt*-embedded enactive interface that is bodily space. One's individual bodily space must be locally adapted to the prevailing mood just as one's gait, personal boundaries, reaching and grasping style must all be correctly attuned to the situation, whether it be a solemn funeral, interesting lecture, tense family gathering or wild party. Indeed, as we shall see later (**3.2**), the brain-body is incredibly sensitive to others' emotional states, which produce profoundly modulating effects on the PPS network. All these considerations automatically structure the enactive interface, co-constituting the motor-intentional profile in lockstep with their demands.

This chapter's focus on object-interaction, we now see, is co-determined by both functional and affective meaning. For instance, one's work computer might elicit hand-muscle activity (Cardelecchio et al., 2011), but its appearance might also be modulated by pleasure or dread, depending on the content of the work and my attitude toward it; these are equally vital elements of the spatial situation. Affectivity in its various guises thus interfaces with a functional and social understanding of bodily space (Teneggi et al., 2013; Bufacchi & Iannetti, 2018; Bogdanov et al., 2021) because it facilitates the agent's capacities to act effectively and appropriately in space, pre-reflectively sculpting the body for forthcoming interaction in conjunction with how valence presents an intentional-object or mood discloses the *Umwelt* as a whole. This line of thought also supports Uexküll's comparable (though slightly less affectively-based) use of 'mood' (**1b.1.3**). Uexküll connects 'mood' with 'tone' and thus imbues it with functional characteristics. For example, a 'search tone', denotes the global orientation of the organism to the *Umwelt* in the modality of searching; once more, this 'mood' modulates the appearance of *all* the intentional-objects encountered, which are filtered through the template of the organism's dominate mood. When the situation has passed, the 'same' objects may appear very different.

In line with the borader themes of this thesis, spatial affectivity further clarifies how lived space manifests as inherently meaningful to the agents embedded there, thus representing another prime example for demarcating lived from objective space, a core aim of this project. Affective intentionality, states, traits or *Stimmung* have no meaningful purchase over Euclidian space. The dimension of width, for example, is never influenced by sadness, joy or surprise. A measuring device that measures width or height differently depending on its mood would simply be a faulty, unreliable device. We would certainly return a tape measure that provides a reading in accordance with a bout of melancholy or mania! Yet affectivity is always modulating how bodily space is spatially embedded in its *Umwelt*.

Does all this entail, then, that affectively-disclosed space is somehow 'not real' as compared to its metric counterpart? For the enactivist, absolutely not. Space can truly be disclosed via affectivity, just as nations and epochs can be truly understood by their peculiar, defining characteristics. But consider further that an object's valence, whether perceived in auditory or visual modalities, can produce not only observable behaivour but measurable profiles of neural activity detectable by neuroimaging and so, according to a materialist view of science, 'real' (Costantini & Sinigaglia, 2011). However, enactivism certainly diverges from a 'Corpuscularian' view of science in which qualitative items should always be replaced with quantitative counterparts (Harre, 1977; Sykes, 2021a). There is, it appears, no good reason to completely dismiss the idea that the brain-body quite literally engages its environment as a space of meaning, affectively or otherwise, even from the most hard-nosed neuroscientific standpoint. By contrast, carefully detailing meaning permits further understanding of how the brain understands its surrounding space as well as augmenting the interpretation of empirical peripersonal space data.

Concluding this section, we have found that affectivity can serve as a salient and informative quality ('valence') of an object that structures individual instances of motor-intentionality or, alternatively, can co-constitute bodily space's current configuration itself as a state. These two categories may not always be neatly separable; when I fear the hissing snake, desire the fresh coffee or feel pride at a successful tennis swing, affective intentionality may then engender a more global type of spatiality, speeding up my reactions to all entities, or, conversely, promoting a kind of global openness to entities as a consequence of increased confidence. Furthermore, the kind of global affectivity characteristic of affective states was found analogous with 'Mood' *(Stimmung),* which filters all or several entities according to a prevailing affective logic. A state or mood might also be longitudinally instantiated in the form of a trait, which was also found to have a bodily spatial signature (Sambo & Iannetti, 2013). We can thus conclude this section by asserting that the type of affective spatiality described here, alongside practical tool-interaction (**2.1**), is only intelligible for a living organism that is situated within a meaningfully-structured *Umwelt*. Within these spaces, the presence of meaning continuously sculpts the enactive interface of PPS, which is itself inseparably tethered to such a meaningful world. In what follows, we will recount the final factor proposed to structure spatial embeddedness in the *Umwelt*.

3. Habit and Temporality

Thus far, we have thus far examined two crucial dimensions determinant of the spatial dynamic between agents and objects, which in turn co-constitutes how agents are spatially embedded in the *Umwelt*. Both dimensions - affectivity and tool-use - can now be incorporated into a final analysis that illuminates the longitudinal instantiation of certain agent-object spatial relationships, uncovering the interpenetration between space, body, objects and time from an interdisciplinary, enactive perspective. Specifically, I argue that the bodily space *qua* temporal entity is sculpted by its repeated modes of *Umwelt*-interaction so that habits, skills and practices become permanent or semi-permanent fixtures of bodily space's form (Carman, 1999; Viljoen, 2010). This sedimentation of habit confers identity to the agent and scaffolds the modal way in which agents find themselves spatially embedded within *Umwelten*, since bodily space consistently 'merges with' its modal environments (e.g., the office, the train, the dojo, the studio) and 'wraps around' (Graziano, 2018) the innerwordly entities found there (e.g., chairs, suitcases, weapons, paintbrushes) as part of a wider form of life.

Habit thus appears to be an essential component of *Umwelt*-embedded bodily space - correctly reconfigured as a temporally extended phenomenon – which always contains traces of the agent's historical past and cultural lifeworld. In simpler terms, human spatiality as form of semiosis is structured by our capacity to master skills, form habits, and become accustomed to patterns existent in the world (Colapietro, 2021). These (re)experienced patterns of stabilisation provide lasting form to bodily space. Put differently, the phenomenon of bodily space is profoundly dependent on the deceptively simple fact that we drastically improve our proficiency in task performance across time, a process often labelled as 'skill' or 'habit acquisition' (Cappuccio, 2023). Habit is frequently considered as a kind of 'bodily knowledge' or sometimes colloquially (albeit incorrectly) referred to as 'muscle memory' but is better defined as a "flexibly adaptive and "predictive" mode of competent action in space which is eminently pre-reflective yet "far from being blindly mechanical" (Cappuccio, 2023, p.85). I would venture that this kind of familiar know-how exerts influence over all the concepts introduced above: spatial micro-affordances, hold, tool-transparency, affective intentionality and affective states. That is, both tool-interaction (**2.1**) and affectivity (**2.2**) as detailed above are mediated via familiarity, mastery and/or habituation with relevant phenomena.

Moreover, both semiotics and phenomenology qualify their target domain (i.e., sign-systems and experiential phenomena) by clarifying that semiotic and phenomenological meaning typically develops and unfolds (or is at least learned) so that, for example, a tool's meaning may lay 'dormant' until the agent has successfully acquired the resources to access it. After having witnessed a functional cycle (**1b.1.2**) emerge between tool and task once or more, subsequent perceptions of that tool allow it to manifest as a useful *for-something*, modulating the agent's relation to surrounding space (Jappy, 2023). A strange, unfamiliar tool will not afford any utility to the brain-body perceiving it. As with von Uexküll's foreign acquaintance who encountered a ladder for the first time and saw only ‘bars and holes’, one may have a geometric presentation of a tool upon an initial perception of it only to see it as a ‘*for-something’* after witnessing it in use.

Furthermore, both disciplines postulate that individual habits reside amongst a wider ecosystem of contextual associations (e.g., Dreyfus 1990; Eco, 1990, 1997/1999; Deely, 2015). Indeed, the more frequently the agent uses the tool as the ‘*for-something*’, the greater their proficiency becomes (Legg & Black, 2022) and thus the greater the tool’s impact upon bodily space. This proficiency in turn sediments into “anticipatory-predictive dispositions” (Cappuccio, 2023, p.85) that remain ‘on-hand’ and enable the pre-reflective transition from goal planning to goal actualisation. For example, the ‘habit’ of opening a door presupposes one’s walking through it, alongside the implicit expectation that there is a room or hallway on the other side, which pre-reflectively structures bodily space’s mode of *Umwelt*-embeddedness.

As we shall see, it is precisely via habit that we shall encounter a crucial convergence point between body, space and time. In making this subtle connection explicit, we arrive closer to a more comprehensive model of bodily space and unify our account with other prominent themes in ECS (see **4.2.2**). Therefore, in this ultimate section on object-interaction in the *Umwelt*, narrowing our focus specifically to habit, time and tool-use by utilising both philosophical and experimental examples, we shall interrogate habit’s role in further depth, with special attention as to how it reveals bodily space’s spatio-temporal underpinnings.

3.1 Habits, Tools and Place

As already intimated, acquired habits relieve us of the need of executing meaningful actions on a reflective, step-by-step basis when completing a goal. Moreover, our spatial environment(s) that serve as the background for enacting such goals likewise become accessible *on the basis* of these habits, so that places and entities within them become functionally associated according to the logic of place (Casey, 1997). Heidegger’s term for the interconnectedness of interrelated actions was ‘referential totality’ (*BT*, p.71/71), which, like ‘semiosis’ (e.g., Kull, 1998), highlights how enacting one task necessitates the existence of others; to consider any one action in isolation from the meaningful whole in which it is embedded would be to deprive it of oxygen, as would separating the action from the setting in which one enacts it.

Regarding this expansive interconnection of mutually dependent habits, we find a parallel insight from the earliest origins of semiotics. Colapietro (2021, p.13) informs us that: "From a Peircean perspective, at any rate, the mind is first and foremost a more or less integrated network of various types of habits". Linking this insight to embodied tool-use, Colapietro (p.14) further adds that:

> The most rudimentary somatic understanding of physical objects, then, is a socially mediated understanding (others intervened in our earliest attempts to intervene in the flow of events)… No single, isolated habit accounts for this ability; rather this ability draws upon a network of habits.

Accordingly, object-interaction, culture and habit all coalesce into such a Peircean 'integrated network' of pragmatic associations (Colapietro, 2021) that co-constitutes the agent's primary mode of *Umwelt*-embeddedness. Indeed, meaningfully organising this otherwise scattered network of associations is essentially the function of semiosis, whereby external, culturally-dependent and interconnected meaning-relations serve to, in this particular case, orient the agent within surrounding space and confer intelligibility to individual acts of spatial sense-making that take place there. For example, West (2021, p.26) showcases how, through habits of movement, for the soldier hearing a command, as linked to both 'role' as solider and 'place' of the army barracks: "the effect of the command to ground arms does not rely upon conscious deliberation; it is rather virtually automatic (perhaps unconscious altogether)".

Even in accomplishing what might be considered a 'single' activity, such as driving a car, cooking a meal or walking the dog, several habits overlap and interlace with one another as part of semiosis or the 'referential totality'. While cooking a meal, the spatula acquires functional meaning in relation to how it is used with the frying pan, the frying pan in relation to the hob and so forth. A network of habits *a la* Peirce or Heideggerian referential totality is likewise in operation when driving a car or teaching a class because, within spaces of meaning, tools acquire their very meaning in relation to the other (preferably reachable) tools that co-define that spatial situation's task. Consider a task as mundane as preparing a cup of tea. In accomplishing the task, the tea-maker accomplishes much of it pre-reflectively (Cappuccio, 2023). You may even consider how to broach a difficult conversation with your boss while simultaneously intersecting with several zones of space, configuring your anatomy in several positions and using a variety of tools (kettles, mugs, spoons, teabags) in order to prepare the beverage. This operation was not so smooth when you first learned how to perform these tasks or use these instruments, but eventually they became transparent parts of your background coping (Dreyfus 1996, 1999, 2007) and referentially tethered to particular, appropriate places (i.e., the kitchen, not the train).

Imagine the *Umwelt* of a subway train carriage now. To be spatially located (or 'dwell') in this carriage implies the existence of your destination, navigating escalators, elevators and tunnels, purchasing a ticket, pushing the button, cramming oneself into packed carriages, reading the station map, etc. These habits may be dissected independently for the sake of analysis, but ecologically they interlace as part of a daily commute, which is, in turn, related to being an inhabitant of a large city.[94] Throughout this process, each new stage of the task appears 'on the horizon' of an engaged action, pre-reflectively beckoning the agent to enact it, highlighting new places in space in which the subsequent action should be conducted. Indeed, when we enter, say, a bus or restaurant, habit renders us on autopilot as we embark upon a series of purposeful actions that allow us to merge seamlessly with this new setting: paying for a ticket, taking a seat, ringing the bell, etc. This longitudinal, agent-environment attunement that is essentially crystalised in the concept '*Umwelt*' thus underlies the notion of habituated spatial embeddedness as developed here[95]

Habits are, therefore, more than simple uniformly repeated actions (Legg and Black, 2020) but disclosive of ways of being in space and thus co-constitutive of the human capacity of *in*-habiting the spatial world. As such, habit first introduces and then cements the individual within a wider *Lebensform* of interconnected meaning. We can apply this logic to several other forms of life: the pianist perfecting a piece, the jiu-jitsu practitioner mastering a move, the professor imparting knowledge to students and the Buddhist achieving tranquillity each belong to world of music, marital arts, academia and religion, respectively. All such examples pertain to a habituated agent acting meaningfully in various context-specific places. But proficiency need not be restricted to feats or talents. Members of the 'modern world' know how to perform (for us) mundane activities such as operating elevators, light switches and ovens, whereas members of the medieval European world could operate bread mills and looms more naturally than we could. Habit thus facilitates tool-use without conscious effort and links bodily space to the places and epochs that it is embedded in.

[94] Thus, at different scales, for the modern human, both a train carriage and a large city can each be considered an *Umwelt*. For a discussion see Kull (1998).
[95] As Kull and Favareau (2022) note, integrating a Peircean conception of habits with Uexküll's concept of the *Umwelt* (as attempted in this work) provides a more comprehensive as to how organisms exist in their environments over time.

This philosophical position sidesteps the trapdoor of subjective idealism by which meaning is constructed by the Cartesian subject who 'projects value' to an otherwise meaningless objective world of matter. The fact that a meaning may be 'missed' in some cases by individual agents does not speak to its ontological reality as mere construction. On the contrary, one may argue that an agent-world ontology defined by relations of attunement or misattunement foregrounds the subject-independent reality of an otherwise 'merely subjective' phenomenon. Just as the moon does not disappear if I turn away from it, a hammer's meaning as tool is not constructed on the fly simply because I learn to attune myself to its function. By contrast, upon learning its function, I enter into the cultural nexus of meaning-systems that give it relevance because, as Peirce and Heidegger showed, interpretants structure reality before empirical individuals are introduced to them (Paolucci, 2015, 2021). When competence within a domain has been achieved and the habit formed, an object's meaning has been sufficiently absorbed as to be always included in one's opening onto the world, and thus capable of soliciting comportment at the right moment without reliance on reflective cognition to execute the act (Cappuccio, 2023).

At this juncture, we can now examine how this general conceptual framework applies to two empirical examples regarding habit, tool-use and peripersonal space. This examination shall lead us directly onto the spatiotemporal underpinnings of habitual tool-use and thereby of bodily space generally. As a paradigm case, let's utilise the classic example of the so-called 'blind man's cane'. This is an especially pertinent example because there exists a remarkable yet apparently unnoticed convergence between the phenomenological and empirical literatures regarding how non-sighted individuals utilize the cane to navigate their spatial surroundings. On the empirical side, Serino et al. (2007) empirically tested the relationship between bodily space and the use of canes to navigate the environment in both habitual (non-sighted) vs. non-habitual (sighted) populations. Before delving into their experimental findings, we should first note that Merleau-Ponty pre-emptively discusses this exact same phenomenon from a phenomenological perspective in significant detail.

As we shall realise, Merleau-Ponty's phenomenological analysis quite intuitively pre-empts current scientific findings that, during engaged activity, the brain-body's map of PPS extends outwards to the end of a tool (**2.1.3**). Indeed, with reference to the cane itself, Merleau-Ponty prophetically claims that "when the cane becomes a familiar instrument, [the body] no longer begins at the skin of the hand but at the tip of the cane" (*PoP,* 188/153). The term 'familiar' will turn out to be of key importance for this phenomenon.

Familiarity with a tool, as facilitated by habit, modulates the way that surrounding space manifests for tool-using agents. Merleau-Ponty echoes Heidegger's observation that perceptual and/or theoretical cognition does not exhaust the manner by which tools are accessible; rather, we must take the tool and *use it* for it to modulate the way in which we are embedded in the *Umwelt*. It is therefore vital that one acts upon surrounding space directly with the tool for bodily space to change its form adaptively. Subsequently, familiarity and tool-transparency then converge to instantiate a longitudinal, pragmatic modulation of the way that tool-using agents are spatially embedded in the *Umwelt*. In the case of the cane:

> If I want to become habituated to a cane, I try it out, I touch some objects with and, after some time, I have it in hand: I see which objects are within reach or out of reach of my cane (178/144).

According to Merleau-Ponty, then, one must *both* wield the tool in goal-directed fashion *and* surpass a minimum threshold of familiarity with it for the body to truly "begin at the tip of the cane" (188/153). We cannot fully understand any tool by taking it by itself in isolation because, in agreement with Peirce and Heidegger, all tools are *de facto* relational entities; just as we understand our moods by noticing that 'external' things excite or annoy us (Dreyfus 1990), we understand the tool only through the other 'external' entities that we engage with it. A tool is a semiotic, relational phenomenon in that it only acquires meaning in connection with the spaces, objects and distances it is used to touch, know and explore, all of which are synthesized and subordinated, via functional cycles, to an active goal or task-at-hand (e.g., navigating a busy street). This means that engaging surrounding space via the tool, not passively looking at it or reflectively thinking about it, is essential for unlocking the tool's potential as something ready-to-hand, consequently rendering an otherwise inaccessible spatial zone as something available to the blind tool-user (see Viljoen, 2010).

During all instances of cane-use, the agent's operative motor-intentional profile transitions from the cane featuring as an intentional-object *of* tactile perception into *co-constituting* motor-intentionality itself, where it is an ineliminable but transparent component of the task-at-hand (**2.1.3**). What then distinguishes between the habituated and non-habituated user? I claim that there is something like a gradation of 'readiness' found between the first-time user compared to habitual users. For the inexperienced tool-user, the task-at-hand presented by the tool is experientially dimmer. Even if the first-time user successfully utilises the cane as something ready-to-hand, embodying it during usage and thus rendering it transparent, this tool-enabled means of engaging the world has not yet fully penetrated the core of their longitudinal mode of spatial embeddedness. Like an elastic band, PPS will quickly snap back to its original form when the tool is put down, all but forgotten. Without habit, whilst the tool-user may partially embody the tool, they still access their spatial surroundings somewhat reflectively, like an amateur scientist who consciously makes estimates and hypotheses (Cappuccio, 2023).

By contrast, on Merleau-Ponty's (1945/2012) proto-enactivist account:

> Habit does not consist in interpreting the pressure of the cane on the hand like signs of certain positions of the cane and then these positions as signs of an external object – for the habit relieves us of this very task; (189/153-154).

This final comment is especially revealing because it seemingly takes aim at what today would be describable as a cognitivist interpretation of tool-use. Reading such an account, we might expect to learn that a disembodied and computational mind constantly calculates and represents its current position in relation to a represented external environment, with the cane acting as one element in this neurocentric computation of the physical body's actions relative to separate, external entities. Such an account of cane-use might run as follows: '*Object Y is approximately a metre away from Object Z, which is a half metre away from me, therefore I should turn right after X steps*'. Arguably, this deliberative, reflective account may well be the most fitting description for the *untrained* cane-user. If one were to pick up and use the cane for the first time, one might walk cautiously, probing various areas in the outer environment, tapping the walls and floors, reflectively calculating how this tactile data can map one's current spatial position in relation to the physical environment. The neural correlates of *this* act would indeed match those of the reflective cognitive procedure just described.

However, Merleau-Ponty would likely reply that this description is far less applicable to the *habitual* user. This is because habit has permitted the cane's incorporation into the body schema's permanent structure.[96] After several repeated usages of the same tool for the same task, reflectively cognising about how to correctly use it is rendered unnecessary because, as Merleau-Ponty notes, "habit has relieved them of this very task". Just as when I walk out my front door each day, I need not thematically judge the distance between myself and the door, cautiously measure each step, search for the door handle and calculate the amount of exertion required to open it, so the habitual cane-user need not

[96] I am here treating the body schema and bodily space as synonymous, as is the other in other accounts. However, for my treatment of ways in which these constructs differ, see **4.3.1**.

introduce the cane as an alien element in some calculative task of when navigating in the *Umwelt* (Dreyfus, 2002). Instead, the tool transparently renders all such adaptive behaviours immediately on-hand during use, permitting one's surrounding space to pre-reflectively manifest on such a basis. As such, 'far-space' becomes immediately accessible with the body-incorporated cane even when simply holding but not using it, as habit 'takes care of' an automatic operation that anticipates the action as part of an optimal grip upon the *Umwelt*.

We can thus extract three falsifiable claims regarding the habitual cane-user as expounded by Merleau-Ponty:

1. The (lived) body no longer begins at the material body *proper* but extends outwards to the tip of the cane.
2. For this extension to occur, the cane-user must typically utilise the tool and actively engage other entities in surrounding space.
3. After having relegated this process to habit after gaining familiarity, the cane-user no longer relies on reflectively cognising the environment's position in relation to the tool's position; this mode of know-how has become absorbed in the act of tool-use itself.

Now, we might wonder how this set of claims holds up against a parallel and ostensibly unrelated experimental investigation into habit, PPS and cane-use conducted over a half-century later. Fortuitously, Serino et al. (2007) independently conducted an innovative between-groups study that examined PPS responses to passive and active wielding of the cane in both habitual and non-habitual users. They tested one sample group consisting of eight experienced (1 year or more) non-sighted cane-users and another consisting of 16 sighted (but blindfolded) non-habitual cane-users. The sighted group underwent training with the cane, which involved touching objects placed at a distance of 50-150cm, within a width range of 80cm. As a control, both groups were also given a short (14cm) handle, weighted as to match the feel of the cane. As expected, following 10 minutes of tool-use, the sighted subjects underwent the 'tool-transparency' effect, as measured by a tactile-audio integration task. That is, their reaction times (RTs) to cross-modal stimuli became temporally identical in both near and far space. The sighted subjects were tested again 24 hours later, whereupon it was observed that their PPS had receded back to a profile similar to that of pre-training and PPS did not enlarge when passively holding the tool. For reasons previously discussed, when the sighted/non-habitual participants passively held the cane *without* using it, their PPS retained its regular size, without extension.

Thus, a single session of tool-use, while sufficient to, as Merleau-Ponty described, make the lived body "begin at the tip of the cane", it produced no lasting effect on bodily space for those users devoid of habit. Crucially, this was different from what was found with the blind/habitual sample group. When the habitual-users' RTs to audio-tactile stimuli were measured, the experimenters found that RTs were stronger for the stimuli located in *far*-space. In contrast to the sighted group, the blind cane-users exhibited a PPS extension upon *merely holding* the cane. That is to say, simple tactile perception of the cane produces a PPS extension similar or identical to that observed during actual usage. Thus, while a single act of tool-use (even one capable of engendering tool-transparency) fails to make any detectably enduring imprint upon bodily space, *habitual* usage instead deposits a trace of skilful tool-use into bodily space; this 'trace' is then activated by mere tactile perception of the familiar tool so that the brain-body becomes attuned to a forthcoming interaction even while remaining motionless.

As shall be discussed later, the activation of this habit-instantiated 'imprint' exemplifies the broader phenomenon of spatio-temporality. But first, assessing another tool – the computer mouse - utilised in Bassolino et al. (2010), further expands this analysis. Crucially, this study showcases how bodily space responds to tools very remote from those typically encountered in our ancestral past. PPS is an evolutionarily ancient system, observable in various primates (di Pellegrino & Ladavas, 2015; Graziano, 2018) and likely in birds, reptiles and other animals also. Indeed, central to the present thesis is that peripersonal space is an ineliminable component to being spatially embedded in an *Umwelt*. However, modern humans clearly operate in vastly different *Umwelten* from those of other animals and our pre-civilizational ancestors.[97] Indeed, one of the key outstanding questions posed in a recent overview of PPS (Vignemont, Serino, Wong and Farne, 2021, p.9) is: "did peripersonal space evolve as a tool for survival… do we still need peripersonal space in a future in which brain-machine interfaces feature heavily?". This open question is certainly one that merits addressing.

Moreover, spatially extended tools (e.g., rakes, tongs) enable the brain-body to lay claim to an area of space lying at the outermost reach of said extension, as reflected in both the neurophysiology and phenomenology of tool-use. But what if the tool modulates an area of

[97] In contrast to Uexküll, Heidegger tended to sharply distinguish between animals and humans. For similar reasons, Heidegger argued that, while they do have an *Umwelt*, animals are nonetheless 'poor in world' (Storey, 2016). However, here we are assuming bodily space exists on a human-to-animal continuum, *a la* Peirce.

space that is not physically connected to it? That is, what if the tool is virtual? While spatially extended objects such as the hoover or garbage-clamp may have some prehistoric analogs (e.g., a fishing spear or modified stick for reaching fruit), virtual tools can remain *within* PPS yet permit interaction with areas *outside* PPS. This set-up is important for probing how PPS reacts when the embodied agent's capacity for interaction extends beyond even the parameters of a physical tool proper. The mouse-screen interface nevertheless represents a technological achievement in its own right while simultaneously allowing researchers to examine the PPS network's reaction to engaging an area of space that is physically detached from the tool in-hand.

To approach this question, Bassolino et al. (2010) employed the humble computer mouse and screen interface, recruiting habituated participants who used a computer mouse every day. As a computer mouse engenders a functional pairing of near and far-space without any physical connection occurring between the tool and the distal area of space interacted with, participants operating the mouse become motor-intentionally linked with the screen. Accordingly, multisensory measures showed that participants' PPS expanded outwards to incorporate the computer screen, which was located 70cm away, far further than what was observed with sticks and canes. Bassolino and colleagues note that this expansion is selective for the space surrounding the hand, often labelled 'peri-hand space'.[98] Pre mouse-use, PPS was distributed equally around both hands. Subjects who held the mouse but did *not* utilize it for purposeful activity displayed no changes in their PPS, but this lack of effect applied selectively to the left hand. For the right hand, passive holding was sufficient to trigger tool-transparency. Importantly, it was only the condition in which users passively held the mouse with their *right hand* that PPS expanded outwards to incorporate the computer screen.

Accordingly, we encounter a pragmatic pairing between the task-specific body part (i.e., the hand) and a tool (i.e., the mouse) in coordinated spatial reference to the task-at-hand, cemented by habit. Crucially, the same habitual effect previously found between habitual and non-habitual tool-users (Serino et al., 2007) was in this case replicated in reference to single individuals. That is, only the hand most accustomed to using the tool (i.e., the right hand, not the left) displayed the anticipatory tool-transparency effect during passive holding of the mouse. Thus, unlike in Iriki et al. (1996) and Berti & Frassinetti (2000), but like Serino et al. (2007), the PPS extension occurred even when participants simply held

[98] Peri-hand space was previously analysed in a section (**2.2.1**) dealing with affective intentionality (see Zanini et al., 2021).

the mouse without really using it. As with Serino et al., it seems the case that a previously acquired habit triggers a future-directed spatial attunement aligned with the appropriate task upon mere tactile perception of the tool. Unlike a computer mouse, the cane is typically used for exploring entities located at the spatial zone around its tip; a recalibration of bodily space aligns with this new mode of embeddedness, simultaneously reflected in peripersonal space's neural instantiation.

Once again, this empirical finding dovetails with earlier phenomenological descriptions of embodied tool-use. Merleau-Ponty's notion of the body schema, frequently compared or conflated to PPS (Holmes & Spence, 2004; Martel et al., 2016; D'Angelo et al., 2018), emphasized that "the body schema is neither the simple copy nor the global awareness *of the parts* of the body [...] rather, the subject *actively integrates the parts according to the organism's projects*" [emphasis added] (130). What mandates this 'active integration' of various body parts is, therefore, the task-at-hand, which brings different aspects of the schema online and conjoins them; this spatial integration, if enacted sufficiently often, becomes a fully-fledged habit. This is why Merleau-Ponty claimed that the lived body begins at the *tip* of the cane specifically: the cane's tip is the point of interaction, the place where sensory information connects with the tool-extended body and where vRFs expand to. In Bassolino et al., this expansion encompassed the screen too, which was the 'point of interaction' for the spatially extended lived body, the terminal location of the agent's motor-intentional orientation.

As Heidegger (*BT,* pp.103-109/100-107) illustrated, agents can remain in one particular place while being phenomenologically located elsewhere due to their actions. Because the mouse is rendered transparent, in some sense the agent is spatially situated 'there' (i.e., at the screen) whilst still objectively remaining 'here' in their objective location.[99] Once again, this particular phenomenology is measurably reflected in bodily space. We might also consider videochat or piloting a drone as other examples of this general phenomenon whereby the effects of one's spatially displaced engagement are physically tangible (e.g., as

[99] See De Preester (2012) for a similar neurophenomenological account applied to the incorporation of prosthetics and other forms of technological artefact.

pixels on a computer 1000 miles away or a drone's air-bound movements), requiring agents to phenomenologically be 'in two places at once'.

While the complexities of technological spatiality deserve lengthy treatment elsewhere, there is an interesting parallel here to Heidegger's own brief discussion of ontic, technological spatiality. Heidegger (*BT,* p.106/103) employs the example of a radio which remains objectively fixed at one location but is phenomenologically nearer (more enmeshed in Dasein's situation) when turned on. p.106/103) employs the example of a radio which remains objectively fixed at one location but is phenomenologically nearer (more enmeshed in Dasein's situation) when turned on. Just so, it appears that, when using the mouse to interact with the computer, the computer is phenomenologically brought nearer via the mouse despite no change in its objective position. The transformation of the mouse into a ready-to-hand tool engendered by purposeful usage renders it transparent and foregrounds the computer as the primary motor-intentional object, indexed by the screen's inclusion in the boundaries of bodily space. Thus, unlike the radio, which is itself (or at least the radio programme) bought nearer when switched on, the computer is semiotically brought near via another tool (mouse), which temporarily defines the agent's current spatial situation.

Thus, as the phenomenological and cognitive semiotic traditions keenly foresaw, habit scaffolds perception and motoric action by permanently sculpting one's longutudinal mode of spatial embeddedness in the *Umwelt*. One notable consequence of this is that, when triggered by tactile perception in the right context, a tool automatically orients one toward contextual, forthcoming action, simultaneously bringing to focus how tactile perception is distinct from visual perception in pre-reflective spatiality. Firstly, touching a tool is a narrower, more circumscribable bodily spatial event, whereas, alternatively, we are accustomed to visually intending many tools at once, which provides an open horizon of possibilities in bodily space (Gallese & Sinigaglia, 2010, 2011). Secondly, in the agent's past experience, it has likely been the case that actual tool-use is statistically more likely to follow tactile rather than visual perception of the tool. One is more likely to bring the water bottle to one's mouth when touching it than when seeing it, for example. Via a semiotic-phenomenal integration of co-occurring actions, this likelihood is intrinsically reflected and sedimented in one's spatial experience and its neural correlates.

As such, it appears that an examination of the convergent philosophical and scientific literature regarding habitual tool-use repeatedly brings bodily space's underlying temporal structure to the fore. Indeed, the fact that, during the *present* moment, a *prior* acquisition of habit brings forth a *future-directed* spatial attunement leads us naturally to consider what a fully-fledged spatio-temporal model of bodily space might look like. Therefore, such an account is sketched out in the following section.

3.2 Spatio-temporality

The apparent emergence of tool-transparency during passive, tactile tool-perception - seemingly contradicting our previously stated distinction between 'potential' tool-perception and 'actual' tool-use (**2.1**) - warrants further explanation and contextualization. Providing such an explanation necessitates an exposition of bodily space's temporal structure. Indeed, this discussion's pertinence is reflected in the *second* 'outstanding question' recently posed to researchers in the review of PPS published by de Vignemont, Serino, Wong and Farne (2021, p.8), which asks: "Is peripersonal space a matter of temporal immediacy in addition to spatial immediacy? How do the spatial and temporal factors interact?". Here, we shall address this question by examining temporality *proper* (albeit not exhaustively) by synthesizing the previous discussions and experimental research on habit (**2.3.1**) and tool-interaction (**2.1.3**) with philosophical accounts of human temporality. Thereafter, these philosophical accounts of time-consciousness will be conceptually grounded in the neuroscientific theory of pre-reflective sensorimotor cognition labelled Embodied Simulation Theory (EST) (Gallese, 2005, 2016; Gallese and Sinigaglia, 2011, 2018).[100] The resulting analysis should account for what is arguably the most prominent way in which spatial and temporal factors interact in tool-use, culminating in a spatio-temporal account of bodily space.

A situated convergence between *past-present-future*, traditionally conceived, speaks to the very heart of the classical phenomenological studies of temporality. Perhaps the earliest and most famous of these investigations is Husserl's (1921/2001) phenomenology of present time-consciousness. A vast amount of illuminative secondary literature (e.g., Gallagher 1997; Kortooms 2002) is available on this topic, so I shall here provide only a scant overview before applying this framework to our present theme, showcasing how phenomenological accounts of dynamic, non-linear temporality explicate the intersection between tool-use, habit and bodily space. Husserl (1921/2001) famously employed the example of a melody to showcase the tripartite structure of the phenomenon of present

[100] Additionally, throughout ECS generally, there has been repeated success in emphasising the anticipatory components of enactive perception (e.g., Varela, 1999; Berthoz, 2002; Rietveld, 2008; Bruineberg, Kiverstein & Rietveld, 2018; Gallese, 2018; Robertson & Kirchoff, 2020; Cappuccio, 2023).

time-consciousness. A melody that one hears is not (and cannot be) experienced as a disconnected sequence of discrete auditory events dispersed across Newtonian time.

Implicit in every moment of meaningful auditory perception is an overarching order. Listening to a melody is a *Gestalt* event in which the different temporal passages of the intentional-object are seamlessly stitched together into a coherent, meaningful whole, a standpoint from which any sequestered past, present and future dissolve. Within the 'pure present', termed the *primal impression,* the immediately-receding piece of the melody just heard is pre-reflectively retained alongside the pre-reflectively expected piece of music that has yet to arrive. The melody's receding 'past' aspect is held in place whilst the forthcoming 'future' part is anticipated, or to use Husserl's term 'protended', giving rise to a holistic phenomenon. Husserl's eventual term for this temporal structure of the intentional-object in consciousness is 'passive synthesis' (Husserl, 1921/2001), since the melody's duration is automatically presented as a coherent, unified entity without interference on the part of the listener to render it so.

Heidegger (1927/2010) adopts a similar logic regarding tripartite temporal convergence yet now in relation to Dasein's entire lifespan. On Heidegger's account of human existence, the present moment is always structured by one's future plans, which pre-reflectively manifest as a projecting forward into possibility; we are always implicitly beckoned towards some future state of our Being which, reciprocally, endows meaning to our past and present (see Blattner, 1999). Such is the non-linear temporal structure of Dasein's being-in-the-world. Like Husserl, Heidegger insists that his account of primordial time is incompatible with (and more fundamental than) a sequential, linear model of time which he dismissively labels 'vulgar time' but is technically known as 'chronometric time'. Like a melody, a cohesive human lifespan cannot be constituted by a sequence of disconnected, isolated events occurrent one after the other, like seconds on a timescale, in which one homogenous temporal unit (e.g., nanosecond, hour, year) replaces the next. One's existence is rather co-constituted by one's long-term projects, biographical history, current values and so forth, which establish a future-directed orientation while retroactively 'calling back' to imbue one's past with meaning in reference to this very life journey. These dimensions pre-reflectively interlace as part of Dasein's inherent temporal structure, which for Heidegger also encompasses and subordinates one's spatial structure.[101] Most

[101] Also worth noting is Merleau-Ponty's Husserl and Heidegger-inspired account of temporality in lived space discussed back in **1a.2.5**. However, while Merleau-Ponty's discussion of cane-use was integral to this

importantly for our purposes, we see that protensional content can take as its origin comportment that occured in an earlier period in the agent's life.

Uexküll, seemingly independently of the phenomenologists, likewise asserts that a future state or spatial potentiality produces a direct bearing upon one's physically and immediately situated spatial present. When discussing complex behaviour that unfolds across a prolonged duration, Uexküll favours the term 'plan' over 'instinct', believing it to carry less reductionist baggage and to be better suited to capturing the spatiality of a living organism. One benefit that this terminological choice yields is that we can better visualise a 'potential-here' or 'end-point' intelligently shaping the organism's presently-situated, goal-directed behaviour as an inherent feature.[102] A plan, structured almost like a narrative with a beginning, middle and end (Greimas, 1971) provides continuous direction and organisation to temporally extended and meaningful actions in space until their completion. Uexküll's choice example is the migratory route of a flock of birds (see **chapter 1**), whose eventual destination is already constitutive of each moment of their purpose-driven movements. Each bird's destination, and thus their future, constantly sculpts their bodily space while traversing enormous distances across space and time. For migrating birds, their overall flight path constantly shapes and directs their passage through a sequence of 'heres' and 'nows' which permits them to act meaningfully and instinctively on a large spatio-temporal scale.

What applies to migrating birds certainly applies to intelligent, tool-using human behaviour. Because the schematic structure of bodily space develops over time through the accumulation of skills and habits, it cannot be meaningfully located only in the 'pure' present moment. Indeed, if we consider the developmental trajectory of infanthood to adulthood, we typically find an upward curve representing the quantity of activities the agent can carry out with proficiency.[103] If bodily space (in addition to the tightly connected yet separable notion of the body schema) are inherently temporal phenomena, then an account of how agents are spatially embedded in the world of things must be informed by

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section, in his account of temporal lived space, he deals more so with the agent moving from space to space in the format of what he calls a 'succession of passages'. Instead, we are here dealing with an immobile agent who pre-reflectively anticipates a future. As such, Husserl's and Heidegger's accounts of time are more fitting for our present discussion.

[102] 'Physical' may be another term requiring clarification. It is not physical in the same way a user walking from A to B is visible in that it is not observable and has no casual influence over other nearby material elements (e.g., small pebbles underfoot). However, the organism's body itself moves into different sites in physical space.

[103] This perhaps serves as a developmental analog to Uexküll's aforementioned ranking of higher species according to those that have access to greater amounts of complex sign-systems.

how temporality scaffolds these interactions. If indeed some crucial aspects of embodied-enactive spatiality are difficult to exhaustively capture *sans* any corroborating account of time, we can assert that bodily space, like macroscopic objective space (Rovelli, 2006), is inherently spatio-temporal in nature.

Ontologically, we are always somehow ‘ahead of ourselves’, becoming who we are through our actions, travelling along a meaningfully-structured life trajectory, or, better, straddling several interlacing trajectories (e.g., as spouse, citizen, parent, etc.,) that confer directionality while simultaneously imbuing our present and past with that same logic of significance.[104] A broader ontological notion of non-linear temporality as found amongst living beings continues to hold when we restrict our parameters to bodily space. Indeed, I claim that this somewhat complex phenomenon features a neural signature and a route to coherent expression within a neuroscientific framework.

To start with the simplest possible articulation of this idea, we can follow the phenomenologists and biosemioticians in asserting that the situated brain-body, while seated in the present, is often simultaneously directed towards forthcoming spatial interactions, which define its very situatedness. This future-directedness is a general ontological feature of lived spatiality but, in tool-using bodily space, is particularly factored into the agent’s ontic situation, thus becoming neurophysiologically measurable. As suggested, one key piece of evidence for this claim is that, upon simply touching a familiar tool, the brain-body’s primary mode of spatial-embeddedness shifts in direct accordance with the kind of task that the tool *would be* used for, despite no ‘real’ action taking place (Serino et al., 2007; Bassolino et al., 2010).

Cognitive semiotics may have a slight explicatory advantage over phenomenology here, as its pragmatist inheritance makes it take greater pains to emphasise the prominence enjoyed by *probability* in skillful interaction, in lieu of a more open-ended ‘potentiality’. One may find exactly this insight in Eco’s (1975; 1979) pragmatist-inspired account of probability. As Betancourt (2005, p.316) notes, for Eco probability “is a reciprocal connection between immanence and remembrance.” The function that prior exposure to a cultural artefact has is that, when it is subsequently reencountered, the unlimited potential roles it *could have* are whittled down to a which was already discovered as most

[104] For instance, one may become a professor by following an academic path, with a goal (e.g., furthering human knowledge) in mind. Upon reaching that goal, they may understand that their prior choices had led up to this current situation and the past had guided them all along, directing them through successive stages.

appropriate (Jones, 2002). Eco himself (1997/1999, p.206) notes that a "field of expectations" opens up, but that prior experience narrows down this near-infinite field of possible expectations to those most congruent with "context and circumstance" (Paolucci 2017, 2018). A cognitive semiotic account of situated tool-use thus suggests that the context in which one engages an artefact automatically suggests how one must use it, thereby drawing the agent into that particular, protended reality.

As discussed, when habituated agents grip familiar tools, the probability of them purposefully wielding them sharply increases if compared to when they simply observed one. As the specifically *tactile* (i.e., not auditory or visual) perceiver's imminent-future is now much more defined by the tool's associated utility, bodily space automatically reflects this newly opened-up spatio-temporal reality in its enactive interface. Furthermore, a specific action-possibility presented via tactile tool-perception is notably demarcated by the most *likely* way that the felt object is to be used. Holding a kitchen knife orients my body to the possibility of cutting a vegetable rather than my stubble, for instance. But, as always, this phenomenon is contextually mediated. A competitive knife thrower's enactive interface may enact a different spatial profile when holding it, so that the distance at which they habitually throw the knife aligns with their bodily space,[105] with an increased PPS emphasis on the knife-throwing hand in particular (Bassolino et al. 2010; Martel et al. 2016; Zanini et al. 2021), which is strikingly similar to Merleau-Ponty's exposition of the body schema (**1a.2.2**).

This protended 'possible-future', or perhaps more accurately 'probable-future', thus always inhabits one's spatial horizon, reconfiguring bodily space by pre-reflectively soliciting the agent towards enacting previously learned context-appropriate tasks under the right circumstance. Once more, it is clear that describing the brain-body's relation to its *Umwelt* in purely metric terms fails to capture the totality of the phenomenon of bodily spatiality. Whilst remaining situated within the present, it is always this futural, protending dimension of spatiotemporality that shapes, structures, and orients presently-situated bodily space in a manner that is both pre-reflectively experienced and empirically measurable. Indeed, compare Husserl's present time-consciousness, Heidegger's primordial temporality of Dasein, and Uexküll's account of intelligent long-term behaviour

[105] Our knife-thrower, if highly habituated, may even involuntarily have such an experience in the contextually-maladapted kitchen while chopping vegetables. The PrCC and MiP to this protended act while be dim due to the mismatch in context and action. Subsequently, a top-down process, even an automatic one (Cappuccio, 2023), will reorient the knife-thrower to the correct spatial situation.

or ‘plans’ to the following depiction of goal-directed movement across space found in Vignemont, Serino, Wong and Farne’s review (2021, p.10):

> Typically, while walking, the step that I make is made in the peripersonal space of my foot and, while I move forward, my peripersonal space follows-or, better, it anticipates my foot’s future position. Action guidance thus depends on the constant fine-grained monitoring and remapping of peripersonal space while the movement is planned and performed.

One encounters even here the acknowledgement that bodily space non-thematically anticipates the brain-body’s “future position” and that this continuous anticipation is wholly constitutive of the act of walking (and of ‘here and now’ PPS), not tangentially ‘tacked onto’ the body in motion by some discrete module or computational process. Yet this pre-reflective anticipatory scaffolding that guides action is not restricted to movements *simplicter*. Even more complicated movements, such as operating a computer, car or tennis racket, acquire order via the same constant, anticipatory remapping of PPS. It is this way that teleological actions enacted in space and time obtain a logical, meaningful spatio-temporal logic. Indeed, the early Heidegger similarly argued that “equipmental ordering derives from the directionality of temporality” (Malpas, 2000, p.213). One might therefore assume that interacting within the *Umwelt* in everyday life is constantly replete with these kinds of spatio-temporal phenomena, scaffolded by tool-use and habit, which we have now seen are essential to successfully operating in a qualitatively-structured *Umwelt*. This is why, in select cases, the ‘passive holding condition’ triggers PPS expansion whereas this effect was notably absent in most ‘classical’ experimental paradigms in which primate and/or human participants enacted novel, unhabituated tasks (Iriki et al., 1996; Berti and Frassinetti, 2000; Costantini et al., 2014).

In sum, as spatially embedded agents, the future always bears down upon one’s present, opening up possibilities for fluidly embarking upon contextual, forthcoming interaction(s) in the *Umwelt* (Gallese & Sinigaglia, 2010, 2011). But this phenomenon is not homogenously salient across all spatial situations. Because of the temporal scaffolding sedimented by habit into one’s enactive interface, an observable profile of tool-transparency (**2.1.3**) *sans* any actual tool-use is particularly pronounced when touching the computer mouse, cane or any other task-connected familiar object. In turn, the specific, meaningful action (e.g., navigating, cutting, typing, drinking, throwing) opened up by its tactile perception is dependent upon a prior familiarity with that object; an agent without prior familiarity with the object will not experience an opened-up horizon of possibility (Gallese & Sinigaglia, 2010) in the same manner as the habitual user. Accordingly, ‘passive’ tool-*perception* can display the same neurophenomenological profile as ‘active’ tool-*transparency*, which indexes the future-directedness of the agent’s spatiality as cemented by habit acquisition. However, the question remains as to how this spatio-temporal profile can be grounded in the framework of cognitive neuroscience, which shall be the focus of the subsequent section.

3.3 Embodied Simulation and Spatio-temporality

One strategy for operationalising bodily space’s spatio-temporal profile from a neuroscientific framework is by employing Embodied Simulation Theory (EST) (Gallese 2001, 2003, 2016, 2018; Gallese & Sinigaglia 2010, 2011, 2018; Jeannerod, 2001). EST has already been linked with both phenomenological (Gallese, 2003, 2011; Gallese & Sinigaglia, 2018; Zahavi, 2012) and semiotic (Gallese & Cuccio, 2018; Paolucci, 2021; Cuccio & Caruana 2023) accounts of mind in numerous research papers. For our account of enactive spatio-temporality, ‘simulation’ helps distinguish between an identical activation of neural pathways that *does not* correspond to identical behavioural profiles but *does* correspond with experiential profiles. Thus, the experience of tool-protension as described above correlates with neural simulation routines even when no behavioural tool-use actually takes place.

In a paradigmatic application of EST principles to bodily space, Gallese & Sinigaglia (2010, p.130) argue that, because the same neural pathways are activated in both real and simulated action, “bodily space is basically and constitutively given to us as the horizon of our own action possibilities”. This notion has antecedents in Merleau-Ponty, who viewed bodily space as a future-oriented fusion of perception and action (see **1a.2**). Thus, we need not be literally engaged in an action (e.g., walking, hammering, writing) for its end-goal inhabit our lived body, nor for our brains to produce task-specific activation profile.[106] Simulation-enabled spatial sense-making may even extend to the mapping of higher-order phenomena such as distal goals and action anticipation (Gallese, 2018). Once more, all these aspects of spatial sense-making manifest pre-reflectively by structuring one’s immediate sensorimotor opening onto the world instead of serving as fully-fledged, representational thought.

[106] Importantly, what can often delineate a concrete and simulated action is the *intensity* of neural activity (see Rizzolatti & Sinigaglia, 2007; Gallese & Sinigaglia, 2011b).

In this context, embodied simulations index a possible-future that currently inhabits the brain-body for which it need not be reflectively conscious (i.e., tool-protension).[107] The PrCC of these processes was described above using phenomenological and semiotic accounts of temporality. Recall that when habituated agents passively grip highly familiar tools, the potential action that *would* follow from actual usage impacts one's presently-situated PPS absent any 'real' action. Accordingly, an object perceived as a ready-to-hand tool simulates motor-pathways related to its usage precisely because the agent already knew *how* to use it. And, crucially, this simulation only occurs due to sedimented a know-how provided by habit (Gallese, 2016; Paolucci, 2021; Colapietro, 2009, 2021; Cappuccio, 2023). Moreover, following Eco (1975, 1979), we argued that a purely possible-action is narrowed into the most probable action coherent to that moment in a pragmatic "limiting of the unlimited" (Jones, 2002).

Accordingly, the brain-body 'knows' which simulation routine to run out of the numerous possibilities the tool *could* potentially be used for because of its inherent situatedness. Thus, when the habituated tool-user touches the cane (Serino et al., 2007), computer mouse (Bassolino et al., 2010) or other tool, her mode of situated spatial embeddedness, reflected in ES routines, becomes determined by the specific kind of action-possibility coherent with that tool's purpose. Thus, the brain-body automatically simulates the most contextually probable action *sans* any behavioural enactment, which phenomenologically corresponds to the task inhabiting the agent's immediate sensorimotor opening onto space.

Thus, in our specific case of ES, we find that PPS dutifully expands outwards to the tool to render it transparent exactly as occurs in real, concrete tool-usage (Serino et al., 2007; Bassolino et al., 2010); this solicits, suggests and/or prepares the agent to enact the task for real. Because the same activation of neural pathways occurs for simulated vs. real action without any corresponding behaivoural distinction, embodied simulation's role in our account is that of distinguishing between 'actual' and 'potential' tool-use when the experiential and neurophysiological profiles in *both* cases appear largely identical, perhaps aside from the metric of 'intensity'. Actual and simulated actions are two types of a common genus that share a form both phenomenologically and neurophysiologically; yet this is not the case for one crucial dimension: behaviour. Third-person behavioural

[107] Additionally, imagining an action recruits identical motor pathways as really enacting it (Jannerod et al., 2001).

observation of the tool-holding agent *per se* yields no information about correspondent occurrences at the neural and experiential levels.

This speaks to a guiding tenet of the present investigation: that agents directly engaging with the spatial world are profitably depicted in the framework of motor-intentionality, reflecting its phenomenological heritage. This consideration is important when considering that some scholars have accused enactivism of tending towards a revamped behaviourism (e.g., Block, 2005; Di Francesco & Tomasetta 2021). There is certainly partial justification for such a sentiment; like behaviourism, enactivism is suspicious of relying on inner operations as the best explanation for sense-making, instead favouring models of direct, practical engagement. Sharply distinguishing behaviourism from enactivism, however, is the latter's congruence with motor-intentionality. The MiP shares functional similarities with a behavioural description but achieves a fine-grained depiction regarding agent-object relations that behaviourism misses.

For instance, in Serino et al. (2007), both the habitual and non-habitual tool-holder exhibit identical behavioural profiles; each passively holds the cane. Yet what occurs at the neural, experiential and motor-intentional levels is highly heterogenous between each population. Accordingly, the neurophysiological signature (PPS expansion/ no expansion) correlates with differences in motor-intentionality (intending the tool itself vs. tool-transparency) and pre-reflective experience (stronger or weaker/no presence of the task-at-hand). Furthermore, as Gallese and Sinigaglia (2010, 2011) stipulate, visually perceiving a tool also neurally simulates its usage, but seemingly not to the extent of eliciting PPS expansion/tool-transparency. Typically, tool-perception is characterized by one or several action-possibilities being directly co-presented when perceiving a tool. However, while 'perception' is typically suggestive of visual sensation, it of course applies equally to tactile perception.

In our example, both visually perceiving and touching a tool presents the perceiver with the task that the tool is useful for, albeit diversely. It appears that visual perception of the tool does not induce a PPS expansion as in certain cases of tactile perception. Because the habituated agent's bodily space is heavily regulated by repeated uses of that tool, for them merely holding it elicits the task, with a corresponding neurophysiological and experiential profile. Accordingly, action-simulation reflects the fact that, when holding the tool, a possible interaction (e.g., lifting, throwing, opening) has increased its presence within the spatial situation. Agents who no longer touch a familiar tool are, of course, less likely to use it, entailing that that particular possibility no longer stands dominant on the agent's horizon of possibilities. There is a neural-phenomenological correlation here; as the neural simulation ceases, the task's presence dims. All of this may occur without any noticeable change in behaviour, thus subverting the charge of behaviourism.

Therefore, EST helps us articulate the sought-after brain-experience correlation to the temporal scaffolding of PPS, habit and tool-interaction, showcasing a mutual dependence between them. In such cases, the habituated brain-body pre-reflectively anticipates ('protends') the tool's withdrawal into transparency, allowing the task to appear as the primary motor-intentional referent, just as in 'normal' cases of tool-transparency. This is how the brain-body 'knows' how to automatically simulate a highly familiar tool's possible usage upon gripping it, as the spatially embedded agent is pre-reflectively and pragmatically directed towards forthcoming interaction. Subsequently, if this simulated action becomes actual, then the simulation ceases; the simulated possibility became a concrete actuality, enacted also behaviourally. Therefore, when possibility (tool-perception) becomes actuality (tool-transparency), the previous "manifold of action possibilities" shrinks to one 'action actuality', cancelling the other simulations.

EST thus provides a plausible theoretical framework for unifying body, space and time that may explain why rare instances of tactile tool-perception resemble the profile of tool-transparency. Expanding upon this line of thought, recall here that Gallese (2018) argues that ES also contributes to higher-order acts, such as distal goal mapping. This implies that a short or mid-term spatial goal can be immediately implicated in presently-situated sensorimotor cognition. Consider the distal, mid-term goal of buying food at the supermarket. Consequently, this goal produces cascade effects on how you are spatially embedded in your surroundings. If you intend to cross a busy road, your perceived spatial surroundings are innately structured to optimise this goal.

Instead of receiving a mess of undifferentiated sensory stimuli, the combination of bodily abilities (walking, looking for cars), immediate goal-directedness (getting to the other side), and higher-order purpose(s) (e.g., obtaining groceries) generates a cross-modal stabilisation of perceptual input on pragmatic grounds, globally directed towards successful engagement in the *Umwelt*. One sees a gap in the cars in the road *as a* place to cross, subordinated to the local goal of reaching the other side, pursuant to the higher-order purpose of entering the supermarket. Throughout, it is likely that different simulation routines prefigure one's actions before one takes them. Again, all of this pre-reflectively structures one's sensorimotor opening to the spatial world rather than (always) featuring as representational content of reflective thought.[108] Indeed, per Uexküll, one follows a continuously updated 'plan' that automatically maps one's passage from area A to B as a smooth, spatio-temporal succession (see **1b.2.3**).

After having explicated the spatio-temporality of bodily space and habitual tool-interaction alongside its neural correlates, we can briefly expand our conceptual territory by considering some conditions and exceptions. As experimentally demonstrated in Serino et al. (2007), an object's materiality is another constraint that contextually determines the brain-body's response to tool-interaction. Indeed, Heidegger (1927/2010) spoke often of the practical suitability of tools when articulating his notion of the ready-to-hand. For example, a small glass hammer is unlikely to withdraw into transparency when its wielder, however expert, is faced with a nail because of the functional incongruency between the material and task. In addition to such compatibility constraints, we might imagine two or more completely distinctive motor-intentional profiles arising from different individuals touching an identical tool. We here encounter an individuated version of the pragmatist's dictum that an object's meaning is regulated by its most likely usage according to context (Eco, 1979, 1999; Paolucci, 2018).

In such cases, I claim that each individual's bodily space protends the action that they are most habituated to, which structures their enactive interface and produces embodied simulation routines. Considering some of these cases will be informative to the spatio-temporal structure of tool-use. Imagine that, instead of a blind cane-user, a blindfolded professional javelin thrower is asked to grip an object of near-identical properties to the cane. It is possible that their acquired and entrained habit of javelin-throwing entails that their unique sensorimotor orientation to surrounding space manifests differently to the cane-user's. The habituated javelin thrower is accustomed to wielding the felt object within near-space whilst being visually attuned to far-space, where the javelin should be thrown towards. This particular bodily spatial alignment between near-space and far-space is notably divergent to that found in the PPS extension following cane-use.

For our blindfolded athlete, haptically perceiving a throwing-compatible, elongated tool likely elicits a temporary functional alignment between near and far-space otherwise

[108] I refer to the reader to Merleau-Ponty's (1945/2012) phenomenological reading of the Schneider case (Goldstein & Gelb, 1918). Due to a brain lesion, Schneider was robbed of several regular capacities such as (on Merleau-Ponty's account) an inability to project himself in lived space.

typically active during a real act of throwing, facilitated by related simulation routines. This functional alignment differs from the spatial profile operative during cane-use, despite the object being significantly similar in each case. All this is to say that different habits acquired by different individuals may sculpt the brain-body's automatic response to touching a tool in radically different ways, but always to anticipate the most likely forthcoming action. Thus, when gripping familiar tools, the brain-body neurally simulates and pre-reflectively protends its future enaction, which registers on the experimentalist's radar in the form of a measurable PPS extension (Serino et al., 2007; Bassolino et al., 2010).

Additionally, we should again erect a warning sign as to the danger of inferring a subjectivist ontology from this addendum. True, there exists subjective heterogeneity between the spatial profiles of simulated actions (i.e., between cane-user and javelin-thrower holding the same object) that hinges upon individual capability. Even if two distinct neural, motor-intentional and experiential profiles can arise from holding a singular object due to diverse networks of habits and associated simulation routines, both can nonetheless still be firmly placed within the 'public' *Umwelt*. Cane-use and javelin throwing are public, culturally-mandated acts (or 'interpretants' for Peirce) that existed prior to the empirical individuals who enact them. Individual users partake in the pre-existent, intersubjective, and rule-based acts of using them in the appropriate manner in the publicly spatial world. As Heidegger would've insisted, when throwing a javelin or navigating with a cane, I use a tool likely made by others, according to rules I did not create, and, if others are present, I exist in their world(s), and they in mine.

Finally, there may be a further outstanding debate as to whether potential actions are best described as 'simulated' in a phenomenological lexicon. Since 'simulation' and 'real' are traditionally considered antonyms, this proposed dichotomy may diverge from some phenomenological and enactivist accounts of temporal consciousness, Heidegger being the most prominent example. In a phenomenological lexicon, the future-directedness of the (simulated) action-possibility might be viewed as no less 'real' than the concrete action. All such acts are equally co-present in one's spatial being-in-the-world and differ only in their temporal profile, not in their ontological status of reality (Blattner, 1999).

However, it would be absurd to posit no meaningful distinction at the phenomenological level between concrete usage and simulated/potential usage. Certainly, the habitual tool-holder cannot claim to have hammered a nail after just passively holding it! Any such carpenter would not keep their job for very long. Indeed, the recruitment of neural pathways during an actual versus protended action are not interchangeable. While this remains an open question, at the neural level, the language of EST seems appropriate to distinguish between observable action that achieves its goal and that which has no behavioural register; in both cases, an experiential difference undeniably exists, likewise differing in a gradation intensity. Thus, positing a 'simulated' action as distinct from a 'real' action remains appropriate for detailing the neurophenomenology of tool-interaction in its spatio-temporality.

In summary, habit acquisition instantiates a longitudinal spatial relationship between the agent and *Umwelt* that sediments into a dormant capacity for contextual interaction that can be triggered whenever the spatial situation demands it, most prominently via the tactile perception of a familiar tool. This was further explicated by synthesising the frameworks of embodied simulation, phenomenological accounts of time and cognitive semiotic accounts of pragmatism. When a habituated behaviour is triggered by the situation, it manifests as a reflex-like ability to either actually perform a concrete action or, alternatively, elicits a protended action via embodied simulation that foretells or implores an imminent action of the same kind. At the neural level, this functions by eliciting the same neural pathways as when the action is really executed and is pronounced enough to show up on a neurophysiological register via a shift in PPS. Therefore, for habituated agents, simulated action-possibilities always exist on the horizon of the spatial situation as solicitations to be enacted in space, pre-reflectively structuring one's spatial embeddedness in the *Umwelt*. Like von Uexküll's migratory birds, the continuous manifestation of solicitous action-possibilities and simulation routines pre-reflectively orient the agent within a teleological trajectory, guiding them through successive 'heres and nows' that arise until the act's completion. Accordingly, just as situated spatiality is not metric, situated spatio-temporality is not chronometric.

Thus, we have concluded our final thematic analysis of object-interactions in space by disclosing their spatio-temporal structure, structured by habit and protension. This was achieved by drawing upon a variety of disciplines and triangulating them through the interdisciplinary framework of enactive cognitive science. For reasons outlined above, object-interaction appears largely incompatible with a strictly linear model of time,[109] as

[109] However, we must acknowledge that scientific paradigms have changed considerably since Heidegger wrote *Being and Time*. Sequential linearity as a model for physics and biology has been mostly displaced by

the phenomenon of habituated bodily space seemingly envelops past, present and future within a single spatial situation. This was a commonplace insight in philosophical literature, which now can be said to have a cognitive neuroscientific register also. To reiterate our core finding, the presently-situated tool-user can experience an action-possibility automatically soliciting them toward action (future) when merely holding the tool (present) due to having previously acquired practical know-how at some earlier stage (past). This activates the same PPS expansion via embodied simulation as seen during 'real' tool-use. This phenomenon also bypasses the prior distinction uncovered between tool-perception and tool-use (**2.1**), showcasing an important exception to this rule. Indeed, each temporal dimension converges during an act as simple as gripping a handle, exemplifying the more general way in which past, present and future consistently intertwine and co-determine one another as part of our embodied, spatial being-in-the-world.

4. Summary

Combining resources from across neuroscience, semiotics and phenomenology, this chapter has sought to explicate how *Umwelt*-embedded agents spatially relate to objects from an embodied-enactive standpoint, with a view to detailing the 'pre-reflective cognitive correlate' and 'motor-intentional profile' to bodily space, in addition to promoting the 'enactive interface' interpretation of PPS itself. With the assistance of these philosophical and empirical resources, we have thus examined an array of theories, data and concepts pertinent for disclosing bodily space. In doing so, we have uncovered several notable and mutually illuminating convergence points between these disciplines, demonstrating how combining resources from each discipline bolsters claims made in the others, hopefully enabling an integrative account of bodily space that achieves greater comprehensiveness than what each discipline might achieve separately. From these analyses, we have witnessed how such diverse disciplines can enter into a "mutually illuminative" relationship (Varela, 1996) that coheres with the definitively interdisciplinary thrust of ECS (Varela et al., 1991; Gallagher & Zahavi, 2012; Newen, De Bruin & Gallagher, 2018; Gallagher 2023), which helped us thematise the comparatively understudied theme of spatiality in ECS.[110]

complex systems approaches (e.g., Froese, 2010; Colombetti, 2018), which emphasises feedback, recursivity and dynamic coupling, concepts which arguably sidestep the early Heidegger's critical glare.

[110] Additionally, how a fine-grained examination of embodied-enactive spatiality contributes to ongoing conceptual and definitional debates shall be dealt with in detail in the final chapter.

We began this chapter with the negative assertion that any 'object' located in the human *Umwelt* cannot include entities such as protons, planets or peptides because such entities do not structure the way in which agents are spatially embedded in relation to tasks, goals and a general form of life. By contrast, tools (alternatively: *zeug* or *pragmata*), are defined by their phenomenological-semiotic relation to a meaningful action lying *beyond* the tool's objective properties, functionally nested within a wider network of pragmatic and cultural meaning. This core insight has scaffolded the conceptual purview of the present chapter. Unlike a positional, quantitative spatiality, a situational, qualitative spatiality is defined by an ever-shifting horizon of contextual interaction with objects, both potential and actual. Divergently contingent upon perception or actual usage, I aimed to showcase how useable equipment always contributes to the dominant meaning of the brain-body's acts of situated, spatial sense-making, either by continuously presenting action-possibilities or by reconfiguring bodily space itself whenever those action-possibilities are taken up (**2.1**), which simultaneously co-constitutes the situated agent's affectivity (**2.2**) and temporality (**2.3**).

By defining tools as 'meaning-carriers' (von Uexküll 1934/2010), we found that they manifest qualitatively by being spatially 'available' to agents in a modality describable as 'ready-to-hand' (Heidegger 1927/2010). Objects *are* tools insofar as they are directly 'cognised' in a manner emphasising their contextual utility over their objective properties (Dreyfus, 1990). The presence of such meaningful entities profoundly structures how embodied agents are pre-reflectively embedded in an *Umwelt*, defined here as a qualitatively relational space of meaning. As ready-to-hand entities, tools pre-reflectively solicit context-appropriate actions to those perceiving them, enabling agents to relate the spatial world pragmatically, qualitatively and pre-reflectively as well as physically, quantitatively and objectively.

Agents are thus tethered to their *Umwelt* insofar as tools continuously present them with interaction opportunities that, in turn, structure the horizon of possibilities open to them (Gallese & Sinigaglia, 2010), the precise content of which differs from place to place and culture to culture, since bodily space is always a contextually-grounded phenomenon. Conceived thusly, an environment *qua Umwelt* (Lotman, 2002) is a far cry from a sequence of sites mappable onto a Cartesian grid (Casey, 1997). Instead, the brain-body's surrounding space is referentially structured so that it is tethered to its *Umwelt* via possibilities, tasks and goals and not only via properties of width, height and depth.

To better demonstrate this, I first sought to disentangle tool-*perception* from tool-*use* at the experiential, neurophysiological and motor-intentional levels. To do so, I examined Merleau-Ponty's phenomenological description of 'hold' (**2.2.1**), noting that in real-life spatial scenarios, the tools populating *Umwelten* are rarely (if ever) mapped out equidistantly from agents.

'Hold' designates the existence of spatial distance in pragmatic and qualitative terms, which is experienced as a change in the influence that objects wield over us, sculpting both the lived and objective body for a forthcoming interaction. Indeed, if it is true that, as the concept of affordances suggests (Gibson, 1979), agents directly perceive tasks *in* tools (e.g., I see the ability to write *in* the pen), then closer tools entail that said tasks enjoy a greater presence both phenomenologically and physiologically, even to the extent of producing muscle activity in task-relevant body parts (Cardelecchio et al., 2011). Since each tool represents an action-possibility, and possibility defines affordance-perception, every visually perceptible unused tool surrounding the agent represents an action-possibility that is phenomenally brought closer via its proximity (Gallese & Sinigaglia, 2011).

Accordingly, an agent not currently engaged in any particular activity might be depicted as surrounded by various action-possibilities all featuring competing degrees of hold. Crucially, this open-ended, possibility-inflected relationship to surrounding tools in the *Umwelt* ceases if the agent chooses to *actually* use any specific tool. If, for any reason, one of the surrounding action-possibilities available is taken up and acted upon (e.g., I begin writing), then that prior action-*possibility* becomes an action-*actuality*. This distinguishes the profile of tool-perception from tool-use: in tool-perception, a tool is characterized by its solicitation to a relevant interaction, thus serving as an object of intentionality, with a corresponding MiP and PrCC. When that solicitation is taken up and acted upon, the tool remains an integral part of the dynamic; yet, to actually fulfil its role, it must slip into the background by withdrawing into transparency, ensuring that the task-at-hand *itself* now dominates the agent's primary motor-intentional orientation. Reflecting a philosophical heritage, this phenomenon was labelled 'tool-transparency'.

Conversely, when undergoing tool-transparency, the way in which agents are spatially embedded is considerably tapered by the current task-at-hand, whereby a previously open horizon of action-possibilities is narrowed down to a single, practical instance of interaction that replaces it. The enactive interface of PPS thus reflects this new bodily spatial configuration: during tool-use, the neural correlate to tool-transparency is that of visual receptive fields bypassing the agent's extremities, extending to the tool's outermost edge, returning to their original parameters only when the tool is put down (Iriki et al., 1996). Tool-transparency thus highlights the characteristic adaptability and plasticity of PPS, showcasing how bodily space automatically reconfigures itself according to situational demands as defined by the task-at-hand.

It was further highlighted that agents are affectively embedded in space in relation to objects in several important ways. Firstly, we saw how emotion is intimately connected with action and motor-intentionality, as exemplified in 'affective intentionality' (Slaby, 2008). This influence can occur subtly, without the agent's explicit awareness, endowing objects with a certain quality that accentuates effective interaction with them. This '1-to-1' dyadic, motor-intentional relation between agent and object can be cashed out in terms of 'valence' (**2.2.1**). Valence modulates the sensorimotor appearance and accessibility of surrounding objects; e.g., a desirable item appears closer, an unpleasant item seems further (Valdés-Conroy et al., 2012). But a frightening item might also appear closer, or increase PPS itself, as it greatly impacts one's spatial situation and thus prepares the agent to avoid or escape from it (Vangoni et al., 2012; Ferri et al., 2015). Affective intentionality thus facilitates contextually appropriate interactions with objects. It is noteworthy that valence interfaces with our prior discussion of hold, since an intentional-object of stronger negative or positive valence has a greater hold in the sense that it enjoys an increased presence that, like hold (Cardelecchio et al., 2011), can activate task-relevant body parts (Zanini et al., 2021).

A pivotal distinction proposed above differentiates affective intentionality from an affective *state* (or mood), the latter of which temporarily dominates bodily space *qua* enactive interface entirely (**2.2.2**). A dyadic intentional-relation is different from (but not incompatible with) these global affective states, such as those characterized by anxiety (Sambo & Iannetti, 2013; Spaccasassi & Maravita, 2020) or confidence (Masson et al., 2021), which cast the entire *Umwelt* in a specific light, even if no delineated intentional-object caused it. Bodily space can thus be embedded in the *Umwelt* according to a dominant affective state's disclosive logic, which modulates all inner-*Umwelt* entities according to this logic, co-constituting how other entities manifest themselves.

Fear and confidence served as case studies that map onto negative and positive valence and spatial 'closedness' and 'openness', respectively. Furthermore, we saw how a state can be longitudinally dispersed in the form of a trait (Sambo & Iannetti, 2013). Critically, there need not be any specific intentional-object that increases confidence; inducing confidence with testosterone (Masson et al., 2021) or by asking participants to recall positive memories (Vergallito et al., 2019) triggers an omnidirectional PPS expansion that automatically reflects an increased openness to the surrounding world. Affectivity thus profoundly co-determines how agents find themselves spatially embedded, both in the sense of affective intentionality and the way that moods sculpt the overall tone of PPS. Moreover, 'hold', taken as a confluence between salience and solicitation, is clearly influenced by valence, whereas an affective state is analogous with 'tool-transparency' because both modulate how *other* entities in space are made accessible to the agent.

Finally, we examined how habit and temporality structure bodily space. Namely, habit instantiates pragmatic associative relations (between, for instance, tools and tasks or objects and the emotions they elicit) and sediments these relations into one's enactive interface on a longitudinal basis. This effect apparently bypasses our previously stated distinction between tool-perception and tool-use. Whenever we act upon object-affordances, they (tools) are included within our motor-intentional orientation to *other* entities, determining our current mode of spatial embeddedness. As demonstrated, purposeful action is typically indispensable for this withdrawal and subsequent embodiment of tools. However, in some cases of 'passive holding', habit has deposited a 'trace' of prior interaction that is permanently stored in one's enactive interface, which drastically alters spatial embeddedness when triggered. *How* it is triggered appears crucial. When habituated agents simply hold familiar tools, bodily space suddenly reorganises itself according to task-appropriate action despite no corresponding behavioural enactment. The action-possibility that the tool enables thus solicits the enactive interface by presenting the task as a potential reality, featuring both an experiential and neurophysiological register, the latter of which is explicable via Embodied Simulation Theory (e.g., Gallese, 2004, 2006, 2018; Jeannerod, 2001; Gallese & Sinigaglia, 2011; 2018).

Drawing upon phenomenological accounts of temporality (e.g., Husserl, 1921/2001; Heidegger 1927/2010; Gallagher, 1997), we further highlighted how habit showcases world-embedded bodily space as a temporally extended yet non-linear spatio-temporal phenomenon (**2.3.2**). Even when spatially situated in the 'here and now', a prior familiarity with a gripped tool directs agents toward its future enaction. Because the spatially embedded brain-body is always sculpted by forthcoming activity, the future-directedness of tool-using spatiality is thus particularly salient (and scientifically measurable) under certain conditions, such as when holding a highly familiar tool. In a less pronounced way, even when looking out onto space, future interaction with an object or place is phenomenologically protended and neurally simulated *before* actually embarking upon said action. Therefore, we are never enclosed within a spatial here or now but extend into our modal possibilities (Gallese & Sinigaglia, 2010). Moreover, we found that habit is more so structured by probability than by pure potentiality (Eco, 1975; 1979, Jones, 2002; Betancourt, 2005; Paolucci, 2018). That is, habit teaches us the most likely use for our tool in line with the current circumstance, which automatically triggers the aformentioned alterations in experience and neural activity. Accordingly, as a space of meaning, both metric space and chronometric time fail to do justice to the enactive phenomenon of bodily spatiality.

Another key argument forwarded here is that bodily space reflects a more general way in which embodied agents are pre-reflectively embedded in an *Umwelt* and that underscoring this relationship of embeddedness performs an explanatory role. In paradigmatically enactivist fashion (e.g., Gallagher & Zahavi, 2012), I claim that this embeddedness permits successful spatial interactions without conscious deliberation on the part of said agents, as evidenced throughout the PPS experimental literature. Spatial embeddedness entails that agents predominantly engage their surroundings as meaningful spaces, and that 'meaning' in its various guises (e.g., hold, valence, habit, etc.) automatically guides spatial engagements before reflective cognition appears on the scene. My claim that PPS is reflective of a general modality of embodied situatedness, emergent in the form af an 'enactive interface', will be dealt with in greater depth in **Chapter 4**.

Thus, we can propose that pre-reflective embeddedness in surrounding space - as relationally structured by objects and their utilities and not (only) by co-containment within some topographical location (Malpas, 2000, 2008; Sloterdijk, 2012) - dictates the brain-body's most immediate cognition of its spatial surroundings (i.e., the *Umwelt)*. The complex network of meaningful relations that gives birth to this phenomenon is describable at both the first-person (pre-reflective, cognitive-experiential) and third-person (motor-intentional, behaivoural, neurophysiological) levels. Understanding this relationality is crucial to disclosing lived/bodily space itself. As spatially embedded agents, we do not passively receive input about a static spatial volume around us, nor is every area of space interchangeable with another, as it is in a Cartesian grid (Casey, 1997). Rather, zones of surrounding space are heterogeneously inflected with meaning as determined by the meaning-carriers (i.e., interactable objects) encountered there. In effect, what colours our experience of an *Umwelt* is the extent to which we meaningfully impact upon, or are impacted by, innerworldly objects dispersed within it. The 'enactive interface' of PPS represents the lived body's insertion into this world on spatial terms. This reciprocal and dynamic coupling between organism and environment, so prized by enactivists (Thompson, 2007; Chemero, 2009; Kiverstein, 2018) is thus exemplified in the meaningful spatial dynamic existent between agent and *Umwelt*, which is structured in accordance with the myriad of factors detailed in this chapter.

To briefly recap the core ideas formulated above, we discovered that the enactive capacity for spatial interaction with objects in the *Umwelt* is modulated by several key factors. We saw how nearby tools modulate ('hold') the sensorimotor system, as well as how they structure bodily space's morphology itself whenever agents use them whilst engaging in tasks (tool-transparency). Valenced affordances, present in the format of affective intentionality, also modulate objects' directly perceived meanings, guiding contextual interaction. Alternatively, bodily space can be globally configured into an affective state or mood; for instance, fear can dictate the global tone of the room and consequently the perceived velocity and location of all nearby or approaching objects (and opposite reaction is found in confidence). Additionally, the logic of an affective state can be observed in a 'spread out' fashion in the format of an affective trait, potentially influencing all spatial situations across a lifespan, albeit less pronouncedly.

Finally, our investigation arrived at the temporal structure that seemingly undergirds *Umwelt*-embedded bodily space. We saw that affordances are, in some sense, solicitations toward possible future-actions. Therefore, we are not imprisoned within an encapsulated now but rather face the surrounding world as a horizon of possibilities (Gallese & Sinigaglia, 2010). Moreover, we uncovered how particular modes of regular *Umwelt*-engagement become sedimented in the brain-body by learning and repetition (i.e., 'habit'). Habit sedimentation can be powerful enough to automatically present an action to a tool-holder *sans* any concrete action, directing the agent towards an imminent spatial enactment in the *Umwelt*. Neurally, this correlates with embodied simulation routines, which help distinguish between real and protended actions while also preparing the agent to embark on the action in space if necessary (Gallese, 2003, 2005, 2018; Gallese & Sinigaglia, 2010, 2011, 2018).

Thus, this chapter's three major themes of 'T*ool-interaction and affordances'*, (1) 'A*ffectivity*' (2) 'H*abit and spatio-temporality*' (3) have, with the help of our interdisciplinary investigation, hopefully, explicated the agent-*Umwelt* relationship as it exists in the format of a pre-reflective and pragmatic embeddedness within qualitatively-structured spaces of meaning, instead of as bits of extended matter contained in a grid, volume or empty void (Casey, 1997). But, even after carefully disclosing the *Umwelt*'s structure thusly, one must never lose sight of the fact that human beings do not exist as isolated organisms within these meaningful spaces. Rather, essentially every way of being in space is simultaneously influenced by the presence of other people with whom we share these spaces with, as well as the shared cultural-semiotic milieus that shape our most foundational capacities for spatial sense-making. Accordingly, in pursuit of further comprehensiveness for our enactive model of bodily space, we must turn next to the irreducibly intersubjective dimension of bodily spatiality, and thus move from the '*Umwelt'* to the '*Mitwelt*'.

Chapter 3: Bodily Space and Others - The *Mitwelt*

Chapter Overview

Thus far, we have uncovered bodily space as an individuated yet culturally-inflected and non-privative zone of contextual action-possibilities that is constitutively embedded within an *Umwelt*. We have further seen how a significant part of bodily space's structure, alongside lived space more broadly, is scaffolded by the availability of useful equipment found dispersed within this *Umwelt*. Because equipment structures the way in which the body is embedded in space, it was concluded that the phenomenon of bodily space is indescribable without accounting for the objects that it engages, pursuing a central claim that bodily space is inherently a relational phenomenon.

In this chapter, I develop the idea that surrounding space (*Umwelt*) is equally, or even more so, structured as an intersubjective space shared with others (*Mitwelt*).[111] It is thus equally erroneous to depict an 'individual' bodily space without factoring in the influence that others impart upon it. In a sentence: bodily space's structure depends on the existence of a public world in which we meaningfully act alongside others, in addition to one's capacity to accumulate learned skills, dispositions and cultural habits that develop over a lifetime of intersubjective and group interactions. This shift of focus from individual, tool-oriented spatiality into the realm of shared space (both with and without tool-use) is crucial for comprehensively disclosing bodily space. To introduce this change of focus, I will here give a brief overview of our operational definition of *'Mitwelt'* alongside individual bodily space's place within it.

Indeed, the very notion of a shared space that is of equal importance to 'individual' bodily space positions our discussion within classically enactivist territory (Newen, 2018; Froese et al., 2020). If lived spatiality is constitutively and irreducibly an intersubjective phenomenon, then the inherited Cartesian model of consciousness is seriously at risk. Leaving aside for a moment Descartes' actual model of objective space *proper*, if we apply the Cartesian model of consciousness to spatiality, we are forced to posit an individual unit of consciousness who is placed inside a spatially extended world with immediate access solely to its own, individual slice of occupied space (Arisaka, 1995; Malpas, 2000, 2008;

[111] Again, our division of *Welten* certainly should not imply that the worlds of objects and others somehow exist in separate spatial dimensions. Rather, I have adopted this strategy simply for thematic purposes and to organise the large amount of empirical literature available on PPS. Indeed, the first section should serve as a bridge between the *Umwelt* and *Mitwelt* by focusing on the observation of tool-use in social contexts.

Slotertdijk, 2012).[112]By contrast, the notion of social spatiality developed here entails that our most immediate understanding of our environment arises from the intersubjective reality of worldhood (phenomenology) and external, publicly-available sign-systems (semiotics) into which inidividuals are meaningfully immersed, and from out which individual consciousness develops. As agents spatially embedded in the world, our bodily spaces are always sculpted by the actions, intentions, words and moods of others just as much as our own. Therefore, as a space of meaning, the world is never a mere projection of meaning I that alone ascribe to it. Rather, as shown by both Heidegger and Peirce, it is structured by a pre-existing cultural meaning that I am thrown into and formed by.

Correspondingly, in cognitive semiotics, the anti-nominalism and anti-Cartesianism of Peirce counteracts any model of spatial consciousness in which we face a spatially extended world as solipsistic beings (Violi, 2008; Paolucci, 2021). Even the semiotic equivalent of 'individual mind', which we may take as 'interpretant', was considered by Peirce to be a "sop to Cerberus" (Paolucci, 2021, p.63), so was his reluctance to place semiosis in the mind of the singular subject rather than a community of interpretants who are introduced into semiotically-mediated practices. This certainly applies to the relationships between bodily agents in space. Indeed, for Deely (2015, p.273), reality is composed entirely of relations, including "the relations of physical bodies". As such, for Deely, semiosis is constituted by a 'suprasubjective' character that grounds the inescapable publicness of sense-making acts (or more specifically: their referents) and even intersubjectivity itself, insofar as even the most isolated individual exists in a world of shared cultural output and pre-existent sign systems, even if this hypothetical individual refrains from 'ontic' intersubjective relationships (Heidegger, 1927/2010).

Indeed, Heidegger and Merleau-Ponty arrived at parallel conclusions in their own phenomenological works. Conveniently for our analysis, Heidegger's treatment of the phenomenon of social being-in-the-world parallels ours by immediately succeeding chapters on tool-use and space. I would venture that this ordering is not accidental. The preceding chapters of *Being and Time* focused largely on object-interaction, distinguishing between primordial spatiality and the objectified spatiality that Heidegger insists is derivative from it, with the former hinging on the relational notion of 'worldliness'. Thereafter, Heidegger makes explicit that it would be philosophically incoherent to

[112] Malpas (2000) suggests that Heidegger inherits a Cartesian conception of the body that is bound up with *res extensa*, hence his sidestepping the issue of embodiment in *Being and Time*.

separate the '*worldly character of the world'* as lived by individual Dasein from the other Dasein co-existing within that world. That is, each individual Dasein does not experience reality as a singular discrete window onto the world but rather "the world of Dasein is a *with-world* [*Mitwelt*]". Indeed, throughout this chapter, I will aim to show that this fundamental philosophical claim can find empirical support.

However, the existential character of directly being-there-with-others [*Mitdasein*] in this *Mitwelt* must be uniquely analysed in a way that neither treats others as mere useful pieces of equipment (angering the spirit of Kant) nor as objectively present 'others' who fill up space within the objective world, intersubjectively accessible only through cognitive interpretation. In addition to claiming that an individual is ontologically constituted by the existence of others, Heidegger also proposes that it is an ontological feature of Dasein to exist in specific situations in which circumspectly being-with-other-Dasein is almost as direct and transparent as being a self-aware, individuated Dasein cognisant of one's inner thoughts*, a la* Descartes. We can turn to Heidegger's unique terminology to better understand this distinction, reapplying them to suit our current ambitions. While the terms '*Mitsein*' and '*Mitwelt*' are well-known, seemingly less well-known in the literature is '*Mitdasein*' [119/116]. *Mitdasein* is an important piece of terminology as it seemingly indicates the concrete *act* of Dasein engaging circumspectly with other Dasein, paradigmatically in reference to some shared goal or project.

True to form, Heidegger posits that the presence of others is fundamentally co-constitutive of Dasein's mode of being-in-the-world. Optimally, while we do not treat others as ready-to-hand tools, they are nevertheless typically engaged in a kind of ready-to-hand modality, as active participants in the shared cultural milieus that we inhabit, which, for the most part, do not present as something objectively occurrent but rather as inherently meaningful zones of inter-action. However, positing the dissolution of traditional subject-object metaphysics in favour of the unification between subject and object that arises during engaged practical comportment is perhaps easier to digest in relation to tools than it is to other people. That is, it is easier to imagine a merger between agent and tool, with the latter obviously subordinate to the former, than to imagine a merger between two separate people, with or without any obvious subordination, where demarcations between selves must still be operative. Indeed, a potential criticism of an enactive account of social spatiality to overcome would be that it fails to sufficiently acknowledge the demarcate boundaries existent between people (Jacob, 2011).

To anticipate this, I shall here outline a compatible account of 'minimal individuation', before showcasing how individual spatiality is still nevertheless predicated on a social spatiality. While, even for Heidegger, *Dasein* is always already co-constituted by others, it can *also* be open to the world as an individual, unique being. Clearly, I can keep a secret or entertain a personal opinion if I so wish; even as a servant or employee, I may retain a private opinion of my lord or employer. Just so, I apparently have access to private thoughts and autobiographical details that are not readily open to others, just as others have their own. More bluntly, if I do not drink water, it is only me who dies of thirst. This is all to say that some notion of individuality cannot be completely disregarded. Therefore, before showing how bodily space is a deeply intersubjective phenomenon, some minimal affirmation of the kind of selfhood enjoyed by individual agents is necessary. Indeed, even Heidegger clearly did not advocate for any doctrine of no-self, as Dasein is, at least in some respects, ontically separable from other Dasein, even if always ontologically co-embedded alongside them in the world. Thus, the perennial problem of selfhood is articulated by Heidegger thusly:

> [Selfhood] contains an ontic indication… that an I is always this being and not others, albeit an undifferentiated one. [The 'self'] is what maintains itself as an identity throughout changes in behavior and experiences *and in this way relates itself to the multiplicity,* (115/112; emphasis added).

For Heidegger, the self is that which retains its distinctiveness across changes in location, context and situation and engages with the multiplicity of *Dasein* who share this kind of uniqueness. This is to say, even if consciousness is not a self-sustaining substance that can be cleanly decoupled from society and culture, we should refrain from claiming that we exist only in absolute anonymity amongst crowds of intracultural clones. Heidegger adds that "we can probably always correctly say ontically of this being that 'I' am it'" (116/113) and later claims that being spatially 'here' (e.g., for me, at this desk, in this room, in Rome, Italy) underpins a sensible notion of selfhood. Even as a being whose consciousness is structurally dependent on absorption in a social world, I can be alone in a room whilst undergoing the unique experiences associated with such a predicament. Yet, simultaneously, others always play into the bass notes of this consciousness, even when nobody is around. Even while being lonely, loneliness takes its 'being' from the felt absence of others among a wider social world: in this way, Dasein is always somehow tethered to the *Mitwelt*, regardless of individual circumstance.

Thus, when engaging others in public, whereupon all parties share in a mood or perform a specific function, one temporarily becomes seamlessly aligned with others in reference to that shared commonality. One retains 'minimal (ontic) individuation' but essentially loses oneself as a fully demarcated Cartesian subject:

> One's own Dasein, like the Dasein-with of others, is encountered initially and for the most part in terms of the surrounding world taken care of that is shared [*Mitwelt*]. In being absorbed in the world of taking care of things, that is, at the same time in being-with toward others, Dasein is not itself (125/122).

Again, it is the ontic manifestation of this distinction that is most pertinent to our interdisciplinary aims here. In the previous chapter, we analysed spatial embeddedness by way of agents' concrete interactions with tools or 'innerwordly entities'. Just so, a prime example of the way in which agents engage the world non-thematically and in attunement with others is in the form of practical comportment with others towards a common end. Walking to a common destination, imparting a skill to a learner, even passing a condiment all structure the way that agents are spatially embedded in the *Mitwelt*. As articulated in *Being and Time*: "Dasein understands itself... in terms of its world, and the *Dasein-with of others is frequently encountered from innerworldly things at hand*"[113] (120/117, emphasis added).

Furthermore, as well as our engagement with objects, our being-with-others is founded upon a concrete, publicly-accessible world whereupon we act alongside others against various contextual backgrounds, populated by meaningful entities that are jointly available to us all. When I point to a book 'over there', the other can follow my gesture and see the referent that I point to. Not only do contextual objects make a place what it is (e.g., books make a library, medical equipment makes a hospital; see **Chapter 2**), but so too do the *people* we encounter there (e.g., librarians and students, doctors and patients). Other people and their actions, gaits, speech, uniforms, moods, and dispositions confer proper meaning to the school, the sidewalk, the subway, the pub, the restaurant, the gym or the manifold of places that one encounters in one's culture and epoch.

Additionally, recall that even von Uexküll (1934/2010, p.69/70), who indeed asserted that individuals inhabit their environments in the format of 'personal bubbles', added that these bubbles constantly intersect in the shape of shared sign-systems: "each of our fellow human beings [are] enclosed in bubbles that effortlessly overlap one another because they are made up of subjective perception signs." We might also recall Uexküll's foreign friend

[113] This category most prominently includes (but is not limited to) tools [*Zeug]*.

who, upon only seeing bars and holes when first facing a ladder, saw these geometric shapes transform into a ladder upon *witnessing another man* climb it.[114]

Merleau-Ponty (1964/2004; 1945/2012) likewise consistently emphasises how human beings engage in joint action and understanding as shared components of a single co-embodied act, or even co-define the bodies of each other. This is the case even before one can make any cognitively-based interpretations about the other. The term he chooses to describe this phenomenon is 'intercorporeality'. Important to note, however, as Marrotta (2012, p.144) illustrates, is that even this has an aspect of bodily selfhood:

> There is then, in Merleau-Ponty's account of intersubjectivity, no need for an analogical transfer in order to be present to another's 'seeing,' because my sentient body is not a self-enclosed identity, but rather, a 'limitless' and 'open-ended' schema. Its identity is accomplished (but never completely accomplished) in relation to others, other bodies, other expressive movements; it is accomplished, in part, by means o*f an ongoing self-differentiation*; (Emphasis added).

On the theme of semiotic perception, detailing how shared, cultural knowledge informs and penetrates perception is also a central task of Eco's *Kant and the Platypus* (1997/1999), considered the pioneering work of cognitive semiotics. Eco's method is particularly informative when considering cases in which the identity of a perceived object is uncertain, such as Marco Polo encountering a rhinoceros on his travels and believing it to be an (uglier than expected) Unicorn, or the eponymous platypus, a seeming hodgepodge of various animals to those who were first presented with it. Eco's aforementioned 'encyclopaedia' (1979) is again useful here, as the encyclopaedia acts as a repository of shared cultural knowledge that includes knowledge of things encountered via sensory modalities. It is also an enactive and situated phenomenon (Violi, 2017), as it links semantic, 'knowing-that' knowledge with pragmatic, 'knowing-how' knowledge (Paolucci, 2021b). One's cultural background is, therefore, rarely detached from the perceptual acts of the individual *interpretant* and thus the encyclopaedia (which is to say, one's culture) heavily impacts how one perceives entities in surrounding space (see also Cuccio & Gallese, 2018). As a cultural artefact, the encyclopaedia is far closer to a public telephone book than to a personal diary and, as we shall see later, the encyclopaedia's capacity to inform us as to the content of the other's mental state is highly situated and pragmatically ordered (Violi, 2017).

Thus, in cognitive semiotics, Merleau-Ponty's and Heidegger's phenomenology, and our own interdisciplinary account of shared space, we see that a significant portion of

[114] Today, we might assume that mirror mechanisms played a key role in this act.

embodied intersubjectivity is grounded upon shared interactions that are scaffolded by useful equipment, social roles (e.g., as colleagues, family members, party-goers, etc.) or other kinds of meaningful relations in shared space. Moreover, each place that we inhabit retains its own socio-logical structure that grounds the way the actors within these places behave (Casey, 1997; Malpas, 2008), with unique, culture-based narratives that govern action and expectation there (Greimas, 1971), thus providing a sensible ordering to one's dealings in the social world. Accordingly, the meanings of objects and signs, alongside the qualitative character of public places, seamlessly converge to pre-reflectively ground bodily space within a cultural *Mitwelt*. Indeed, all these stipulations presuppose a public and intersubjective world of which we are all an extension, and with which we can fluidly engage as co-participants, while implicitly trusting that others are equally tethered to this shared world and will interact with us in (somewhat) predictable ways.

To be clear, however, this conception of social space need not necessarily imply a constantly harmonious co-existence with everybody. Rather, bodily space's structure is inherently co-constituted socially independently of whether this sociality is cooperative, hostile, competitive, amorous, etc. My claim is that bodily space remains co-constituted by sharing a world with others irrespective of the qualitative modality in which it is shared. Indeed, even a fistfight involves two unified bodily spaces acting towards a common end. Thus, as Brandt (2020, p.42) shows, there are three basic ways to be socially spatial in a third-person, semiotic sense: *Prey* (O1), *Opponent*, *Predator* or *Competitor* (O2) and *Ally* (O3). This role-based dynamic typically unfolds in reference to a mutual Object (i.e., an entity that one shares or competes for). In such an example, Brandt asserts that: "in order for the Subject to take control of an attractive O1 for example, it has to counter an antagonistic O2"; this demonstrates how "subjectivity is embodied and situated, immediately involve [and] inscribed in a pluri-subjective drama" (p.43). How Brandt's tripartite classification of social-spatial schemas maps onto experimental paradigms will be dissected in the following section (**3.1**).

In sum, then, it is clear that for the disciplines of both phenomenology and semiotics, individual bodily space is something that is intrinsically shaped by the presence of others, as well as by our intersubjective interactions in space with them, often mediated through tools or cultural customs. This stands as negative evidence for a Cartesian viewpoint on both space and consciousness itself. If we were each locked into our own solipsistic perspectives, structured as a kind of 'tunnel vision' onto the spatial world, then any immediate effect that sharing a space has upon, for instance, tool-perception or affectivity would be null. Every individual would be banished to their personal bubble, remaining mostly unaffected by the sequestered personal bubbles of those with whom we co-inhabit surrounding spaces. Below, I intend to showcase the myriad of ways in which the contrary is the case. Indeed, as we will see, the empirical literature paints a remarkably convergent picture to that of our theoretical account of social spatiality. Henceforth, we shall again uncover several mutually illuminating convergences between the relevant philosophical and experimental literatures with respect to how embodied spatiality is intrinsically enmeshed in a public world and scaffolded by the spatial existence of others and their presence, actions, words and gestures. This will both mirror and enrich the prior chapter on object-interactions.

In what follows, I propose three major factors structuring the intersubjective dimension of bodily space that have emerged from the literature: 1) *Tool Observation and Co-transparency*; 2) *Social Affectivity*; 3) *Interaction*. Analysing each of these dimensions shall help us disclose how bodily space is constitutively embedded within spaces of shared, social meaning in a manner complementary to the prior chapter on the *Umwelt*, in service of a relational account of embodied spatiality from an enactive standpoint.

1. Tool-Use Observation and Co-transparency

1.1. Co-Transparency and Motor-Intentional Alignment

In a previous chapter (**2.2**), we discussed how using a tool triggers its withdrawal into transparency, facilitating complete bodily absorption into the task-at-hand. As transparent, the tool becomes a constitutive component of motor-intentionality, functionally directed towards something other than the tool itself. In turn, withdrawal engenders an extension of PPS to the tool's boundary for the activity's duration, as measured by receptive field extension (Iriki et al., 1996; Berti & Frassinetti, 2000; Iriki & Maravita, 2004). Crucially, when a 'passive holding' condition was introduced into these experiments, the tool-transparency effect failed to appear. This is because engaged world-interaction is typically a prerequisite for the current task-at-hand to replace the tool itself as primary motor-intentional referent, with this newly withdrawn tool being successfully *in-corporated* into bodily space.

However, as discussed, a striking counter-example to this general rule emerges when habituated agents touch highly familiar tools, since bodily space extends in anticipation of an imminent interaction, as sedimented into the enactive interface via habit (**2.3**). Now, we can analyse a second counter-example whereby ‘passive holding’ assumes the profile typical of tool-transparency for a reason other than (but akin to) habit-engendered protension (**2.3**). This is largely due to what I term ‘motor-intentional alignment’, which leads to what I term ‘co-transparency’. There are interesting and informative conceptual implications as to why (under certain conditions) PPS extends when tool-use is simply witnessed in others, but not enacted by agents witnessing it. Recall that bodily space takes much of its structure from practical engagement within a social world in which we meaningfully interface with similar others. As Heidegger noted, a prominent way in which we become acquainted with others is via reference to mutual tasks:

> The others who are ‘encountered’ in the context of useful things in the surrounding world at hand are not somehow added on in thought to an initially merely objectively present thing, but these ‘things’ are encountered from the world at which they are at hand for others [*BT* 118/115].

Correspondingly, several experimental studies have found that witnessing tool-use can engender PPS extension in passive perceivers of the act (Costantini et al., 2011; 2014). This provides further confirmation regarding the situational flexibility of bodily space with the additional caveat that this flexibility reflects an intersubjective way in which agents are spatially embedded in the world. As already intimated, we are not spatially situated as solitary and circumscribed beings encased in impenetrable spatial bubbles. Henceforth, we shall focus on a species of spatial co-embeddedness whereby the bodily spaces of participating parties communicatively intersect via reference to a single action, either performed or observed. Thus, the ‘enactive interface’ interpretation of PPS pursued here extends to cases in which agents embedded in the *Mitwelt* motor-intentionally align toward particular tasks, even if one party is not symmetrically included in its physical enaction. Indeed, this very asymmetry is itself disclosive of one important aspect of shared space: the interpenetration between visual perception, intersubjectivity, and the world of objects on a motor-intentional basis, even during divergent actions.

Specifically, a study by Costantini et al. (2011) introduced an important alteration to the classic PPS tool-use paradigm, yielding informative data for understanding the extent to which tool-perception and bodily space are moulded by a situated social reality. Namely, they examined how participants’ PPS responds upon simply witnessing another person use a long tool to interact with far-space yet without engaging in action themselves. Furthermore, this study featured an unambiguous phenomenological influence from the outset, with Heidegger’s notion of ready-to-hand incorporated into the paper’s title: “Tool-use observation makes far objects ready-to-hand".[115] The primary takeaway of this study was that participants who stood next to a confederate using a lengthy tool to interact with far-space (the confederates thus undergoing tool-transparency) simultaneously undergo their *own* process of tool-transparency.

Thus, under certain conditions, mere visual perception, alongside physically sharing a space with another, is sufficient to induce PPS to expand *as if* a tool were used, whereby the perceived intentional-object is suddenly registered as 'interactable' and thereby, as the authors claim, 'ready-to-hand'. This experiment showcases that witnessing objects becoming task-paired tools via bodily interaction causes the witnesser's PPS to mirror that of the active tool-user. Previously, like the foodstuff in the pre-tool-use condition in Iriki et al. (1996), the object's action-possibilities were not yet fully present within the agent's enactive interface. Indeed, the objects featured a comparatively weak hold due to being located outside of the observer's peripersonal space. Accordingly, even if the participants themselves did not personally explore the *Umwelt* with the tool, witnessing tool-use in action committed by another was sufficient to trigger tool-transparency. We might, therefore, label this phenomenon: 'co-transparency'.

In parallel with previously discussed experiments, co-transparency only emerged when tool-using confederates used their tool for a specific, goal-directed action; passively holding it was insufficient. However, Costantini and colleagues uncovered another caveat: observers had to hold a *similar* tool to that of the confederate for co-transparency to emerge. Participants holding short pliers or simple rods (both insufficient for interacting with far-space) did not undergo the co-transparency effect. For the observer's own PPS response to match the tool-user's, participants had to hold an identical or highly similar tool to that of the confederate. How this caveat reflects the way that the observer is co-embedded in space via the perceived other will be detailed below. Additionally, the same experiment found that subjects newly judged further away objects to be closer following tool-use observation, again demonstrating the interpenetration of action, perception and intersubjectivity in spatial cognition.

Crucial to the interpretation developed here is the idea of reaching space, which some (though not all; see Graziano, 2018; Hunley & Lourenco, 2018) researchers see as directly

[115] While the term 'ready-to-hand' arguably does not map on exactly here (because objects in far-space may still be ready-to-hand), this experiment showcases how the presentation of an object drastically alters as a consequence of action.

equivalent to PPS. Under normal circumstances, reaching space is broadly equivalent to a space of accessibility within the surrounding world. I can access what I can plausibly reach, and so this particular slice of the world manifests itself to me on a more pronouncedly interactive basis, determining the limit of PPS.[116] So far, so simple. With tool-use, accessible space increases because the tool allows agents to engage a larger spatial area. But if bodily space is indeed intrinsically social, then what is registered as 'accessible' hinges on how one is spatially situated amongst others in relation to this shared surrounding world. 'Accessibility' is not a solitary Cartesian affair, since as communal beings, we pre-reflectively experience the space accessible to others as accessible for ourselves too when it is directly shown to be so *through* the other. In other words, how we are pre-reflectively situated in our environment is immediately informed by what others can tell us about it with their actions.

There is likely a pre-reflective knowledge transmission at play here, whereby PPS instantly reflects what it has learned about the surroundings from co-specifics, provided that there is some kind of compatibility between both parties. In acknowledging via direct perception that further-away objects are, in fact, available for interaction with a tool such as that we currently hold, our phenomenal experience and neural activity are updated to reflect this new spatial reality. Even if we can technically reach an item with the tool we are holding, it is not necessarily also registered as 'accessible' if we remain inactive, as reflected by lack of PPS expansion in classic paradigms. Typically, agents must really interact with entities to render them as primary motor-intentional objects. But due to space's imminently shared nature, upon perceiving a further-away item becoming accessible to another, it likewise becomes a motor-intentional object for oneself too. As such, it seems accurate to propose that, due to their location in far-space, objects previously bereft of strong affording-features suddenly become infused with them after another person visibly engages with them, giving the said objects a new meaning and essentially manifesting to us as 'interactable' by proxy.

These findings indicate that one's spatial embeddedness is always sensitive to what one observes others do in our surrounding world, even if nobody directly or physically interacts with each other. When objects around oneself are directly observed as manipulable, one's PPS must keep up with this new phenomenal fact, shifting their mode of spatial

[116] Of course, as seen in Bassolino et al. (2010), digital and virtual technologies mean that, in the contemporary era, we have access to a far greater quantity of space than this.

embeddedness within surrounding space to pre-reflectively render those items as *manifestly* interact-able, as facilitated by motor-intentional alignment. Individual bodily space is therefore pre-reflectively shaped by entering into a particular socio-pragmatic situation which is defined by the tool's task and then cemented by the phenomenon of co-transparency. We may also consider that, in some cases (e.g., with technological artifacts) agents must already know what the tool's function is, relying on their implicit encyclopaedic cultural knowledge (Violi, 2017). Just as the ladder was first seen as 'bars and holes' for Uexküll's foreign visitor until he saw somebody climb it, co-transparency likely only emerges when the observer understands what the tool-user is doing, permitting motor-intentional alignment.

However, it is important to note some empirical and theoretical limitations to a notion of completely overlapping, socio-pragmatic spaces that occur during *all* cases of passively observed tool-use. As mentioned, co-transparency did not emerge in some experimental conditions. Subjects, in fact, had to stand nearby the tool-user while gripping a compatible tool with the confederate's performed action. But why this effect was observed only in the tool-compatible condition reveals some of the functional underpinnings of co-transparency and shared spatiality. As Costantini et al. (2011, p.2662) rightly note: "If tool-use observation always led to reaching-space remapping, regardless of the observer's actual possibilities to act, it would be definitely misleading, because it would represent out-of-reach objects as ready to hand". Indeed, co-transparency *must be* selective in order for our 'enactive interface' hypothesis to hold, as it is crucial that bodily space is sensitive to, and reflective of, situational demands, whereby not every instance of observed tool-use has direct implications for the observer's own spatial situation.

Like other dimensions of lived space, co-transparency is imminently contextual so that some kind of inter-individual compatibility between user and observer is necessary not only for select cases of co-transparency to emerge but presumably for normal, everyday spatial functioning also. Thusly, agents are prevented from rendering transparent all of the hundreds of tools that they likely witness in use on a daily basis. Instead, some kind of situated, pragmatic attunement must shape co-transparency with respect to *particular* tasks that we observe when near others. Otherwise, we would find ourselves (neuro)phenomenologically aligned with *every* task that we see others perform indiscriminately. Just imagine a brief walk down a residential street on a Sunday afternoon. You wouldn't want to embody your neighbour's hose as he cleans his car, your other neighbour's broom as she sweeps the floor and your postman's cart as he pulls it, all during a single outing; if so, one would be very spatially diffused![117]

In true cases of co-transparency, by contrast, an agent holding a task-appropriate tool witnessing another agent interact with objects in far-space with a comparable tool suddenly finds themselves spatiotemporally aligned with the other's motor-intentional orientation in space, pre-reflectively experiencing those very same objects as interact-able. On pragmatic grounds, the observer becomes pragmatically aware of the tool as a means of object interaction in their lived experience. Reflecting this change, the tool withdraws to become motor-intentionally transparent. All of this entails that the shared intentional-object shifts from background to foreground for the observer, assisted by the future-oriented nature of bodily space which anticipates imminent action, helped along by the public nature of semiosis that binds co-specifics together within a shared spatial reality.

By way of further explication of this phenomenon at the neural level, we can add that a kind of 'pairing' [*Paarung*] occurs between each party, a notion originating in Husserl's phenomenology of intersubjectivity in *Ideen II* and later redeployed to explicate mirror neuron functionality (Gallese, 2003, 2004; Zahavi, 2012). Indeed, noting the concept's similarity to MN functioning, Zahavi (2012, p.245) proposes that "for Husserl, the most basic form of empathy [involves] the pairing of self and other [which is] not initiated voluntarily".[118] Husserlian pairing occurs when two similar others, who are intrinsically cognisant of their similarity, find themselves naturally aligned and recognisant of each other on an embodied, pre-reflective basis. Or, in Heidegger's (1927/2010) slightly more esoteric language: "In being with and towards others, there is a relation of Dasein to Dasein… The other is a duplicate [*Dublette*] of the self" (p.121/124).

Gallese (2003, p.175) explicitly links Husserl's *Paarung* to mirror neuron functionality. Indeed, it is important to reiterate here that both mirror and peripersonal neurons cluster in the frontal lobe, in areas F5 and F4 respectively (Rizzolatti et al. 1997; Graziano, 2018). Intriguingly, Iacoboni (2008, p.21) tells us that mirror neurons were discovered due to "Rizzolatti's intuition" as to the existence of "space maps" in that zone of the frontal lobe. At the neural level, motor, premotor and somatosensory areas map the other's actions onto one's own sensorimotor system (Warren et al. 2006; Gallese 2018; Lomoriello et al. 2021).

[117] It is possible that some kind of 'spatial diffusion' characterizes intersubjective bodily space in schizophrenic spectrum disorders, as we shall see later.
[118] See also Sykes (2021a) where I discuss this in greater detail.

The social and sensorimotor-spatial areas of the brain are thus seemingly in close communion both functionally as well as topographically. Accumulatively, these data suggest that 'Pairing' is thus a paradigmatically embodied and space-centric version of intersubjectivity since its emergence requires two (or more) embodied agents to be present in close proximity, in which the other is 'mirrored' both neurophysiologically and phenomenologically.

While *Paarung* appeals to a more abstract, universal humanity (we intrinsically know that others are somehow like us and the brain-body reacts accordingly) it emerges most concretely (or at least measurably) in 'local' cases, such as holding the same tool within the same space as another, which produces a mirrored PPS response likely subserved by MNs. Indeed, core to mirror neuron functionality is that MNs need not activate for 'mere' movements but for meaningful actions, forging a motor-intentional link that unities agents with objects (Rizzolatti et al. 1988, Gallese 2003). Because the other's meaningful intentionality is perceived and/or simulated, the observer's PPS pairs with that of the observed party, sometimes irrespective of the harmony or quality of the social interaction at other levels. This entails that the brain-body 'pairs' with the other at higher levels of meaning, allowing the spatial experience of one individual to be partially 'imported' to the other, under the right circumstances (see Gallese & Sinigaglia, 2018).

Regarding co-transparency, we can conclude that, for two nearby individuals, their motor-intentional alignment towards a mutual intentional-object is pragmatically ordered, so that the passive observer's bodily space reflects either the other's motor-intentional profile essentially mirroring the world as presented to the other individual, or, instead, anticipation of a likely forthcoming interaction. [119] In any case, motor-intentional alignment facilitates this effect. If we each inhabit the same spatial zone, hold the same tool, and our attention becomes jointly fixed upon the same intentional-object, it likely follows that some variety of co-operative or similar bodily interaction will be forthcoming. As such, our enactive interfaces must reflect this new reality by either mirroring each other or motor-intentionally converging, often with interchangeable results. Whether co-transparency occurs by protended interaction or direct mirroring is an open question, but either case ultimately supports the idea that one's spatial world is profoundly and irreducibly intersubjective. Here, it is as if two *Umwelten*, (which, though always

[119] This can also be sedimented via habit; see chapter 2 section 3.

ontologically connected, may be ontically separate) strengthen their junctions via reference to a shared entity.[120]

Subsequently, the same research group (Costantini et al., 2014) conducted a follow-up experiment with a similar set-up, this time with a neuropsychological patient and employing an elongated stick and laser pen. Recall that Berti and Frassinetti (2000) found that using a stick to bisect a line in extra-personal space induces tool-transparency whereas using a laser pen does not. Notably, the subject in question was a patient ('P.P') with hemispatial neglect located in near-space. Hemispatial neglect patients suffer from brain lesions in which there is neglect for the side contralateral to where the brain lesion is located (i.e., a left-hemispheric lesion obliterates visual input on the right side). For P.P, neglect was localised to near-space but, due to tool-transparency, temporarily extended to far-space. Tool-transparency thus 'closed the distance' between near and far, causing the neglect previously in near-space to expand outward into far-space (see **2.1.3**). Costantini et al. (2014) expanded upon this line of research by combining the Berti and Frassinetti (2000) paradigm with their own prior study (Costantini et al., 2011) to discover if the two effects were compatible.

Costantini and colleagues recruited another patient ('S.B.') with hemispatial neglect in near-space, testing two conditions: one in which S.B. observed the confederate bisect a line with a laser-pen, and another with a stick. In each condition, the patient held the same tool as observed in usage. Supporting the findings of the studies preceding it (Berti & Frassinetti 2000; Costantini et al. 2011), only in the 'observed-stick-use' condition did S.B undergo 'co-transparency'. Generally speaking, while passively holding a stick fails to engender the functional pairing of near and far-space found in tool-transparency, the intersubjective nature of spatiality means that pre-reflective 'pairing' can render it so even without action on the part of the observer. I labelled this effect 'co-transparency' since both observed and observer undergo tool-transparency simultaneously, even if only one party in the shared space need actually utilise the tool via the power of motor-intentional alignment. Costantini et al. (2014) further demonstrated that co-transparency is sufficiently influential that the neglect located in S.B's near-space extended outward into far-space, even without any interaction there on the part of the observer. Thus, both the

[120] However, while aligning, they do not necessarily merge. Cases of bodily space merging 'proper' will be dealt with in the final section of this chapter.

pre-reflective perception of surrounding space and PPS size are intimately attuned and tethered to the actions of others, penetrating even to the level of neuropsychopathology.

In sum, the Costantini et al. (2011; 2014) studies sharpen our understanding of the interplay between individual and shared bodily spaces, bypassing any strict dichotomy (and indeed showcasing a Peircean continuum) between them. As the authors agree,[121] co-transparency based on unidirectional observation facilitates a temporary joining of two *Umwelten* within a *Mitwelt*, or at least a substantial strengthening of a junction that already existed there. However, this begs the question: what occurs if closeby agents are not oriented to the same object cooperatively, but competitively?

1.2 Shared but Separate: Antagonists and Allies

As should be clear, the motor-intentional unification of bodily spaces discussed above arises pre-reflectively; bodily space simply automatically realigns itself to mirror the new logic of the shared, spatial situation. Above, we analysed motor-intentional alignment in its broadly cooperative format. Unfortunately, our spatial lives are not always so harmonious; frequently, you and I may each be oriented towards the same item yet positioned within a competitive schema. As introduced above, in Brandt's (2020, p.42) semiotic account of 'basic' intersubjective spatial consciousness, he posits a tripartite model that broadly covers the formats in which the other might be engaged: as *prey* (1), *opponent* (2) or *ally* (3). Each of these interactive schemas follows a distinctive semiotic logic so that competition (2), like cooperation (3), registers an observably distinctive spatial profile. Still, even when the self-other relation is antagonistic (1/2), the other is no less an active participant in shaping the spatial situation, as we shall discover.

Traditionally, competition arises from the scarcity of singular items jointly present to two or more individuals or groups. Should we be in competition with the other party for a single, scarce resource, we may not align with their bodily space in the same manner as found in co-transparency, yet we are in another sense their physical mirror image. Conducive to the 'lived/objective' distinction pursued here is evidence that some MN populations map surrounding space in metric terms but that other MNs map space in 'operational' or pragmatic terms (Lomoriello 2023, p.8) which occurs in both an ego-centric and 'we-centric' way (Gallese, 2003), as to account for the possible actions of others

[121] Personal communication.

(Caggiano et al., 2009). Thus, here we should expect to see that competition has an automatic imprint upon bodily space that, while minimally individuated, takes place within this 'we-centric space' (Gallese, 2003), partially facilitated by motor-intentional alignment. Within this we-space's competitive configuration, agents may align and mirror each other but without doing so in a congenial manner. Simultaneously, this spatial dynamic between competing agents will continually take into account the possible future actions of the other in a manner reflecting peripersonal space's anticipatory nature (Serino, 2019; De Vignemont et al., 2021).

To return to a core theme, as an inherently situated and 'worlded' phenomenon, bodily space automatically reflects the quality of one's social relationships. Accordingly, if perception of objects in surrounding space is always informed by situated social reality, then competition or an asymmetry in social status should produce a unique social-spatial signature. After all, two people can attune to each other in an interaction while remaining in distinct roles (e.g., professor and student or warden and prisoner).[122] Primate studies (Fujii et al., 2009) have indeed found that the parietal activity typically activated by the perception of useable objects placed within PPS was reduced when a more dominant monkey looked at that same object. This discrepancy in status rendered the perceived object to become 'not really mine' for the lower-status monkey, despite no objective changes to the object's form or position. Constable et al. (2011) showed that reaching actions towards objects diverged according to whether it was assigned to themselves or to the experimenter. This evidence further showcases how being spatially situated hinges upon the phenomenological-semiotic meaning that currently infuses one's surroundings, whereby 'higher-order' social complexities (e.g., social role, property rights) exert influence over 'lower' sensorimotor (i.e., visual intentionality) cognition in the enactive interface of PPS.

Bloesch et al. (2012) and Abrams and Weilder (2015) report behavioural evidence for this same general phenomenon in humans. Firstly, Bloesch et al. found that, for observers standing next to a tool-using confederate acting upon far-space, the object interacted with appeared closer, as measured by self-report. This finding seems to further support our concept of co-transparency. However, Expanding upon this finding, Abrams and Weilder

[122] See the previous discussion of the spatial consequences of social role in light of the semiotic work by Sebeok in **1b.2.3**.

(2015) subsequently aimed to provide evidence for one of two potential hypotheses. Namely, they inquired whether agents who observe tool-users: *a)* isomorphically simulate the observed action from an identical perspective as others or *b)* include the other's actions into their *own* sensorimotor perception of surrounding space. We might frame this as testing whether observers 'import' the other's egocentric motor-intentionality literally or instead enter into a 'shared but different' we-centric space.

To determine which, they also employed a behavioural experiment whereby participants observed confederates acting upon an otherwise unreachable object with a long tool before judging that object's distance. However, this design was previously only tested with *adjacent* confederates (Costantini et al. 2011; Bloesch et al. 2012). Notably, in Abrams and Weilder's study, confederates were placed both *adjacent* and *opposite* to the participants, with the latter set-up resembling a competitive confrontation. It was discovered that observing tool-using confederates causes the objects they interact with to appear *further away* when located opposite but *nearer* when adjacent to participants, even though the object remained in one location. As Abrams and Weilder note, this does not mean that, in the 'opposite' condition, the other fails to be included in the observer's understanding of near-space. By contrast, knowing that an item is more easily reachable by a possibly competitive other makes that item phenomenologically less proximal: since I am now less likely to successfully obtain that object myself, its phenomenal presence for me diminishes.

Abrams and Weilder (2015, p.4) claim that their results facilitated the selection of the latter (*b*) of the two competing hypotheses:

> Because actor and observer were always adjacent to one another in the earlier studies it was not possible to distinguish between alternatives, but we can do so now. In particular, observers assess the actor's impact on the environment from their own viewpoint. This rules out the possibility that observers simply put themselves in the place of the actor and simulate the actor's actions from the actor's viewpoint.

Thus, the empirical literature indicates that agents can engage in intersubjective spatial interactions whereby one party can mirror the other's actions via motor-intentional attunement while nonetheless retaining an individuated perspective. Agents who observe object-interaction do not completely lose grip of their egocentric space to merge seamlessly with the other's perspective. Recalling Heidegger's notion of 'de-distancing' (**1.3**) helps us understand that, when another person lays claim to an object, its apparent availability decreases, thus increasing its phenomenal remoteness, even if objective distance remains static. The world of objects is still largely presented on the basis of one's *own* abilities and capacities, as a sensorimotor grip upon the *Umwelt* (Gallese & Sinigaglia 2010; 2011; Rietveld & Kiverstein, 2014). But this world of useful equipment does not rest exclusively on one's own isolated, circumscribed cognitive tunnel, and is instead constantly informed by what our fellow human beings tell us about our shared environment (Costantini & Rizzolatti, 2011). As such, the other's impact is also included in one's individual enactive interface. Individual bodily space is thus moulded by our manifold relations with others, who inform us without words that certain objects are accessible or inaccessible, even if this very inaccessibility stems from the object belonging more firmly to *their* 'scope of potential action' than to our own.

However, the language employed in these studies might inadvertently imply conscious reflection on the part of the observers. By contrast, the inclusion of the other's perspective into one's own immediate experience of space occurs pre-reflectively, without conscious exertion. On this account, the other's presence is immediately included in one's situated perception of the object just as equally as its geometric form; each is equiprimordial, to use Heidegger's term, for perceiving the object in space and for the global meaning of the perceptual act. The presence of the other, alongside his adumbrated capabilities or potentialities (e.g., quickly grasping the object), are simply interwoven with one's own immediate perception of the *Umwelt* and the objects therein. 'Nearer' and 'further' have qualitative dimensions that are again decoupled from objective metric space and are instead intimately attuned to spatial dimensions of the *Mitwelt*.

Another relevant contribution to this scholarship we must note here is Patanè et al.'s (2021) introduction of the variable of 'ownership'. This study again highlights how conceptually complex, 'higher-order' social factors automatically impinge upon pre-reflective, sensorimotor cognition (Rietveld & Brouwers, 2017; Rietveld, Denys & van Westen, 2018). Specifically, Patanè et al. investigated how the observer's PPS responds to observed interaction with items assigned to themselves as compared with items assigned to the confederate. Both parties were assigned a colour-coded glass placed inside their PPS, noting prior evidence that measurable responses typical of affordance-perception are suppressed when objects are identified as belonging to another (Constable et al. 2011). In this study, greater visuotactile integration (a marker of PPS expansion) was detected when the observer reached for their own object and also when the other reached for the other's object, in an iconic, mirroring effect (see Cuccio & Gallese, 2018). Bodily space's neural profile thus mirrored the PPS processes of the other's reach towards their own object, supporting the results of Costantini et al. (2011; 2014) and the present enactivist account, insofar as PPS is sensitive to, and moulded by, situated social reality, subserved by both peripersonal and mirror mechanisms, even when the observer remains passive.

Crucially, subsequent to these results, a 'shared object' condition was introduced: the experimenters instructed participants that one green glass placed in the middle of them now jointly belonged to them both. According to our framework, this entails that the phenomenological-semiotic profile of the spatial situation has drastically changed. Previously, if a participant reached to grasp the other's glass, visuo-tactile integration would not occur. Yet subsequent to this 'shared glass' manipulation, the same action (namely, reaching to grasp a further away 'co-owned' glass) suddenly caused a VTI to emerge; this VTI also occurred while watching the other perform that same action. Crucially, all that had changed was the acknowledgement of the new social reality that this (objectively unchanged) object was now 'shared', thus not belonging to 'the other', entailing that the physical object underwent a 'my object' phenomenological-semiotic transformation that, due to the intersubjective nature of bodily space, automatically registered neurophysiologically.

Thus, either grasping a shared object or watching one be grasped – phenomenologically brought closer via co-ownership - both triggered PPS recruitment, as did grasping one's own object or watching a confederate grasp theirs. These results support the notion that the way in which the PPS network interfaces with the world of objects (*Umwelt*) is fundamentally shaped by the agent's embeddedness in the *Mitwelt* and helped along by ES routines. This finding demonstrates that even relatively 'higher-order' notions such as object ownership can be observably reflected in the enactive interface of bodily space. Because bodily space is a worlded phenomenon, the way that agents are spatially embedded within this world is always structured according to cultural norms and practices. If agents are to act fluidly within a *Mitwelt*, then, *qua* enactive interface, PPS must be attuned to such sociocultural intricacies (i.e., cultural norms of ownership) and automatically reflect them more quickly and urgently than is accomplishable by reflective cognition. Put differently, one does not decide how one's PPS divergently reacts to, say, either the shared or the personal object, PPS simply reflects the commanding social reality of the spatial situation which endows a given object with its contextual meaning.

Crucial to properly contextualising these experiments is reminding ourselves that neural mirroring need not be literally isomorphic in every regard; what is mirrored is the observed act's global intentionality (Rizzolatti & Sinigaglia, 2007; Gallese & Sinigaglia, 2011b; Cuccio and Gallese, 2018). As expected, when either participant 'crossed over' to reach the other's object, no VTI change was observed, indicating either no or a diminished PPS alteration.[123] This motor-intentional profile can be mapped in semiotic terms, as formulated in Brandt (2020, p.43), as 'antagonistic iconicity'. This is because the embodied simulation routine assumes an iconic relation between each agent's intentional orientation/action to a singular object that is competitive precisely *because* the routines and actions match each other in synchrony (Cuccio & Gallese, 2018). Since an icon can assume *either* an isomorphic or parallel relation, the fact that each party intends one singular object in the same way (with each party's perspective remaining linked yet individuated) destines an interaction to be competitive whilst displaying properties oftentimes found in collaboration and empathising acts.

While in the laboratory setting, this "semiotic drama" cannot approach the harshness of real-life competition (the stakes for participants are low), in ecologically valid encounters (very common in the animal world and occasionally for 'civilised man' too) antagonism between competing parties can be severe, even lethal. Simply consider two predators facing one freshly-killed meal. Yet, as stated, antagonistic encounters are no less intersubjective encounters than cooperative ones, as the other is implicated as an irreducible element in this spatial situation. Additionally, in real-life, cooperative scenarios, where the other presents not as an opponent but as an ally, we here nevertheless align with the other *qua* other, without ever mistaking our own experiences for hers, aside from in some clinical aberrations (Gallese & Ferri, 2014). Indeed, as Heidegger intimated, this minimal individuation is the marker of true intersubjectivity.

To conclude this line of reasoning, the final study that we shall mention is a recent experiment by Fossataro et al. (2023), which found that peri-hand space shrinks when

[123] We should add that the effect labelled here as 'tool-transparency' did not emerge because the action was very brief in duration. PPS expansion due to tool-use typically requires around 5 minutes.

another person's hand is nearby. Even with no physical object present, the possibility of world-interaction still appears shaped by the bodily presence of another. Indeed, bodily space *qua* horizon of action possibility (Gallese & Sinigaglia, 2010; 2011) is always informed by how we may be aided or constrained in our movements by the possibilities of another within that shared space. As we just saw, the mere fact that an object belongs to the other shifts the way in which we find ourselves spatially embedded in relation to objects (Fujii et al., 2009; Patane et al., 2021). It is possible that one's peri-hand space shrinking in size is therefore not merely an index of having to metrically share an objective space and thus having 'less room' but is also a reflection of the agent's implicit awareness that one must typically account for the other's scope of potential action upon entities within their own scope of action. This PPS alteration may stem from another's mere presence, or instead it might be moulded by an absent 'third' object, since, in ecological settings, physical objects usually scaffold and mediate how agents navigate their limbs in close-quarters within shared space.

Since, in ecological settings, witnessed actions are typically tied to their referent or intentional-objects in space (Gallese, 2004), my socially-cognisant peri-hand space accounts for the likelihood of a mutually accessible object there, even if none is directly present. Developmentally, children learn how to interact with others by passing objects, playing games, sharing toys, and so on. The other's hand as power for exploration has likewise accustomed my body, via habit, to expect the other to be interacting with nearby entities that impact upon my own action-possibilities. One's individual bodily space is thus shaped by the meaningful presence of both others and objects, retaining a permanent imprint of their existence within its own profile. Typically, we encounter others most frequently in the modality of contextual interaction with shared objects in contextual locations: we make room for them on bus seats, pass condiments on the table, exchange money at the till, use sports or DIY equipment in coordination and so forth. From its earliest developmental stages, therefore, bodily space is built upon the presence of others in the world in a way that matters for our own actions, bolstering the proposal that, even if tool-using space and social space may sometimes be experimentally separable (de Vignemont & Iannetti, 2015; Candini et al., 2019), they profoundly interpenetrate each other in almost all areas of life.

Thus, we have uncovered a further mutually illuminating convergence between prior philosophical accounts and contemporary experimental data. We shall conclude this section with a brief discussion on how the implications of these data converge with our theoretical baseline (**Chpt. 1**). The interconnectedness between others and tools in human social-spatial reality entails that learning how tools function, how to maintain interpersonal distance, and how to navigate public places are likely intertwined in normal development, with co-transparency and motor-intentional attunement assuming a major part in this story.[124] In essence, we learn how objects work from and through others within the public world and vice versa. For similar reasons, Heidegger likewise highlights how a shared concern or practice often lies at the fundament of our being-with-others, in a paragraph notably replete with spatial terminology:

> Being-with-one-another is based initially and often exclusively on *what is taken care together* in such being. A being-with-one-another which *arises from one's doing the same thing as someone else* not only keeps for the most part *within outer limits* but enters the mode of *distance and reserve* [122/119; Emphasis added].

Bodily space thus threads together the discrete but frequently interconnected meanings present in both objects and others in surrounding space, situated against a backdrop of cultural context that frames human action even when we are not consciously aware of its influence. An implication of a Heidegger's insight is here on display insofar as a prominent mode of "being-with-one-another arises from one's doing the same thing as someone else"(122/119); received ontically, this temporal conditional (i.e., 'at the same time') entails that, while lived space is ontologically public, its public nature becomes especially ontically prominent whenever we are both motor-intentionally directed towards the same object in the same space at the same time. Moreover, while mirror mechanisms are crucial for most forms of pre-reflective spatial cognition in a developmental sense (Gallese & Sinigaglia, 2011b), only when literally sharing a space can experimenters uncover direct and observable occurrences of neural mirroring in relation to shared objects. Indeed, as Costantini & Sinigaglia (2011, p.445) cogently sum up this phenomenon:

> The modulation of an affordance relation from an individual to another one is likely due to a space mirror mechanism that allows the individual to match others' surrounding space with his or her own peripersonal space, thus mapping others' action potentialities onto his or her own motor abilities.

[124] Notably, motor-coordination, object-interaction and social norms and personal space regulation are all disrupted in ASD, further implying their interpenetration in typical development. See also section **3.3b**.

Finally, again reapplying Peirce's concept of 'thirdness' for our purposes provides convergent illumination here. Bodily space in a social world is not only dyadic, synthesising observer and observed, but is rather fundamentally structured via synthesis *in reference to* a shared object (i.e., triadically). 'Thirdness' is thus the scaffold and enabling condition of motor-intentional alignment. As Fuchs (2018, p.193) corroborates, joint attention and action bring with them a "circle of primary, dyadic intercorporeality [that] is opened up and transformed into a triangle". This 'third' entity inaugurates this triangulation that elicits a temporary alignment between the bodily spaces of those within its gravitational pull, potentially assuming a variety of schematic forms in accordance with our biological nature and cultural norms. This third element, the intentional-object, thereby serves to attune the spatial interfaces of discrete individuals via motor-intentional alignment.

Here, bodily space's temporal dimensions again become noteworthy, whereby habit, a watchword of Peirce and Merleau-Ponty, entrains bodily space to adopt a form that is in reference to the objects typically present within shared surrounding spaces. This is clearly again in contradistinction to a Cartesian model of spatial consciousness. That is, as social beings, we become accustomed to sharing tools, tables, hallways, recreational activities, etc., which gradually moulds and socialises our body schemas in accordance with the manifold settings it typically finds itself in, people it encounters and the kinds of social customs that govern them. On a long-term basis, therefore, we become culturally unified with others (partially) via the objects that we practically engage alongside them so that our bodily space's structure develops alongside theirs and theirs alongside ours as 'co-inserted' within a cultural milieu.

In sum, retaining our driving hypothesis that lived space is a relational phenomenon, and that persons and objects confer a core structure to this nexus, we revealed that bodily space is tethered to its surrounding space via the objects that are wielded, perceived and grasped, by others as well as by ourselves, even when we are not mirroring their actions isomorphically or interacting with them directly. Developing upon findings from **Chapter 2**, we found that our relationship to objects in space is always already co-constituted by how said objects figure into our shared, social lifeworld. Reciprocally, how we relate to others is always already constituted by their impact upon surrounding objects, whether actually or potentially, or in competition or cooperation. Arguably, however, we have only focused upon intersubjective bodily space in comparatively constrained parameters, whereby, for physically close agents, a motor-intentional object for one enters the spatial-sensorimotor grip of the other. In this sense, one may argue that the intersubjectivity under examination here has been rather akin to Uexküll's own description of Homo Sapiens' *Umwelten* - as separate bubbles which unify via mutual perception-action loops and signs. In the following section, we will turn to an arguably stronger example of this phenomenon, namely, how agents become spatially aligned or intertwined with one another at an affective level.

3.2. Social Affectivity

In the previous section (**3.1**), we saw how agents spatially interface with others via the sharing of intentional-objects at the motor-intentional level. Here, we shall proceed onto how agents spatially interface with others at an affective level. As with the prior discussion, this section shall both parallel and enrich its counterpart in the previous chapter on tools (**2.2**). Affectivity is perhaps the dimension most closely associated with the 'defensive space' and corresponding 'second skin' (Graziano, 2018) interpretation of PPS. This is likely because fear (and potentially surprise also) triggers bodily space into an avoidant, high-arousal orientation towards the *Umwelt*. As the story goes, if the skin is a protective barrier, this 'second skin' adds a further layer of protection, keeping the world at a distance to prevent us from integrating with something or someone dangerous. But as discussed in **Chapter 2**, fear is certainly not exhaustive of affectivity's role in bodily space. Even more so with the *Mitwelt*, we interface with others in a myriad of ways that are not categorisable as defensive.

Since bodily space mirrors the broader way in which the lived body is spatially situated, it stands to reason that it engages the *Mitwelt* functionally, defensively and perhaps in ways that are distinctively affective yet are neither defensive nor functional. As spatially-embedded beings, the valence of nearby entities greatly co-constitutes how they pre-reflectively manifest to us (see **2.2.1**). As discussed, fear and its corresponding peripersonal consequences can be triggered by hazardous objects such as speeding cars or falling rocks but also animals such as dogs or, if one is very unlucky, tigers, sharks and snakes. But valence likewise dictates how we immediately encounter the other: as a friendly, threatening, alluring or annoying person, to offer but some examples. In turn, these aspects dictate whether we remain fundamentally open or closed in our orientation towards them, whether we can (or want to) ingratiate ourselves into their current opening onto the shared world.[125]

At almost every moment, moreover, we find ourselves spatially (co-)embedded in some kind of social context. In directly intersubjective encounters, for instance, much hangs on what the other person means to us within the unspoken context of the immediate situation: what kind of person they are, what they're likely to do, their possible compatibility, if they wield authority or require assistance, if they seem nice or nasty, etc. The semiotic notion of role seems of central importance here for mediating affective social responses (Violi, 2008); for instance, the other's sadness at a funeral might well induce me to tears, thus drawing me into their contextually appropriate affective state, whereas their sudden raucous laughter may not. Placial context, alongside the way that the other is affectively disclosed to us as part of this context, determines an intersubjective encounter's dominant meaning and, as such, we naturally find it reflected in bodily space.

Indeed, contextual factors contribute to how bodily space automatically responds to another's presence when encountered as part of the *Mitwelt*, with affectivity contributing to the making apparent of this contextual grounding. In simple terms, how we feel about the other, alongside the kind of setting in which we encounter them, goes far in making certain factors about them salient and instantly graspable. Affective framing (Slaby, 2008; Maise, 2013) is thus neither an abstract nor whimsical addition onto the pragmatically-ordered sensorimotor world; indeed, as articulated by two pioneering figures of the enactive approach: "In primates, especially apes and humans, affective comportment and sensorimotor coupling play a huge role in social cognition" (Varela and Thompson, 2003, p.19). Presumably, this coupling of sensorimotor and affective cognition applies to 'higher mammals' generally because what is unique to so-called higher animals is that they operate in complex social organisations. This supports the notion that sensorimotor capacities, affective input and sociality all co-constitute the enactive interfaces of sophisticated organisms, with human beings simply having "more sign-systems" (as phrased by von Uexküll) at their disposal, ensuring that a greater number of complex social artefacts derive from us and structure our *Welt*.

[125] Of course, some affective states may be too complex to be classified as simply 'open' or 'closed', such as nostalgia, apprehensiveness or resentment. Such affective states are certainly not diminished in this account but may exceed what can be spoken of meaningfully within an account of bodily space. However, see **3.3** for further detail.

An embodied-enactive account of spatiality should, therefore, emphasise the interpenetration between sensorimotor, social and affective dimensions of pre-reflective spatial cognition. As observed with object-interactions (**2.2**), affectivity need not counteract the body's practical physical abilities, shunning the pragmatic world and reinvesting into sentimental reflection or hysterical irrationality. Rather, affective framing informs the body's pragmatic, sensorimotor capacities and co-constitutes an optimal grip upon the surrounding social world that solicits us towards a suitable and socially appropriate kind of engagement (Dreyfus 2000, 2002). Affectivity is thus an ineliminable dimension of being spatially embedded in the *Mitwelt*. As such, we shall deal below with affective intentionality, affective co-attunement, empathy and other emotions, noting how they relate to bodily space generally.

2.1 Socio-Affective Intentionality

Previously (**2.2**), we saw how affectivity scaffolds the agent's spatial relationship to objects in two broad modalities: *1)* affectively-inflected intentional-objects (the *desired* chilled drink, the *feared* blazing fire); *2)* global affective states or 'Mood' (whereby all objects are tinted according to an affective tone). Broadly, this *individual* vs. *global* sub-categorisation of affective intentionality maps neatly onto social spatiality. To account for (*1*), we shall examine intentional affectivity as directed at co-specifics. However, this is not to suggest that no differences exist. Indeed, tools differ from persons in a glaring respect: tools tend not to reciprocate our emotional states. The fridge door handle is indifferent when we open it and does not share in our hunger or excitement in absorbing its contents. Interacting with others, however, is a different story, resembling a paradigmatic case of the dynamic coupling that is prized in enactive cognitive science (Thompson, 2007; Froese, 2011; Fuchs, 2018; Kiverstein, 2018).

As discussed, sensorimotor coupling can apply to a Husserlian 'pairing' between two agents directly (dyadically) or in motor-intentional reference to a singular object (triadically) (Gallese, 2003, 2004; Zahavi, 2011, 2012). Alternatively, an affective state can be iconically copied, or the simulation of it can produce a contextual yet completely contrary emotional state in oneself, e.g., I feel annoyance at the other's laughter during a funeral (Cuccio & Gallese, 2018). Most social interactions typically unfold through a series of such coherent, context-bound reactions (verbal, gestural, physical, etc.,) which converge into a synergistic and meaningful *Gestalt* (Fuchs, 2018). In normative social interactions, we continuously influence, mirror and 'riff off of' each other whilst partaking in joint actions and communicating verbally and sub-verbally. Throughout such interactions, participant's affective states continuously sculpt the ebb and flow of this dynamic, informing them as to how smoothly things are going, modulating their comportment and hinting at what is likely to unfold next. As we shall see, peripersonal space performs a pivotal role in this process's fluency.

First, however, let's lay down some theoretical cornerstones. Like Heidegger, Merleau-Ponty (1945/2012) tellingly deals with 'Others in the Social World' immediately after the chapters 'Space' and 'The Thing in the Natural World'. In this section of *PoP*, Merleau-Ponty aims to convince the reader of the shared world's ontologically manifest reality, dispelling any extant philosophical commitment to the notion that the other is ontologically constituted by the Cartesian ego. For Merleau-Ponty, the human gaze phenomenologically evidences such a commitment. As an expressive gesture, the gaze's very existence is presupposed by a wider, public world that threads together those in close proximity within a truly interconnected space, accessible to all present and serving as a common reference point for meaningful orientation. Co-embedded in this shared space, it is not only *I* who features as an intentional-object for *the other's* gaze, just as she can for mine, but the other's gaze *points me toward* certain parts of this shared reality that we are jointly tethered to, and, in principle, any aspect of this world can become my own intentional-object if the other directs me to it.

But it is rare that any such gaze be expressively neutral. In the *Mitwelt,* the gazes that one encounters are almost always configured into some kind of discernible expression. It is precisely the emotional expression, illuminating the faces of those we encounter, that makes manifest the kind of ontic social meaning currently pervading the spatial situation. As expected, experimental research aiming to uncover the same general phenomena has independently arrived at mutually illuminating findings. Accordingly, we can now turn to cases in which an expressed emotional state measurably affects the bodily space of another inhabiting the same *Umwelt*. We can now examine empirical accounts of dyadic affective intentionality in the *Mitwelt* and bodily space.

Ruggiero et al. (2017) and Cartaud et al. (2018) demonstrated that both PPS and interpersonal-comfort space respond to the perceived valence of the other, as gauged by a manipulated facial expression. It is the other's expression that, perhaps more than anything else, informs us that the other is taking us as an intentional-object. In turn, their expression dictates how we intend them in reciprocation (I am fearful, suspicious or angry at the angry other). Using Virtual Immersive Reality, Ruggiero et al. (2017) found that self-reported reaching-distance (indexing PPS) and comfort-distance both increased when facing angry but not happy or neutral faces. The authors speculate that PPS size increases because "anger prompts avoidant behaviours, and thus an expansion of distance, particularly with a potential violation of near body space by an intruder" (p.1232), as PPS expansion often indexes fear in this way (Vangoni et al., 2012; Ferri et al., 2015; Rabellino et al., 2020; Zanini et al., 2021). By contrast, we rarely aim to maintain distance from happy or neutral others.[126] The pragmatic, future-oriented dimensions of PPS thus again manifest here, since angry others receive a wider berth in anticipation of escape, or to give oneself more room to manoeuvre in interactions that may likely turn unpleasant or worse.

Subsequently, Cartaud et al. (2018) found that an angry face presented within PPS elicited a stronger electrodermal response than happy or neutral faces. Again, both the self-reported interpersonal comfort space as well as PPS 'action space' (measured by Reachability Judgement Task) were influenced. This suggests that intra-PPS angry faces elicit stronger physiological agitation and subjectively judged discomfort than other conditions. The authors (p.9) suggest that their results "showed that both peripersonal-action space and interpersonal-social space are similarly sensitive to the emotional meaning of stimuli, which suggests that they may rely on common mechanisms in relation to the motor action system". The motor-intentional dimensions of these two studies reveal that discrete spatial orientations to the environment arise when one encounters the other in an explicitly affective manner. When directly facing another human's gaze, we acknowledge they are currently intending us while, reciprocally, they serve as our own intentional-object. This dyadic relation shifts one's spatial embeddedness in alignment with what this other means for us in our situation. If they are happy, we are (typically but not always) happy for them to come closer. If angry, we anticipate trouble, keeping them at a distance and perhaps enlarging our PPS to reflect the likelihood of having to make quick movements to escape or confront them. Individual bodily space can thus be greatly and automatically determined by the affective intentionality of the other.

[126] However, interestingly, comfort space shrinks when people with depression face happy people (Iachini et al., 2015b).

Alternatively, affective phenomena not explicitly derived from others can also determine how I intend others in the social world. Tajadura-Jiménez et al. (2011) found that playing music provoking either negative or positive emotions influences the agent's comfort level regarding a nearby person. It was discovered that participants who listened to positively-valanced music were more comfortable with people approaching them and were also happier for them to stand closer. A positive disposition induced by music thus opens one up to spatial encounters with others, while negative music closes one off. The wide-reaching consequences of 'Mood' informs how one automatically encounters others within the *Mitwelt*, and this pre-reflective, affective filtering of others may even function somewhat independently of their outward behaviours or characteristics. That is, depending on the dominant mood commanding the spatial situation, the very 'same' person otherwise acting identically might present differentially had one just listened to sad or upbeat music: what appears during one mood as an endearing quirk might otherwise seem an irritating bad trait. Mood thus figures into the way that one is spatially embedded in the social environment by inducing a willingness to be either spatially open or closed to others, ontically manifesting in the experiment as greater comfort or discomfort for interpersonal closeness.

Once again, meaning performs a pivotal role in disclosing social-spatial intentionality, which is not reducible to the mechanical psychophysics of visual and/or auditory perception. Music is not *only* mere vibrations (Tajadura-Jiménez et al., 2011), nor is the other *only* a visual assemblage of photons psychophysically transduced via the cochlea and retina respectively, before being shunted to their associated sensory pathways. Rather, the meaning supplied via the music (or the other) determines both how I intend the other and the global way in which I find myself spatially embedded: as depressed or engaged, as able and willing to integrate with others or not. Moreover, because the social world does not present others to me solely on a one-to-one basis, 'third' factors like music or other artforms can readily mediate the *Mitwelt's* current manifestation and those within it. Indeed, this demonstrates that several people can be intended in accordance with an induced affective state; presumably, Tajadura-Jiménez et al. (2011) demonstrated that *all* others may arrive within close proximity to the subject without triggering a feeling of threat, not just experimental confederates.

It follows, then, that because PPS is an enactive interface that unites the agent with their social world, it is intimately co-attuned to the other's affective state(s) in accordance with the logic of the situation. Recall from section **2.2** that affectivity modulates how surrounding entities show up even if they do not serve as the direct cause of the affective state itself. Regarding other people, it appears self-evident that the valanced sounds that others emit (e.g., a soothing voice or an enraged shout) both provide vital information as to how to interact with them while perhaps globally influencing the agent's omnidirectional relationship to all surrounding entities (e.g., by being made calm or tense).[127] Just like objects, one can maintain an affective intentional relationship towards individual people (he annoys me, she surprises me) or one can be attuned to the social world generally as disclosed by Mood in a global sense (my good mood casts everyone in a positive light… after all, people aren't so bad…).

To reiterate the key point here: even if the other is not the source of the dominant affective meaning currently permeating surrounding space, the agent's relationship to innerworldly others is altered *by reference to* the valenced (i.e., meaningful) intentional-object. Meaning thus threads together the subject, the other and the music into one coherent *Gestalt* that discloses bodily space in its situatedness. Peirce's 'thirdness' is at play here once more, whereupon a triadic, meaningful relation (i.e., semiosis) determines, in this instance, what the other signifies to the interpretant: a possible threat (negative valence), a potential friend (positive valence) or a bland, anonymous figure (neutral). Indeed, a network of possibilities arises from a single sign based on "context and circumstance" (Paolucci, 2021), to which the other plays an indispensable role. Once more, this semiotic relation manifests pre-reflectively, simply presenting the surrounding world *as such* without requiring any decision on the agent's part for it to be so. And even if it is only my own bodily space that is modulated by the music, the contagiousness of mood likely entails that my easy-going demeanour (or scowling visage) spreads my mood onto others.

In sum, bodily space is affectively embedded in the *Mitwelt* in a multitude of important ways. One clear example is when one is taken as an affective intentional-object by another person and/or one takes the other as an intentional-object in reciprocation. At the pre-reflective and motor-intentional levels, our spatial openness to others is promoted by our positive feelings towards them, or, alternatively, their anger towards us causes

[127] An interesting empirical investigation that has not yet been conducted could focus on how differently valanced sounds influence the interaction with differently valanced objects or people.

peripersonal space to shift in anticipation of defensiveness, anticipating situational demands (Cartaud et al. 2018). Alternatively, we can speculate here that our own anger might make the other appear a hyper-salient intentional entity within surrounding space, enabling a clear focus upon them, with PPS expanding to facalitate action. Emotions thus inform and co-construct the intersubjective 'intentional threads' (Merleau-Ponty, 1945/2012) that bind us together in lived space. In short, the affective structure of intentionality can present others in a meaningful light that is simultaneously pragmatically grounded and oftentimes future-directed. While this dynamic typically takes form of a dyadic intentional-relation (intentionality terminates at the other himself), we shall next discuss affective intentionality in its triadic format.[128]

2.2 Affective Co-Attunement and the Embodied Abduction

As discussed, Merleau-Ponty forwards the case that intending the other, or them intending us, does not exhaust how intentionality structures the *Mitwelt*. Like Peirce, Merleau-Ponty believes that an anti-Cartesian position is evidenced when two or more parties intentionally align to a separate, third entity that is instantly communicated via a shared look. To analogous ends, Ellena et al. (2020) conducted an experiment that investigated how valanced facial expressions presented at diverse spatial locations influence spatial attention, inquiring into how the perceiving agent's visual intentionality is influenced by both the location of the expressive face and the particular emotion expressed. Crucially, they employ not angry faces but fearful faces. The experimenters claim:

> Our results show for the first time that a redirection of attention is induced by looming fearful faces intruding into PPS and also reveal the spatial logic of the redirection mechanism. Specifically, a fearful face has a centrifugal effect on attention, forcing attention towards the periphery (p.1).

Explicating this 'centrifugal' effect shall be the primary focus of this section: that is, a *nearby fearful* face, more pronouncedly than other distances and emotions, directs one's attention *away* from itself, as measured by a behavioural reaction to visual stimuli. Later, we shall see that this result has important conceptual implications. In a follow-up study, Ellena, Battaglia & Ladavas (2021) presented subjects with an approaching face displaying either a positive, neutral or negative emotion. This time, participants rated whether the face they saw expressed joy, fear or neutrality, as well as the emotion's intensity on a Likert

[128] We briefly discussed how the other can be modulated by a third element, which may count as triadic in a semiotic register. However, we will hereafter turn to cases in which the other attunes our own intentionality to a singular affective-object, affectively aligning two or more parties.

scale of 0 – 9. Skin conductance (SCR) was utilised to measure emotional arousal. The strongest physiological responses were registered in the 'Near Space+Fearful Face' combination, especially for faces expressing greater intensities of fear. By contrast, joyful faces did not produce any comparable skin conductance response. The authors suggest that the evolutionary bias towards rapid threat detection, alongside the PPS network's defensive functions, explains why fearful faces elicit stronger autonomic responses than joyful ones.

Thus, the authors found that the autonomic responses triggered by fearful faces nearer to the body (i.e., within or approaching PPS) are physiologically more impactful than both joyful or neutral expressions, as well as further away fearful expressions, consistent with both the extant PPS and affective neuroscience literature (Ferri et al. 2015; Maise 2013). Ellena et al. (2021) claim that their results pertain to the 'defensive' dimensions of PPS more so than the 'action' dimension, though they add that further research on affective, action-based PPS is warranted on this topic. Below, I will suggest how this can be the case. But independently of whether they pertain to action or defensive space, I aim to show that all results such as these strongly uphold the 'enactive interface' interpretation of bodily space and exemplify the phenomenon of 'affective co-attunement' whereby two or more agents become affectively attuned to one emotion-eliciting stimulus in shared space.

Reapplying the phenomenological notion of 'hold' (**2.1**), I first posit that facial expressions of people encountered within or approaching bodily space feature a greater psycho-phenomenal presence for the perceiver, thus enjoying greater power over their sensorimotor grip on the environment, which also registers psycho-physiologically via skin conductance and attentional focus. Because such faces wield a greater power over the agent, they assume a stronger, more pronounced role in determining the meaning of one's spatial situation. However, this could apply equally to anger as to fear. Why, then, is the 'centrifugal effect' present only for the latter emotion? Importantly, the fearful other attunes one to the same fear-inducing intentional-object, engendering a multiscale shift in PPS form, spatial attention and increased skin conductance simultaneously in alignment. The closer the negatively-valenced other is to us, the more likely it is that the danger that they signify is imminent, whether this danger stem from the other themselves (anger) or an unknown danger made manifest through them (fear). As we shall later see later, however, this introduces problems for a direct social perception (DSP) account, which has elsewhere been adopted here.

Another detour to Peirce's 'thirdness' regarding this redirection of spatial attention is illuminating here (Ellena et al. 2021). Let us stipulate that the experimental subjects witnessing the fearful face did not feel it was fearful *of them*, as was apparently the case for anger (Ruggerio et al., 2017; Cartaud et al., 2018). Indeed, Ellena et al. (2020, p.7) note: "fearful faces intruding into PPS may increase the expectation of a visual event occurring in the periphery", while Ellena, Battaglia & Ladavas (2021, p.2009) claim: "the proximity of the fearful face *provided a cue to the presence of a threat* in the environment and elicited a robust and urgent organisation of defensive responses" [emphasis added]. Thus, the fearful other acts as a cue foretelling danger with autonomic consequences that automatically redirect attention to the spatial periphery (Ellena et al., 2020). This 'cue', a species of sign that features both a triadic and anticipatory function, assumes a pivotal role in formulating the explanans for these empirical results. Specifically, the gaze *qua* cue signifies to its interpretant some kind of imminent danger which, crucially, cannot be directly present in the interpreter's own perception. Rather, this danger's existence is semiotically mediated, whereby the perceived, fearful other serves as an indexical sign *through which* danger becomes concretely manifest in the perceiver's situation, eliciting contextual behavioural and physiological reactions.

Contrast this semiotic mode of perception (i.e., affective co-attunement) with witnessing a facial expression worn by another person that takes *oneself* as an intentional-object as discussed prior (e.g., Ruggiero et al. 2017; Cartaud et al., 2018). Upon seeing a facial display of aggression directly targeted at oneself, one may assume an intentional relationship founded upon fear, shock or counter-aggression which is, in turn, intentionally directed back at that person in the form of a dyadic-iconic intentional relation. In this instance, the perception of anger may count as a direct perception (Kreuger, 2018; Gallagher, 2020). Unlike the angry person, fear itself poses no inherent danger but rather gestures toward it, indicating but not directly *being* the fear-producing entity. Instead, a triadic relation founded upon affective meaning[129] between *Perceiver*, *Cue* and *Signified* emerges through affective co-attunement toward some third, fear-inducing entity co-present somewhere in shared space.[130]

[129] See **2.2** for a discussion on semiotics and embodied affectivity. See also Violi (2008).
[130] This dynamic may also apply to other 'core' (Damasio, 1994) emotions such as sadness, happiness and surprise.

Such experiments again remind us of the central and inescapable distinction between lived and objective space; namely, that metric distance can remain identical across conditions while the (emotional, pragmatic) meaning of stimuli promote drastically different spatial realities at the level of meaning, which is what PPS is most responsive to. Once again, spatial distance cannot be exhaustively captured via objective measurement because it features an inescapable qualitative dimension of contextual meaningfulness, which can vary both in its general form and gradation of intensity. As discussed, another's strongly expressive gaze *means something* for our situation whereby simply witnessing it is sufficient to bring forth a spatial situation that automatically absorbs us as co-participants, with empirically measurable results. It was for such reasons such that Merleau-Ponty believed that the power of the gaze - and the automaticity of the responses it engenders - contradicts the solipsistic and Cartesian viewpoint that others must be ultimately constituted by an individual, knowing *Cogito*.

What is important to underscore here is how affective meaning, garnered via the other, is capable of permeating situated bodily space even when the cause of said meaning remains unknown and/or is mediated by another via semiotic relation. The way in which bodily space is spatially embedded in the world is thus inherently shaped by how others disclose this shared environment. As situated beings, the other's face (whether fearful, angry or joyous) can, if even just briefly, overwhelm its perceiver to dominate the way in which both world and innerwordly entities manifest. A strong version of this philosophical claim would run that the expressive, nearby other is equiprimordial in disclosing the nature of individual surrounding space as even our own bodily-motor capacities. It is for such reasons that Merleau-Ponty aptly declares that the "expressive instrument we call a face can bear an existence just as my existence is borne by the knowing apparatus that is my body" [*PoP* 409/367].

However, one may have spotted an outstanding concern requiring resolution: when conceding that bodily spatial modulations can occur by perceiving the other's emotion but *without perceiving its cause,* for this unknown cause to produce an effect (i.e., centrifugal spatial attention, increased skin conductance), we seemingly enter the domain of inferential or even computational cognition.[131] While I am sympathetic to the idea that

[131] To reiterate what was said in the introduction, this account certainly does not deny the existence of these forms of spatial cognition.

agents achieve direct access to their co-specific's fear (or joy, sadness, etc.) by witnessing their expression, this phenomenon cannot extend to whatever produced it. Instead, while we co-experience (or simulate) the other's emotion upon perceiving it, this directness cannot carry over to that emotion's unknown origin. You may be afraid, angry or excited by any number of potential causes of which I have no idea. Indeed, the very notion of 'cue' potentially precludes a DSP account by definition because there is an undeniable cognitive asymmetry between the fearful person (who presumably knows why he is afraid) and his perceiver, who may directly perceive the expression itself and experience the same emotion, yet its unknown cause remains outside of consciousness.[132]

If affective co-attunement to a perceived emotion's cause is solely achievable via a cognitive procedure or deliberative estimation, this entails that knowledge about both the minds of others and, to some extent, one's shared surroundings are indeed constructed or inferred as Theory of Mind (ToM) theorists have it (e.g., Frith & Happe, 1999), whereby the intentional-object of the other's fear is explicitly inferred from their visage. How, then, does 'inferential' social understanding interface with the embodied-enactive interpretation of social spatiality attempted here? Firstly, we should highlight that contextuality is always already at work in crafting a cue's meaning in-line with the place in which one encounters it.[133]

The experimental setting, while not literally context-less (i.e., it manifests *as* an experimental context) perhaps facilitates unavoidable ecological validity concerns. In real-life settings, agents do not face others in a void.[134] Placing the findings of Ellena et al. (2020; 2021) in an ecologically valid context via a conceptual add-on (Sykes 2021a) enables the recognition that no ecologically valid, semiotically-mediated threat *actually* encountered in real-life is truly experienced as an 'empty referent'. That is, within one's experience exists the traces of some *specific* kind of threat or, at least, a probable candidate when encountering the other's expression. And since contextuality mandates that the other's expressed fear does not take *oneself* as its referent but some third entity, bodily

[132] While fear continues to serve as our case example, the phenomenon under scrutiny is not restricted to fear and applies to other emotions, i.e., one may be affectively co-attuned, via the other's meaningful expression, to a surprising or joyful affective-object.
[133] The role of context in determining how a entity, sign or other is immediately encountered was a major commonality in the works of all of the thinkers analysed in **Chapter 1**.
[134] This is not a criticism of the studies. Even so, a centrifugal effect was found which I claim would also occur in a real-life setting. However, to explain this result one must imagine it taking place in an ecological scenario, as there is little utility in redirecting one's attention to another area of the laboratory.

space automatically readjusts under the ‘assumption’ that the threatening stimulus is nearby and imminent.

From these core elements, I claim that the agent automatically and pre-reflectively attributes some context-dependent specificity to this ambiguous threat.[135] Thus, PPS and related neurophysiological processes implicated in sensorimotor cognition must somehow work in conjunction with inference-like ‘cognitive’ processes to react fluidly and accurately to the ‘inferred’ threat without relying on reflective interpretation. To flesh out how pre-reflective, sensorimotor cognition unites with 'higher-level cognition’, an outstanding concern for enactive cognitive science (Rietveld, Denys & van Westen, 2018), we again turn to interdisciplinary syntheses of cognitive semiotics with embodied cognitive neuroscience. Cuccio & Gallese (2018) attempt to explain inference-like situated social cognitive processes via Peircean notions of ‘icon’ and ‘abduction’. Turning first to iconicity, we see that an iconic relation of similarity arises whereupon one agent perceives the other act or display an emotion whilst neurally simulating it, allowing some kind of experiential overlap. As Cuccio and Gallese suggest, the correspondence in each party’s neural activity resembles an iconic sign. A more straightforward example of this phenomenon would be a matched emotional state between an observing and observed party; e.g., when I observe disgust displayed by another, this triggers identical neural activation in my brain (Wicker et al., 2003).[136]

According to embodied simulation theorists (e.g., Gallese 2006; Freedberg & Gallese, 2007; Gallese & Sinigaglia, 2011; 2018), emotion recognition is assisted by automatically triggering the same neural pathways and facial muscles in myself as in the other. Importantly, an iconic simulation is not necessarily the “exact copy” (Cuccio & Gallese, 2018, p.5) of an observed state. Indeed, in classic MN experiments, it was noted that the observed act of grasping *for-something* was neurally simulated rather than the ‘pure’ anatomical movement of the arms (Rizzolatti & Sinigaglia, 2007). As discussed previously, what is actually iconic in such simulations is the goal or overall meaning of witnessed actions or states (e.g., reaching for an object). Thus, it is the other’s intentional orientation

[135] Indeed, de Gelder, Vroomen, Pourtois, & Weiskrantz, (1999) present evidence that, even in cases of hemianopsia, angry faces that cannot be visually processed due to a lesion can still activate the amygdala through the colliculo-pulvinar pathway.
[136] This in itself pertains to the intersubjective nature of lived space, but we are here focusing on a somewhat more complex scenario, in which the perceived emotions carries ambiguities as to its motivation.

(as manifested in their action or expression) that forms the basis of iconic social understanding, not the 'pure' action or expression in itself (Gallese, 2005; Zahavi, 2012). This qualification will be important when discussing the Peircean notion of 'abduction'.

As is common for instances of situated cognition, with embodied simulation accounts (e.g., Gallese & Sinigaglia, 2018), we see that several conditions are in place that determine the extent and modality by which others affectively co-attune us. While I might understand another's emotion directly, it is sufficiently abstracted so that I do not necessarily feel their emotion in exactly the same way; the iconic meaning that arises is not an 'exact copy' of the other's pain or joy. If we see a friend who is visibly happy, but we know we must tell them bad news, we iconically register their happiness, yet this happiness triggers sadness in us due to the knowledge that we must ruin it with forthcoming bad news. Moreover, the shared object of emotional arousal needs to be somehow equally present and motivating from within the observer's situation.

The fact that such stipulations either constrain or amplify the simulation and sharing of emotions is conducive to our 'worlded' interpretation of bodily space, whereby PPS reflects the optimal way of being embedded in the environment based on implicit context even before reflective consciousness can cognitively represent the situation. While others' emotions almost always matter for us to some extent, only in certain cases do they involve us directly. We are 'drawn in' to the other's emotional situation according to a gradation of relevance, always encountering others in a particular world and framed in a particular context, which greatly informs how the seen action is interpreted. This means I frequently understand why the other is angry, depressed or relieved without engaging in reasoning procedures, yet without being submerged in their emotions either, experiencing them in an indistinguishable manner and losing my sense of self (Gallese & Ferri, 2014). Perhaps I feel strong sympathy for them, but there is no reason to exhibit fear responses and even less to redirect my spatial attention elsewhere as found in Ellena et al. (2020; 2021). It follows, then, that some affective states are only shareable via ES *asymmetrically* because the context-dependent cause of another's emotional expression is absent from direct perception.

We can now return to this subsection's core *aporia*: while context mediates how facial expressions are responded to, the opaqueness of an unknown cause ('*why are they* *afraid?*') renders context-appropriate reaction incompatible with DSP, and thus potentially with our enactivist interpretation. To resolve this dilemma, we should return to the so-called sensorimotor abduction (Cuccio & Gallese, 2018). Cuccio & Gallese (p.7) claim that more complex forms of simulation-based social understanding often operate in the format of an automatic or embodied abduction instead of explicit inferential reasoning. In brief, standard Peircean abductive reasoning grants us epistemic access to the cause or general rule of what we directly witness as an effect or concrete example (Viola, 2016). As noted by Peirce, scientific hypotheses follow an abductive logic (Paolucci, 2018). The law of gravity is abducted from the falling apple, for instance. Cuccio & Gallese attest to an embodied and pre-reflective (hence: 'automatic') version of this procedure, which informs acts of social understanding, permitting abstract, contextual causes of actions or emotions to be directly perceived in their concrete social effects. This is appropriate for our aims since "the processual and partly sub-conscious functioning of abduction goes so far as to merge almost indistinguishably with perception (Viola, 2016, p.258). Applied to our purposes, we can conclude the fear-inducing but unseen intentional-object is automatically abducted upon witnessing the fearful face.

Incorporating the automatic abduction retains our enactive account of social-spatial cognition while permitting that bodily space can rapidly and automatically respond to complex conceptual cues, incorporating them into pre-reflective, 'online' sensorimotor cognition. Put simply, context is always already implicated in one's sensorimotor opening, whereby bodily space is constantly sensitive and responsive to complex social and situational nuances without relying upon theorising routines. Ellena et al. (2020) empirically demonstrated that when the fearful other functions as a signifier of danger, the sensorimotor system adapts more or less instantaneously to this fact seemingly without conscious deliberation (or instinctually, *a la* Peirce). Seemingly, this reaction's rapidity is incompatible with conscious, reflective interpretation of the face *as* fearful, followed by a deduction that the other is fearful of *something,* then another that this something must also be nearby, with all of this information being shunted 'downwards' from 'higher' cognition to inform the 'lower' sensorimotor domain. Rather, the sensorimotor abduction's contextual content is already structuring pre-reflective spatiality (skin conductance, visual attention directed towards the periphery) despite being mediated and not directly perceived.

However, more recently, Cuccio & Caruana (2023, p.9) claim that the sensorimotor abduction occurs in action perception but not emotional mirroring. This is due to affective habits being "knowledge-based" and not "ignorance-based" like motor habits, whereby emotional mirroring features no ambiguity requiring reconciliation via abductive inference. Rather, Cuccio and Caruana claim that 'emotional mirroring' facilitates social bonding and does not seek to acquire further information. However, here we have likely uncovered an exception. This is because, in select cases of emotional *co-attunement,*[137] the fearful expression's cause is clearly a matter of ignorance that requires resolution, but most especially because its intentional-referent is something *external* to the agents themselves. That is, both the emotional expression's cause alongside its intentional-referent (i.e., *what-they-fear*) are ambiguous, yet it still somehow elicits sensorimotor responses in the observer. Since we observe and automatically respond to social effects (facial expressions) generated by unperceived contextual factors, the automatic abduction, grounded as it is in context, remains a vital part of emotion recognition in a manner akin to action recognition. In contradistinction to Cuccio and Caruana's claim, this 'intentional mirroring', as applied to affective co-attunement described above, is indeed assisted by the sensorimotor abduction, thereby allowing conceptual knowledge to penetrate the sensorimotor sphere.

How, then, can perceivers endow the other's fearful expression with causal specificity and thus become affectively co-attuned? As a final means of explicating the automatic abduction, Cuccio & Gallese (2018) employ the semiotic concept of 'encyclopedia' inaugurated by Eco (1979), which we have already been introduced to above. While the fear that is iconically registered and neurally simulated is not an identical copy (e.g., knowledge of its cause is asymmetrically absent in the perceiver), at the broader level of meaning, situated agents obtain, via ES, an inkling of what it *might* be. Let's also emphasise that the abduction permits insight into an emotional expression's most *probable* cause, which elicits a "field of expectations" (Eco 1997/1999, p.206). Indeed, the semiotic notion of 'Encyclopaedic knowledge' – an accumulation of empirically acquired cultural facts and know-how - dovetails with the Heideggerian notion of 'worldhood', as both denote a contextual embeddedness within a particular form of life, out of which emerges the capacity for entities to pre-reflectively show up in a particular way (Paolucci, 2015). Abducted knowledge thus draws from the public wellspring of the cultural encyclopaedia.

[137] Indeed, the others note how it is 'dyadic' emotional mirroring that has no need of the automatic abduction, not the kind of triadic co-attunement we are focusing upon here.

Regarding contextually-appropriate responses, Violi (2017, p.235) further adds: "while the encyclopaedia embodies a principle of interpretative freedom, it also fulfils a regulatory function… guaranteeing [both] interpretative freedom and interpretative regulation". Thus, an embodied abduction borrows from encyclopaedic world-knowledge to elicit a sensorimotor response(s) most adapted to one's situation by whittling down an open horizon of possible causes to that most appropriate. Clearly, this is especially necessary if something in the environment is possibly dangerous. The embodied abduction's 'interpretative regulation' thus automatically links a response to the emotion witnessed. In the case of fear, the shared context elicits an automatic 'inference' as to the most contextually feasible fear-inducing thing. The near-infinite spectrum of possibilities that agents *could* face when encountering fear in surrounding space are narrowed and sharpened so that one immediately considers a plausible cause in coherence with the shared situation. Importantly, this 'consideration' is not even necessarily transparent to consciousness but is directly and measurably implicated in sensorimotor cognition via bodily space. The situated encyclopaedia thus provides the most suitable 'content' for the sensorimotor abduction to automatically draw upon.

We have, therefore, discovered that the sensorimotor abduction is not an intellectual act but rather profoundly situated. Indeed, Violi (2017) underscores how the encyclopedia must be understood as a situated phenomenon. Accordingly, the perceived emotion's cause is always abducted in alignment with a contextual frame.[138] Being spatially situated in the *Mitwelt* endows affective intentionality (*fear-of-something*) with an abducted specificity regarding the unperceived intentional-object, with consequences for the agent's phenomenology and subsequent appropriate behaviour. Its content, disclosed by affective co-attunement, structures how surrounding space manifests, along with corresponding autonomic (skin conductance), bodily-motor (possible PPS expansion) and sensory spatio-attentional (centrifugal attention) responses. This is because a specific, probable threat is automatically abducted from the *directly perceived* emotional expression, with the result that expression and context co-constitute the observer's bodily space. As situated agents, the context(s) in which we are co-absorbed determines the most intuitively likely

[138] For a recent account of how active interference and predictive processing diverges from Enactivism, see Gallagher (2023b). Since the notion of 'embodied abduction' does not contain possibly conflicting conceptual priors to the approach to cognition adopted here, I will use it synonymously with 'sensorimotor' and 'automatic' abduction.

conclusion that presents itself whenever the fluency of this absorption is partially disturbed.[139]

Let's now consider some hypothetical, real-world examples to better understand how bodily space may realistically adapt to context via the sensorimotor abduction 'in the wild'. Consider a variety of scenarios in which one sees a fearful facial expression: a dangerous neighbourhood, a safari, a hike, and the workplace. In each scenario, the agent witnesses a nearby other's face configured into a fearful expression. Consequently, bodily space reacts in a contextually appropriate manner at several levels. The observer's enactive interface, body schema and attentional focus simultaneously align with the implications of what this fear indicates so that lived space in its totality becomes structured by the abducted threat. One might expect a human assailant if one is in a dangerous neighbourhood, a wild animal if on safari, an avalanche if mountain-climbing or, more mundanely, an angry boss at the workplace. Each scenario triggers a cascade of contextual bodily-cognitive-spatial responses. On safari, the nearby tree may be attentionally brought 'near' as a zone of potential safety, while an inferred human attacker in the dangerous neighbourhood might cause the agent to instinctively duck and throw his hands up to protect his head. Each action sequence would prove useless in the opposing scenario and arise to the agent spontaneously. Flinching, preparing to run, looking for a nearby tree or preparing to fight all occur without first undergoing a deliberate process because both I and the other are each co-embedded in the same world. Accordingly, affective co-attunement, embodied simulation and the automatic abduction all serve to spatially embed the agent in the *Mitwelt* in alignment with situational demands.

On the topic of 'everyday consciousness', the lack of physiological response towards neutral faces in Ellena et al. (2020; 2021) also merits brie discussion. With respect to other facial expressions, the presence or 'hold' of neutral expressions appears diminished. Neutrality does not impart a strong impression upon its perceiver as the neutral gaze does little to disclose any affective situation that absorbs the observer into its affective logic, since neutrality rarely points towards any aspect of the spatial surroundings. Nor does it disclose the world in a particular way or engender any pronounced intentional thread between agents. Nonetheless, from a Heideggerian standpoint, neutrality may be said to

[139] I.e., when the background of neutral faces one typically sees is interrupted by one scared-looking individual, engendering an instant sensorimotor reorientation in space.

fundamentally ground the Being of anonymous intersubjectivity that makes up the background of our everyday dealings in the *Mitwelt*. As we pass by others on the street, in the workplace or in transport hubs, we are most typically faced with such neutral, everyday expressions, and are only alerted when there is a disruption in this predictable mundanity. Indeed, the very fact that more intense emotions show up more readily on the psycho-physiological radar is testament to this. If our relationship to our surroundings suddenly shifts, this is likely because, out of this ocean of anonymity, a salient face (surprised, fearful, angry) triggers a drastic reorientation to space before (if nothing occurs) we reset to our mundane ('neutral') absorption in the world.[140]

How do these empirical results support Merleau-Ponty's, Peirce's and Heidegger's contention that the egoic self can never constitute the other and that both self and other are immediately co-situated within a shared, publicly-accessible space of meaning? It is difficult to take seriously the prospect of a world in which I *qua* Ego construct the entirety of the other's being - as if he was a character in a script for which I serve as sole author – when this 'character' impinges on my reality so directly and immediately that I am automatically directed toward aspects of it otherwise unnoticed by me, to the extent of altering my neural activity or spatial embeddedness within the environment. In urgent situations especially, we never doubt that the shared world might contain imminent perils when we see this danger's reflection in the other's visible terror. We might thus amend an old adage to say that there is no such thing as a solipsist in a foxhole. Even in casual situations, aspects of our *Mitwelt* come in and out of focus or as a whole can appear scary, exciting, puzzling or tranquil due to the meaning imparted by the other. Thousands of small details at various places, heights and locations can bypass normal, unfocused cognition, yet the presence of others alongside their expressions and gestures can always direct us to these latent aspects, whether purposefully or accidentally because we are both tethered to the same world.[141] It is this way that, as Merleau-Ponty keenly foresaw, both our own bodily apparatus and the presence of others are equal partners in sculpting our bodily spatial existence.

[140] Also consider how otherwise busy places (hospitals, train stations, schools) are well-known to take on an eerie quality when encountered as completely unpopulated.
[141] One might think of a favourite trick of many pranksters to stare intently upwards at nothing, in public, and wait for others to gather in curiosity and copy the action.

2.3 Empathy and Other Emotions

We have elsewhere intimated that the important connection between the peripersonal and mirroring networks, the latter of which are famously implicated in empathy recognition (Wicker et al., 2003) and both neuronal classes are located in the fronto-parietal region. Indeed, the existence of PPS was first hypothesised by Rizzolatti et al. (1981) while his research team was searching for something like peripersonal neurons (Iacoboni, 2008). Mirror mechanisms are traditionally seen as sub-serving certain key dimensions (particularly those involving the body) of empathy. Affectivity, then, should be closely implicated in both empathy and bodily space. To complete this section, we shall turn to empathy's role in bodily space before briefly examining the affective states that have thus far been left out of the present discussion.

Boukricha, Nguyen & Wachsmuth (2011) found a positive correlation between empathy and a tendency to include the other within one's own PPS, as measured by a virtual cooperative behavioural task. This study also posits the framework of Embodied Simulation as an explanation for the findings. Similarly, Gherri et al. (2022) tested the relationship between PPS and empathic concern (EC) using a multisensory measure of PPS and the Interpersonal Reactivity Index. They likewise found a positive correlation between PPS malleability and empathy, claiming that high-EC subjects have "weaker", that is, more malleable PPS borders.[142] Gherri et al. speculate that this finding reflects empathic individuals displaying a stronger tendency to include others with their own PPS representation, which may either reflect or cause higher empathic concern. More empathic individuals are quite literally more disposed towards 'letting others in', as the adage goes.

Pain observation, a classic empathy measure, typically triggers activation in the primary and secondary somatosensory cortical areas (Costantini et al. 2008; Akitsuki & Decety 2009), which has been linked to empathy (Keysers et al., 2010). Moreover, Mahayana et al. (2014) demonstrated that pictures depicting pain elicited stronger empathic responses when they are shown within PPS than outside PPS. Lomoriello et al. (2023) placed a plexiglass barrier between an agent and confederate and measured motor and somatosensory activation with a classic 'pain perception' task. The participant witnessed two conditions: one in which a Qtip made contact with a face and another in which a needle did, either with or without the barrier between them. Both conditions were

[142] The tendency for one's bodily spatial borders to weaken or strengthen to include or exclude the other based on context will be shown to be of significant importance in the following section.

conducted intra-PPS. As measured by event-related potentials and source activation, Lomoriello and colleagues found reduced cortical activity in primary, somatosensory and premotor cortices only in the plexiglass condition. This evidence implies that kinds of automatic, pre-reflective empathy (such as pain-mirroring) is dampened when the other is rendered unavailable for embodied interaction.

Riečanský et al. (2020) reversed this logic by inducing a sensation of complete spatial overlap between self and other and then measuring subjective accounts of empathy. The researchers employed a classic 'pain perception' task where either a needle or a cotton swab made contact with another person's hand. The experimental manipulation in this study involved altering the video presentation to create an illusion of overlap between the observer's hand and the observed hand. In line with previous evidence, this illusion increased neurological responses consistent with empathy. This seems to be an experimental simulation of an otherwise impossible complete integration of physically extended bodies, which bolsters empathising on spatial grounds. This essentially produced a diametrically opposite effect to that found when barriers between individuals are erected. Yet again, we find a relationship between spatial nearness and a situated and pre-reflective kind of empathy based on spatial and motor-intentional integration with the other and does not involve thinking about the other or, arguably, even sympathising with them.

Accordingly, I suggest that shared space *qua* zone of reciprocal interactions is partially compromised when the other is not immediately accessible. This is because a barrier reconfigures the other's possible impact upon us and thereby our automatic, motor-somatosensory abilities to emphasise. Once again, as intimated by the experimenters, an observable difference emerges between objective and phenomenological distance. For at least some dimensions of empathising, the other must be *phenomenologically,* and not just objectively, present (see Dreyfus, 1990). Clearly, affective empathy has a pronouncedly bodily spatial aspect that hinges upon classically enactivist principles; impeding one's capacity to interact with the other reduces our capacity to empathy with her. Empathising is thus partially contingent on the 'intentional threads' that arise between individuals in free, face-to-face interaction in space. Lomoriello et al. (2023, p.8) also note that their evidence suggests a possible reduction in PPS, thereby excluding the other, a phenomenon that will be shown as important in the following section.

We shall conclude this section with a brief discussion of the emotions left outside the purview of the extant experimental literature. There may be a negative valence bias grounded upon the defensive properties of PPS present in the current scholarship (Ferri et al., 2015). Spatial embeddedness operates on a trigger-hair sensitivity to danger due to the very fact that we exist in a shared world; if something excites, shocks or terrifies the closeby other, it is likely to impact upon us also. Yet, that we have predominantly focused on negative emotions such as fear and anger should not imply that positive emotions have no purchase upon lived or bodily space. Famously, happiness is often contagious too. While skin conductance measures may not register this emotion, this does not diminish its reality in pre-reflective spatial cognition. Interestingly, it has been shown that joyful faces sometimes capture attention for a longer duration (Fox, Russo, & Dutton, 2002; Torrence et al., 2017), a phenomenon very different from the centrifugal reorientation produced by fearful faces. Certainly, one also becomes more open to that world in which one is co-embedded when feeling joyful or when interacting with others who are. Phenomenologically, in joy, all things are brought comfortably nearby in some sense, yet keep their distance so as to never overwhelm or oppress the joyful individual. Moreover, a shared joy surely cements those sharing it together even more strongly within surrounding space and likely strengthens the juncture between individual's spatial interfaces, a factor discussed in the next section.

On that note, one way of directly being with-others (*Mitdasein*) spatially is to be drawn into the way in which the world is affectively disclosed. Surprise seems to be a strong candidate for such a co-attunement effect, as is anxiety. Indeed, everyday language attests to the contagiousness of such emotions. For example, witnessing a confident other, an emotion known to modulate PPS (Masson et al., 2021), may elicit a similar confidence in us by contagion. Conversely, it may trigger greater shyness. Most people can attest to times in which another's confidence is contagious and other times in which it is overbearing, causing us to withdraw. Indeed, the confident other whom I am witnessing is unlikely to be drawing their confidence from a public source that is equally available to me, as is the case with some emotions, such as a movie that makes us both laugh. On that note, (Caurana et al., 2020, p.35) note that the pregenual anterior cingulate (pACC) is one region active during laughter production and demonstrated that "pACC sites showed a selective activation during laughter observation, but only if laughter is presented in a dynamical fashion". Presumably, sharing an emotion such as laughter loosens the spatial borders between individuals (Lomoriello et al., 2023). Laughter, as the adage goes, can indeed bring us together.

In sum, singular emotions can produce multivariate bodily spatial responses based on context. Like other dimensions of spatiality, socio-affective spatiality seemingly features a temporal current. A clear expression of fear indicates that there is something *currently present* nearby that serves as its cause. Yet, over the long term, a close friendship with an anxious or confident person (see **2.2.2**) may well cause an increase in my own confidence or anxiety via contagion. This applies equally to happiness and gloominess or an optimistic or pessimistic disposition more generally, assuming that all these affective traits feature unique spatial signatures. Bodily space might, therefore, be 'imprinted' by the affective bodily space of another with whom one is in regular proximity, demonstrating another means by which spatio-temporal existence is fundamentally constituted by intersubjectivity. As Cuccio and Caruana (2023, p.8) note, such processes pertain to long-term changes instantiated by neural plasticity or the strengthening of 'nervous associations', which the authors note is an intriguingly proto-Hebbian insight put forth by Peirce (1878) that coincides with our prior discussions of semiosis and habit.

But there exists one final (and perhaps most profound) way in which individuals apparently align on bodily spatial terms and thus deeply impact each other's bodily space in a near-seamless way, which seemingly is restricted only to cases of direct interaction. This theme shall be examined in the following third and final section of this chapter.

3. Interaction

So far, we have examined how the agent's individual bodily space is fundamentally shaped by being embedded in the *Mitwelt*. However, our discussion has, until now, excluded what is arguably the most important dimension of social spatiality and/or *Mitdasein*: direct, person-to-person interaction itself. Crucial to the foregoing account of bodily space is that space is relational, and that this relationality is founded upon interactions with other entities in space, with human beings standing out as perhaps the most important entity that one directly engages. Bodily space, if taken as a reconfigured example of the extended social self (Fuchs and Froese, 2012), the social bodily self (Ferroni & Gallese, 2022), and intercorporeality generally (Merleau-Ponty 1945/2012), can emerge in its strongest sense as a fusion between the enactive interfaces of discrete individuals following a pre-reflective and motor-intentional alignment between two lived bodies. Unlike in co-transparency (**3.1**), however, a physical object does not act as the centre of gravity for this social-spatial dynamic.

Moreover, the other himself/herself need not serve as the act's intentional-object; rather, person-to-person spatial interaction is best conceptualised as a merger or unification between two bodily spaces in perhaps one of the most striking empirical manifestations of Merleau-Pontian 'intercorporeality'. But what exactly does this term mean? Perhaps the most succinct summary that Merleau-Ponty provides of this phenomenon in *Phenomenology of Perception* is as follows: "insofar as I am born and insofar as I have a body and a world, I can find other behaviours in that world that intertwine with my own" (416/374). This fusion of interfaces, however, can assume a variety of nuanced forms. Detailing the logic and triggering conditions of these forms shall be the focus of this chapter's final section.

At the most fundamental level, we will investigate how one's enactive interface can be open or closed to a nearby co-specific. We might concur here with Brandt (2020, p.43) in that "metaphorically, the surrounding space [in cognitive semiotics] has 'walls' and 'windows'". Just so, depending on the quality of a social interaction, bodily space manifests differentially as opaque or transparent, as essentially disposed toward letting others into its boundaries ('window') or, alternatively, shutting them out ('wall'). Broadly, an 'open' enactive interface loosens the borders of minimal individuation (see the introduction to this chapter) so that the agent becomes spatially co-embedded alongside them in the strongest sense of the term. Direct bodily spatial interaction thus cements each nearby agent as an immediate co-participant in a shared enactive interface that shares the same features as the 'individual' enactive interface but on an expanded scale. This can also be taken as a particularly pronounced spatial manifestation of Heidegger's *Mitdasein* whereby one's 'being-there' is fundamentally co-constituted as that of a social entity and not as an ontically individual Dasein.

Below, therefore, we shall carefully develop this proposed notion of a 'joint enactive interface' (JEI), alongside detailing how it is moulded by higher-order factors such as morality and narrativity, in addition to detailing its disrupted manifestations in clinical disorders.

3.1 Joint Enactive Interface

Enactive paradigms often emphasise person-to-person, embodied interactions over more conceptual, cognitive forms of social interaction (e.g., Zahavi, 2011; Gallese & Sinigaglia, 2018; Kreuger, 2018; Froese et al., 2020), the latter of which typically fall under the purview of 'theory of mind'; i.e., forms of social interaction involving inference, reflection, strategy and interpretation (e.g., Frith & Happe, 1999). An exemplar of the former would be moving a piece of furniture down a flight of stairs, while the latter would be a strategic business transaction conducted remotely over communication devices. However, several researchers argue that such a division is not inevitable in ECS (Kiverstein & Rietveld, 2015; Rietveld & Brouwers, 2017; Newen, 2018). With this in mind, it is interesting to note that one of the first empirical demonstrations of how the PPS network reflects a social interaction's qualitative dimension utilised a predominantly cognitive, non-bodily interaction to do so. Specifically, Teneggi et al. (2013) tested how economic cooperation in the format of a game modulated the PPS of its players.

First, Teneggi and colleagues confirmed that the presence of a human confederate in far-space causes PPS to shrink in adaptation to the presence of an unknown other, whereas a mannequin caused no comparable PPS change. Thus, there was empirical confirmation that the visually-intended presence of the other restructures one's bodily space, a finding that reflects a somewhat apprehensive shift in spatial embeddedness occurent whenever we share a space with those we do not know. This may be a defence-like response or an indicator that that our scope of possible actions shrinks to make way for the 'invisible' spatial scope of the other, as seen in previously-discussed studies (Fini et al., 2020; Fossataro et al., 2023). Either way, we can draw from these data that facing the unknown other shrinks one's PPS as to solidify our individual space with regards to another for whom, at that moment, we do not wish to impose upon or do not yet trust enough to spatially merge with.

Subsequently, Teneggi and colleagues tested whether 'higher-order' social complexities – such as the (arguably culturally-dependent) notion of 'fairness' – are also capable of restructuring PPS. To accomplish this, an economic game was introduced in a between-subjects format. Participants were divided into an 'equal payoff' and 'unequal payoff' group. Crucially, the condition that featured a co-operative, fair interaction involving an equal sharing of the game's monetary resources. It was found that cooperation caused the player's PPS to expand significantly. Conversely, no such effect was found in the condition featuring the negative, 'unfair' interaction. That is, only in the 'co-operative' condition did PPS expand (measured as a larger zone of audio-tactile integration) so that the agent registered the sensory stimulus that was located in the *other's* spatial zone as one usually does within one's own PPS. Moreover, characteristic PPS responses were no longer triggered by the stimuli presented within the participant's *own* PPS. As Teneggi and co-authors note, the participants' PPS was no longer anchored to their own bodies.

The selectivity, size and direction of this response heavily suggested that the participant's PPS had extended to include the other within its own newly extended bodily-spatial boundary, cancelling out effects typically found in individual PPS and rescaling them. This response seemingly owed solely to the cooperative nature of the interaction:

> As a consequence of cooperative, communal interaction, the boundaries of space within which external stimuli are more efficiently processed in order to implement defensive behavior shifted beyond the space occupied by the cooperative other [p.409].

It is highly debatable whether it is accurate to label the space that shifts as 'defensive', for reasons we shall soon discover. Nevertheless, it is important that peripersonal space shifted *beyond* the participants' own boundaries and into the cooperating other's space because this move indicates that the bodily self's extended presence has, in some sense, rendered the other agent transparent; that is, the lived body's outer boundary no longer recognises the other as a fully external being. Motor-intentionally, we are here not dealing with two single, sequestered bodily spaces but one unified, 'intercorporeal' space that is jointly oriented to the same goal of cooperation. Under the global logic of this situation, the other agent is no longer a fully demarcated 'other *qua* other' but rather newly co-constitutive of a temporarily conjoined sensorimotor opening which functions as its own unique kind of *joint* enactive interface, scaling up the features of the individual EI. Surrounding space and, by extension, the innerwordly entities within it, are thereby newly presented on the basis of this joint enactive interface (JEI), the emergence of which is only triggered by an act of co-operation, which seamlessly integrates the two cooperating parties at the bodily spatial level.

Why does this effect emerge? As a situated phenomenon that is always embedded in some kind of context (Fuchs, 2018), bodily space must therefore reflect the 'opening up' of the new horizons of intersubjective possibility the agent now finds himself in. When cooperating, we suddenly find ourselves embedded in the *Mitwelt* as a seamlessly integrated bodily spatial entity in a manner notably distinctive from (but in parallel with) that of individual bodily space. Of course, it is quite intuitive that what can be feasibly accomplished with another person differs substantially from what can be accomplished by oneself as an individual entity. But this change manifests as 'know-how' rather than 'know that' (Cappuccio, 2023). Pre-reflectively, certain tasks in surrounding space that are only accomplishable by two or more people are suddenly rendered available for interaction: lifting heavy objects, laying a large tablecloth, riding a tandem bicycle, etc. Thus, since human beings can achieve more with group cooperation than when alone coupled with bodily space functioning as a horizon of possible action (Gallese & Sinigaglia, 2010, 2011), when we are proactively situated as part of a group dynamic, an array of novel action possibilities become pre-reflectively open to us, which drastically reconfigures how we are spatially embedded. We may consider this as pertaining to the spatial dimension of so-called 'we-intentionality' (Tomasello & Carpenter, 2007; Zahavi, 2015) and the 'extended social self' (Fuchs & Froese, 2012).

In light of the previous section on affectivity, we can also note that the economic game featured both a positively and negatively valenced condition that induced an affective state. In a somewhat simplified way, the player who feels positively towards the confederate is affectively aligned with them and includes him or her within their enactive interface. Yet the inclusion (or not) of the other does not *solely* reflect the player's subjective feelings towards them. Rather, the JEI is equally a reflection of an active, pragmatic and pre-reflective integration of spatial interfaces in which each party becomes fully aligned in reference to a shared task built upon co-operation that profoundly penetrates sensorimotor cognition. This social-spatial phenomenon features both an experiential register (PrCC) and is amenable to third-person measurements via multisensory integration tasks. Granted, players in the 'unfair' condition also interacted. Yet because there was no iconic alignment of motor-intentional orientation *nor* any coherent affective or pragmatic engagement in a shared task as co-participants, bodily space remained without motivation to merge with that of the other.

To reiterate, Teneggi et al. (2013) thus demonstrated for the first time that cooperative social interaction dramatically shifts the bodily spaces of the cooperating parties, uniting them into a joint sensorimotor entity. More specifically, bodily space alters its form so that stimulus (i.e., sounds) responses typically registered within near-space are newly registered in the far-space specifically occupied by the other agent (overcoming typical self-other boundaries and rendering the other transparent) on the sole condition that the outcome of the economic game was 'fair'. Co-operation in its pragmatic, pre-reflective and affective dimensions thus destroys existing boundaries that (ontically) separate individuals within a shared space and reshapes how surrounding entities automatically manifest to cooperating agents in the format of a 'scaled up' version of individual bodily space.

Such results are reminiscent of Uexküll's discussion of territory (see **1b.1.3**). While Uexküll's concept was employed in reference to a slightly different context, the key notion remains in that entities encountered within a qualitatively bounded territory are differentially modulated to those outside it; it would miss the point, however, to merely state that the other is included within one's 'own' territory. Rather, in our ancestral past and perhaps today also, others would co-constitute the very boundaries of this territory, so that 'my' territory, as a group member, would terminate where my tribe members are located, not at my own spatial boundary, extended or otherwise. One can imagine an ancient hominid that experiences the border of its territory over 'there' where his fellow tribe-member stands, whereby, as von Uexküll showed, entities encountered inside and outside this territory are processed very differently. At the qualitative level, therefore, 'my' territory becomes 'ours' for those with whom we routinely cooperate, whereby the field, jungle, neighbourhood or modern battlefield inherently manifests with respect to the spatial power of the collective at the most fundamental level.

Thus, we see that an encompassing alignment between those co-inhabiting a space, engendered via direct interaction within that space (and partially supported by positively-valenced affect)[143] shifts one's mode of spatial embeddedness in a uniquely social way. The pervasiveness of the shift entails that, in the form of the joint enactive interface, one is truly co-embedded alongside the other in the maximal expression of this term. Interestingly, Teneggi et al. (2013, p.407) quote French philosopher Deleuze's (1969, pp.356-357) own phenomenological description of social spatiality:

> As Deleuze said: "The other is neither an object in my field of perception, nor a subject who perceives me: it is first and foremost a structure of the perceptual field, without which this field as an ensemble would not function as it does".

[143] However, we may hypothetically speculate that two people who hate each other, who for some reason are forced to co-operate against their will, would still find their spatial interfaces merging together. The JEI is thus simply constitutive of successful, face-to-face cooperation, potentially independently of subjective liking.

Moving forward, Hobeika et al. (2019) highlight a purported weakness in the extant literature that most enactivists would readily concur with; namely, that prior studies investigating social-action convergence in PPS (Heed et al., 2010; Teneggi et al., 2013) did not study participants and confederates while they interacted but rather after the interaction took place.[144] A fuller exploration of the social and multisensory-motor dimensions of PPS necessitates examining two agents mutually engaging an experimental task within shared space. Accordingly, while PPS was previously measured *after* the task, this study measured PPS *while* subjects interacted concurrently. This study also sought to determine the shape (and not only the size) of PPS, measuring whether PPS expanded equally in all directions or was asymmterically biased towards the other's physical location. In three conditions (collaborative; competitive; audience) subjects performed an audio-tactile task as quickly and accurately as possible, while reaction times were measured. Participants were *told* that the task was performed in conjunction with another sat next to them (*collaborative*), in rivalry with the other (*competitive*) or with another sat nearby but who did not partake in the task (*audience*).[145] Participants also performed the audio-tactile task alone.

The results showed that the right side of the PPS boundary socially extended outwards (i.e., integrated the other into the JEI) *only* in the collaborative condition,[146] meaning that the verbal instruction alongside embodied interaction was sufficient to substantially reshape PPS. In the competitive condition, reaction times increased for both parties yet lateral PPS did not extend, as was also found in the 'isolation' condition. The 'audience' condition displayed no lateral PPS effect, confirming that the 'collaborative' condition's results were not due to the other's mere presence. Rather, the other's inclusion via interaction served as the foundation for the spatial situation, without which the other's presence would remain external from individual bodily space. As the authors explicitly mention, it is noteworthy that PPS expansion was always biased to the right, independently of whether the cooperative agent stood on the left or right side. The authors note the reason may be found "in theories of social psychology [that involve] a cognitive transformation from personal to social level identification" (p.10).

[144] While Teneggi et al. (2013) initially found the mere presence of another modulated PPS, Hobeika et al. (2019) did not. This is likely because Hobeika et al.'s participants were engaged in a task, which accounted for the form of peripersonal space.
[145] Recall that this maps onto Brandt's (2020) tripartite semiotic schematisation of intersubjective spatiality.
[146] Interestingly, this was the case independently as to whether the other was located on either the participant's left or right side.

This explanation strongly supports the JEI model of social PPS, if by 'identification' we do not restrict ourselves to any explicit, intellectualist identification with the other but rather a global spatial orientation toward surrounding space alongside them that simultaneously and pre-reflectively pervades the intellectual, sensory and pragmatic domains according to a newly-disclosed, social-pragmatic logic. The authors further speculate that the observed rightward PPS shift represents a bias occurrent at this group level mirroring that found in individuals' PPS for evolutionary reasons, whereby bias veers towards the dominant hand to maximise average group capabilities. Additionally, a left-ward bias for right-handed individuals was previously observed (Hobeika, Viaud-Delmon & Taffou, 2018), which is seemingly 'cancelled out' whenever individuals are absorbed into the JEI.

By importing the logic of 'group think' from social psychology, Hobeika and colleagues speculated that a rightward bias might reflect a new group-level 'spatial representation'. However, I would add that the individuals' enactive interfaces undergo temporary unification into a joint interface, whereby this new sensorimotor unity stands as its own distinct identity in a manner akin to (ontically) individual bodily space. This should not necessarily be viewed as individual bodily space's deviation or dilution, as is perhaps implicit in the term 'group think'. Note that what is typically the case at the level of an *individual* enactive interface scales up to the *joint* enactive interface during collaborative interaction. We thus find an iconic relation (rightward bias) between individual and joint PPS, yet also a difference, whereby a left-ward bias is cancelled out in the JEI because bodily space exists as a truly socially unified entity.

Thus, Hobeika et al.'s (2019) findings help us recognise that 'spatiality', just like 'decision-making', features both group and individual expressions. While in social psychology this admission often contains somewhat negative connotations (think of the irrational lynch-mob), enactivism does not necessarily follow this paradigm (Fuchs, 2018; Froese et al., 2020; Gallagher, 2020). The different modes of spatial embeddedness characterised as an 'individual' vs. 'shared' enactive interface are simply descriptive terms and not moral distinctions; thus, in collaboration, individual PPS assumes greater symmetricity because one is spatially embedded as an intercorporeal spatial entity, whereby individual bodily space becomes temporarily subsumed into the interconnected bodily space(s) of others.

Of further interest is how language clearly sculpts this shared bodily-spatial reality in profound ways, penetrating sensorimotor cognition (see Di Paolo, Cuffari & De Jaegher, 2018). In Hoebika et al., what occurred during *both* the collaborative and competitive conditions was behaviourally identical, yet what separated each condition was the simple verbal instructions given, producing distinct spatial-sensorimotor effects. Noting the importance of linguistic elements is important generally for the interdisciplinary approach pursued here, as language is a close bedfellow with both semiotics and phenomenology[147] and had already been shown to influence PPS in several studies (Coventry et al. 2008; Ferri et al., 2011; Costantini et al., 2011; Patane et al., 2021). As another example, Gianelli, Scorolli & Borghi (2013) found that manipulating confederates use of pronouns 'I' and 'You' has an effect on reaching actions in near-space.

Indeed, in contrast to approaches that seek to sharply distinguish between action and linguistic domains, as carriers of meaning, spoken words have a substantial influence over the sensorimotor domain with each interpenetrating the other during acts of sense-making (Violi, 2008). At the beginning of *Philosophical Investigations* (1953), Ludwig Wittgenstein, a philosopher sometimes considered a 'proto-semiotician' (Paolucci, 2018), forwarded his paradigmatic example of 'language *qua* tool' by describing a group of builders cooperating on a job. In Wittgenstein's famous example, we encounter language as something that grows organically out of practical, cooperative interaction whereby meaning, community and practical cooperation are tightly interconnected. The use of spatial demonstratives clearly highlights this convergence between a bodily space-centric locatedness in the world and linguistic expression. Moreover, Coventry et al. (2008; 2014) found that agents express preference for proximal demonstratives for reachable objects and distal demonstrative for those outside reach.

But how would this seemingly egocentric phenomenon transfer over when agents are co-embedded as part of a JEI? Rocca et al. (2019) introduced a linguistic element to the cooperation paradigm, measuring participants' usage of locative adverbs such as 'here' and 'there' following cooperative actions to ascertain how collaborating with others in space shifts agents' use of spatial demonstratives. The researchers (p.11) ask an important

[147] Indeed, for 3 of our 4 major thinkers (i.e., Peirce, Heidegger and Merleau-Ponty), action and language were deeply interconnected at one level or another. Further interdisciplinary research on this interesting juncture is required.

question that appears as a recurrent theme in scholarship on social spatiality, including the present one:

> What is the extent of such adaptations, and what type of coordination dynamics do they support? Do participants stably align on a new shared "compromise" reference frame? Or does each speaker fully remap proximal space onto the addressee's action space, with participants oscillating between two distinct reference frames, each centred on the current addressee on a trial-by-trial basis?

Indeed, it was discovered that agents' use of language reflected the shifting of spatial anchoring from the 'individual' to 'joint' enactive interface. Similar questions also arose in scholarship on tool-use observation and intentional alignment (**3.1**); however, this time, the other's experience was indeed imported but into a unitary spatial entity in which the individual ceases to have a completely individual spatial perspective. 'Here' and 'this' are therefore not tied to the 'me' occupying my 'own' objective, spatial location but the extended spatial interface that arises following cooperative acts, which language follows. When we are spatially co-embedded in the format of the JEI, the meanings of 'near' and 'far' (which, as shown, are phenomenological as well as objective determiners) assume a strongly intersubjective formulation.

Again, we must also consider the possibility that, after undergoing a fusion of spatial interfaces, the area of space that appears available to the agent has naturally extended into the other's potential reach, reflecting the updated inclusion of this other as a transparent element in bodily space. Convergence of intentional orientation or rendering the other transparent so that both or even several parties engage the world on a temporary basis as a united spatial interface. Correspondingly, Fuchs (2018, p.191) also leans on the "phenomenological notion of transparency" when explicating "sensorimotor perception of the other" whereby "by means of implicit coupling, [the other's body] is integrated in perception in a manner that we 'see through it". In the JEI, what experientially appears 'near' or 'far' dynamically alter their location, even if one remains fixed within the same set of objective co-ordinates. Thus, even if you and I are standing a shoulder-width apart but have not co-operated, we do not necessarily include each other in our pre-reflective sensorimotor openings onto surrounding space. But, following the emergence of the JEI, what is 'here' or 'there' reflected a unified spatial standpoint. Language and embodiment thus jointly co-constitute the lived spatial reality the brain-body finds itself embedded in.

Rocca and co-authors term the spatial reality that emerges in such cases as 'supra-individual'. This is perhaps closer to the phenomenon than 'group-think' (Hobeika et al. 2019), since it emphasises that one has renounced and/or transcended one's individual bodily space to become part of a novel social-spatial reality in which typical boundaries have blurred. Clearly, the typical boundaries delimiting individual bodily space are not retained when collaborating with others in surrounding space. From this realisation, we can finally develop our notion of the JEI that is grounded in 'intercorporeality', introduced by Merleau-Ponty (1945/2012; 1964/2004; see also Maratto, 2012). Indeed, Merleau-Ponty was greatly invested in the neuroscience of his time and has himself influenced neuroscientific accounts of, among other findings, mirror neurons (Gallese, 2001, 2003, 2011), peripersonal neurons (Rizzolatti et al., 1997; Gallese & Sinigaglia, 2010, 2011) and lesion studies (Gallagher & Cole, 1995). His notion of intercorporeality is often used in explications of social understanding (Gallese, 2011; Tanaka, 2013; Gallagher, 2020). But as Fuchs (2017, p.204) astutely notes, "it means not only the primary familiarity of our bodies with each other, or their pre-reflective communication *but also the entanglement* of human bodies".[148]

Other pieces of Merleau-Ponty's terminological tool-kit are revelatory to this so-called 'bodily entanglement'. In the intercorporeal JEI, our individual spatial level and optimal grip (i.e., our combined pre-reflective sense of direction, orientation and felt capacity for interaction) co-emerge from what Merleau-Ponty terms 'anchorage points' (**1a.2.1**). When cooperatively interacting with others, we drop anchorage in a uniquely socially-grounded situation out of which the surrounding world and innerwordly entities manifest themselves. In collaboration, we are also jointly 'anchored' to the other, and her to us, with our action-possibilities automatically following suit. Our spatial levels and optimal grips align, as evidenced by the cancellation of leftward bias in PPS during interaction (Hobeika et al. 2019) and by what counts as near and far (Rocca et al., 2020) perhaps into the most unified entity that we can be, save any body horror-esque fictions.

Interestingly, however, there exist factors other than non-cooperativeness (Teneggi et al., 2013) that *preclude* this intercorporeality's emergence. Moreover, the previously examined power that language wields over what is typically considered the 'lower'

[148] Emphasis added.

sensorimotor level begs further examination and will thus be thematised in the following section.

3.2 Morality and Narrativity

In this section, we expand upon the thorny issue of how a primarily sensorimotor phenomenon such as bodily space can successfully and rapidly integrate traditionally 'higher-order' cognitive dimensions into its (joint) enactive interface. We will predominantly focus on three experiments (Iachini et al., 2015; Pellencin et al., 2018; Fini et al., 2020), all of which investigated the effects of the other's morality upon PPS. Such studies are vital for the interpretation of PPS pursued here because morality is frequently taken as a paradigmatic example of 'higher cognition'; that is, it requires a capacity for decision-making and is traditionally implicated in the domains of thought and judgement, not of perception or movement.

Accordingly, we require an appropriate theory to make sense of results that appear to show that the content of 'higher-order' cognition can be fluidly integrated into the spatial-sensorimotor domain (Rietveld & Brouwers, 2017; Newen, 2018). To achieve this, we will introduce narrativity as inaugurated into cognitive science by Gallagher & Hutto (2008) and developed in cognitive semiotics (Paolucci, 2019, 2021), connecting it with the earlier analysis of sensorimotor abduction (Gallese & Cuccio, 2018; Cuccio & Caruana, 2023) and with direct social perception accounts (Zahavi, 2011; Kreuger, 2018; Gallagher, 2020). Thusly, we approach a fully-fledged account of intersubjective bodily space that remains enactive, pragmatic and deeply immersed in the intercorporeal world while nonetheless responsive to social complexities without need of reflective deliberation.

We will begin by briefly outlining the relationship between social cognition and narratives. Narrative Competence Theory (NCT) was first articulated in Hutto (2008) and Gallagher & Hutto (2008) and recently embellished by the same authors (Gallagher & Hutto, 2019). NCT was introduced to account for, from an embodied standpoint, 'folk psychological' abilities and what Trevathern (1979) termed 'secondary intersubjectivity': the kind of social cognition involving judgement and linguistic representation, typically not observed in children until 9-18 months (Paolucci, 2022). For aspects of social understanding which are *not* fully discernible through direct perception and bodily resonance with the other, narrative competence is posited as a means of making sense of actions and speech.

Therefore, as a theory suitable for integrating higher and lower forms of social cognition, NCT should help explicate how content from the so-called 'higher domain' of morality can automatically modulate spatial cognition in its 'lower' sensorimotor dimensions.

Indeed, several studies have demonstrated that peripersonal space is measurably responsive to the other's perceived moral status. As we shall see, *how* moral statuses are ascertained will prove important. Iachini, Pagliaro and Ruggiero (2015) were the first to examine the intersection between spatiality and morality, utilising virtual avatars and judgement tasks. They found that both self-reported reachability *and* comfort distances regarding the avatar were judged as greater when the avatar was presented as immoral, apparently implying that immoral others are pre-reflectively 'kept far away'. Indeed, if PPS typically facilitates integration with the other into a unitary, spatially co-embedded entity, then one pre-reflectively resists such integration if retaining serious doubts as to the other's integrity. At the most concrete level, engaging with an immoral other may spell trouble ("*Be careful, who knows what they might get up to*?"). The typically future-facing dynamic that undergirds the PPS network thus informs the embodied agent that the boundaries separating them from the other must remain rigidly in place; no co-absorption in surrounding space should occur, thereby rendering the other as a more remote entity than their more righteous counterpart. Indeed, as Iachini et al. (2015, p.135) note: "when others are evaluated as beneficial we do not need defending[*sic*] our space and thus we get closer to them to facilitate the social interaction." Interestingly, however, subsequent studies have found conflicting evidence that is of theoretical importance here.

Pellencin et al. (2018) stipulated that their study ('*Social perception of others shapes one's own multisensory peripersonal space*') expands the PPS literature by showcasing that the quality of a social encounter modulates peripersonal space even *before* any discernible interaction takes place. Furthermore, this study supports the thesis that bodily space automatically reflects a social situation's prevailing meaning prior to any deliberative processes instantiated in reflective cognition. The use of 'social perception' in this article's title is worth commenting upon, since it implies a direct perception account of the kind generally favoured by enactivists (Zahavi, 2011; Kreuger, 2020). Here, 'social perception' encompasses acts of perceptually intending the other in accordance with an ethical framework. It can be considered a DSP account because 'social perception' is not limited to only perceiving the other's external form but is inclusive of traditionally 'abstract' moral factors.

Baked into this definition of 'social perception', which has Husserlian origins (Zahavi, 2011, 2012), is the idea that 'higher-order cognitive' and 'lower-order perceptual' input regarding the other manifest simultaneously or are co-existent in a perceptual act. That is, upon perceiving the other, we directly see not only their geometric-physical form but also what their presence means for us within our situation in a non-inferential way. Perceiving the other is thereby not restricted to transducing brute sense-data, the meaning of which is subsequently 'filled in' by a separate, thinking module, but is already co-present *in* the very perceived things themselves and thus can have an immediate impact upon the body.[149]

Pellencin et al.'s set-up featured participants who were faced with a virtual avatar that either did or did not belong to their own ethnic group, as one aspect of the study sought confirmation of how bodily space differentially related to in and out-group members. Indeed, shared identity is another factor with important social-spatial implications. As Gallese (2003, p.172) notes:

> Identity is so important within a group of social individuals because it enables them with the capacity to better predict the consequences of the future behavior of others. This capacity, in turn, contributes to optimize the employment of cognitive resources by reducing the 'meaning space' to be mapped.

Subsequently, the experimenters investigated to what extent, if at all, information about the other provided in the format of a brief narrative could override the spatial effect of ingroup membership. In contrast to Iachini et al. (2015), bodily space was not measured with a judgement task but a reworked visuo-tactile task. To manipulate moral judgement, a video was shown alongside text describing the shown person's prior actions, such as: "*Flirting with the boss in exchange of a favor*", "*Posting embarrassing pictures or videos of friends on the web, without their permission*" before PPS was measured with the multisensory integration task. Pellencin and colleagues discovered that PPS 'action' space[150] selectively expanded in the direction of the perceived other *only when* the narratives presented depicted them as moral rather than immoral. Moral information was

[149] On de Vignemont's (2018) account, Dretske (1997) (one of the few DSP theorists in the analytic tradition), adopts a similarly semiotic distinction between direct and indirect perception; if one knows that the postman arrives due to the dog's bark, this is an example of indirect perception, whereas knowing the postman arrives due to hearing his voice is an instance of direct perception. This seems congruent with the distinction adopted here. The embodied abduction is thus employed when hearing the dog's bark.

[150] What the experimenters mean by this is that 'action space' is not PPS measured by reachability tasks or pertaining to 'defensive space'. Action space here pertains to what I am calling the Joint Enactive Interface, which is an action-based, sensorimotor-social phenomenon

thus automatically encompassed into a sensorimotor-intentional act, seemingly facilitating the building of a JEI.

One explanation for this effect is that the other party's morality has significant interactive implications: if PPS facilitates meaningful social-spatial interactions in the *Mitwelt*, it follows that how one interfaces with the perceived other hinges on whether we should (and how smoothly we would) include them within our opening onto the world. At the broadest level, this is because the ethical principles embodied by the other either solicit or repel us, and this spectrum of favourability regarding the other maps onto a pre-reflective disposition to spatially ingratiate oneself with them or not. While in-group membership initially triggered a measurable PPS extension based on comparable principles, this effect was supplanted following the narrative intervention. It appears, then, that bodily spatial integration with others is immanent to the situation and continually shifts based on the quality of the social encounter in accordance with various sociocultural norms and signifiers, whereby one factor (morality) can override a previous one (group membership).

Fini et al. (2020) likewise examined the role of group membership and narrative upon perceived distance returning to an implicit 'near/far' judgement task (Fini et al., 2014; Iachini et al., 2015). Interestingly, they did not replicate findings that compatibility rendered others as experientially closer because in-group members were not judged as closer than out-group members despite ethnic affiliation. Conversely, moral out-group members were judged as metrically closer, in contrast to Iachini et al.'s finding that moral incompatibility made others appear further away. This result is taken to support the 'threat hypothesis'. As the authors note, we encounter others in a dual capacity, as either 'near' or 'far'. But each of these options contains its own dual (sub)aspect. Regarding 'nearness', one possibility is that others seem closer as expressed in everyday language (e.g., "that event brought us closer together"). Conversely, however, phenomenal closeness can be a side-effect of the danger that the other apparently poses which increases their situational presence in lived space ("keep one's enemies close"). Indeed, it is a well-replicated effect that fear causes PPS to expand to increase the processing speed of other entities in case quick reactions are required (Ferri et al., 2015).[151]

[151] The authors highlight that there could potentially be an unknown factor, unrelated to threat, that accounted for the distance effect, as there was no measure of threat itself included in the study.

The slight contrasts in the results between these 3 studies highlight why framing the issue as one of approach/avoid or negative vs. positive valence falls short and why we must include interaction *proper* in our account of the spatial *Mitwelt*. In Fini et al. (2020), metaphorical, 'positive' closeness was inversely proportional to experienced proximity since "participants perceived an out-group member as spatially closer to themselves as compared to an in-group member" (p.762). Fearing the other rendered them as a strongly demarcated intentional-object, defined as something to be wary of and therefore 'closer', that is, with heightened presence in the spatial situation. In Iachini et al. (2015), the immoral other appeared more remote, while the moral other was experienced as closer.

Whereas judged distance was greater for immoral avatars in the 2015 study, judged distance was smaller in Pellencin et al. (2018) and Fini et al. (2020). I propose that two variables may help explain this: 1) *narrative complexity*, and 2) *danger*. Regarding the first, in Pellencin et al. (2018) and Fini et al., (2020) we should note that moral information implying that 'this person is good' was not provided 'matter of factly', as was somewhat the case in Iachini et al. (2015), whereby moral information was typically given as: "*Alice/Francis is an honest woman/man who always tries to be fair with others*". Perhaps the more complex the narrative, the more powerfully the other is experienced *as* immoral due to the participant's immersion in the narrative logic.

What, then, of 'danger'? At a certain threshold, the brain-body apparently gives up trying to avoid the immoral other by keeping them distant and renders them as the dominant entity in surrounding space (thus 'closer') in reflection of their possibly large negative impact upon us. Consider further that, perhaps surprisingly, in the JEI, taken as the strongest marker of integration, we are not, strictly speaking, nearer to the other. More accurately, we are integrated into the other's space, or at least seamlessly co-embedded in space together; in the JEI, each of us becomes transparent for the other (Fuchs, 2018). The nearby immoral other, by contrast, remains a separate entity, an intentional-referent defined by negative valence, who can be both phenomenally closer or further away than a likeable person, depending on the context, but never as part of a unified spatial entity. Notably, Pellencin et al.'s study included a multisensory measure of PPS, a measure that more directly indexes the JEI. This suggests that moral information provided in narrative format can facilitate or impede the emergence of the JEI independently of the other's perceived nearness or farness.

But what is most thought-provoking for our current discussion is how, particularly in the 2018 and 2020 studies, a narrative intervention successfully replaced an initially identical psychophysiological reaction engendered by perceived in-group membership. This is especially interesting as ethnicity is far easier to perceive physically than morality; the former's replacement by the latter supports a DSP interpretation regarding the role of 'higher-order' factors in social spatiality. And since we are here detailing the pre-reflective cognitive correlates to PPS, moral judgements cannot be limited to those formulated in reflective decision-making processes. While there may be something like a dynamic transition from reflective to pre-reflective cognition (insofar as an agent rapidly and unconsciously pieces together evidence regarding the other's morality), phenomenologically such insights arise naturally and intuitively, prior to explicit, jury-like deliberation.

Indeed, 'Narrative Practice' (NP) (Hutto 2008; Gallagher & Hutto 2008) may bridge the explanatory gap here. In these studies, participants did not need to reason like jury members in court to ascertain the presented behaviour's moral value; the narrative simply presented the other as moral or immoral *as such* more or less automatically upon reading the story. The immorality of posting embarrassing photos without permission simply strikes us as bad behaviour, such as seeing someone kick a helpless puppy or steal from a charity collection box.[152] It is noteworthy that, compared with Iachini et al. (2015), Pellencin et al.'s (2018) experiment featured more complex stories used to convey the other's moral status, which successfully reshaped PPS as to include the other in the JEI *if* the story depicted them as moral, e.g.:

> You will see pictures of two pairs of twins who were separated after birth and grew up in different environments. While one twin of each pair has a criminal past of brutally murdering several persons, the other twin is known to be very friendly.

Blunter statements diverge from narratives such as this insofar as the former feature a diminished capacity to resonate with their readers. The narrative instead draws us into its situational logic in a way that the blunt statement fails to, inhabiting us with sufficient power as to trigger changes at the sensorimotor level. Indeed, Paolucci (2021, p.103)

[152] Future experimental work may seek to ascertain how bodily space reacts to situations of moral ambiguity, in which the morality of the perceived action is unclear.

claims that narrativity is not a solely linguistic phenomenon and is tied to meaningful action as much as to language. Accordingly, an ability to skilfully wield the power of narrative features negative or positive applications; emotional persuasion is the basis of all propaganda, after all. Indeed, narrativity is such a powerful tool that it can distort immediate perceptual reality, potentially supplanting a more accurate model of reality for a more fictitious one. As Fini et al. (2020, p.762) note: "evidences show that transportation or absorption into a narrative story can strongly influence perception of the world, even changing people's beliefs about what is real (Green & Brock, 2000)".[153] Indeed, Green and Brock (2000, p.703) define 'narrative transportation' as "loss of access to real-world information". Following the semiotic tradition, I tend towards the notion that we are almost always inserted into some kind of narrative logic, though our situatedness can be radically reframed by new narratives. Post-transportation into the new narrative reality, bodily space itself is differentially receptive to stimuli in accordance with the logic presented by the world that the narrative discloses.

Why, then, is conveying morality via narrative so compelling? Narratives incorporate moral information in the format of meaningful stories. As well as presenting the depicted other in new light, narratives also feature a predictive function, providing crucial information as to what others are *likely to do* next. Interestingly, group membership performs a comparable function (Gallese 2003), yet narratives can subsequently supplant its effects. Narrative competence (Hutto, 2008) permits *singular examples* of the other's conduct to enlighten us more generally as to who they are, what they did in their past and what they are likely to do in the future.[154] The impact of this 'extra information' is likely another case of the embodied abduction at work, by which the sensorimotor system automatically adapts to information inferred from the concrete perception of the other.

As discussed above (**2.3**), bodily space's future-directed, protending function can be detected in its currently-situated manifestation (Serino et al., 2007; Bassolino et al., 2010; Sykes, 2023). Accordingly, this influence becomes increasingly salient within the agent's situation as one learns more about the other, epistemologically assisted by an automatic abduction. The automatic abduction's content pertains to the most likely subsequent

[153] The power of narrativity seems such that experimentalists may be well-advised to use narrative to manipulate their subject's attitudes in a variety of designs.

[154] Of course, in reality, human fallibility and biases entails that we routinely make errors in this regard, as Umberto Eco frequently emphasised (see Paolucci, 2018).

interaction (e.g., scam, lie or help me), e.g.: *'The person who does X does so because they are a moral/immoral person and therefore will likely do Y'*. Here, a *semiotic* narrative competence serves to meaningfully link the token of 'immoral behaviour' to the type 'immorality' (Paolucci, 2019, 2021). Accordingly, PPS does not open itself to include that other who is likely to be hostile or oppositional in the JEI though it may present them as closer 'just in case' quick reaction is necessary (Iachini et al., 2015).

Furthermore, while the other's immorality took the shape of 'dishonesty' in Iachini et al., in Fini et al., it took the shape of 'danger', the second of our two explanations. In the first case, bodily space reacted accordingly by keeping the immoral other at a distance while, conversely, in the second case, it brought them closer to anticipate a quicker response to the danger they signified. Once more, we confront the famed heterogeneity of peripersonal space: morality can open up the JEI to include moral others (Pellencin et al., 2018) while rendering immoral others close (and closing off the JEI) so that we are poised to react to them quickly should their immorality impel them to harm us (Fini et al., 2020). Alternatively, it can keep them at a distance (Iachini et al., 2015), reflecting a somewhat contemptuous, distancing attitude. In their words, Pellencin et al. (2018, p.176) claim: "both a reduced reachability distance (as in Iachini et al., 2015) and an extended multisensory interaction space towards the other may reflect a positive attitude and willingness to interact with the person in the far space". These diverse responses likely pertain to nuances in the *type* of immoral comportment displayed, which is likely automatically abducted with the help of narrative competence (Hutto, 2008; Cuccio & Gallese, 2023; Paolucci, 2019). In all cases, however, bodily space automatically reflects the *Mitwelt's* situational demands, though more research is needed to map out the complexities of this relationship both conceptually and empirically.

The knowledge that bodily space is highly receptive to abducted moral standards thus raises further philosophical questions. If we are told that the other is a violent axe murderer, it is plainly evident why we wish to avoid interacting with him. Yet this general phenomenon may have more complex manifestations. While we might plausibly attest to the existence of cultural universals (injunctions against theft, incest taboos, etc.), it is also clearly the case that the human species has produced immensely diverse standards of conduct, as has been well-demonstrated from anthropological studies to Nietzsche's *Genealogy of morals* (1888/1998). Some broad moral paradigms may be grouped together, such as a warrior ethos that had comparable manifestations in Roman, Viking, Aztec and Samurai cultures or ascetic religious principles shared by Christian, Buddhist and Hindu cultures, albeit with some variations in the details.

Nonetheless, considering this heterogeneity of moral standards, we might justifiably assume that a single individual might produce a variety of discrete PPS responses in various observers, depending on the observing party's moral framework. Someone from a cosmopolitan city or a devoutly religious community may each view the other party as immoral due to their divergent lifestyle, automatically producing correspondent bodily spatial effects. When one encounters the other with the awareness that they follow a different value-system, their lack of resonance with that person likely inhibits the JEI from emerging. Should they instead encounter a 'fellow traveller' coherent with their own ethical paradigm, under correct conditions, their PPS may expand as to include them within a unitary spatial interface during face-to-face interaction.

In addition to attesting to bodily space's contextual-embeddedness, narrativity also speaks to the interpenetration of sensorimotor and 'higher order' faculties via semiosis (Violi, 2008). In most circumstances, one may not easily glean meaningful information about the other person's moral status from their outward appearance. But, upon being informed or otherwise becoming cognisant of it via signs, the observer's peripersonal space may instantly reflect a rejection or acceptance of the other's value system by abducting their moral principles from the relevant material signs present. If this results in viewing the other as immoral, then this immoral other is rejected as someone with whom to build a joint enactive interface with, even if they are 'subjectively brought close' purely because of one's lack of trust in them (Iachini et al., 2015). Accordingly, acts of cognition typically classified under the umbrella of 'executive function' such as moral judgements (Vera-Estay et al., 2015) are, on examination, detectable in agents' sensorimotor opening to the world, facilitated by direct social perception (Zahavi, 2011, 2012; Kreuger, 2018) and semiosis (Violi, 2008; Paolucci, 2019).[155]

Imagining this social effect unfolding in its ecological setting (i.e., in social situations outside the laboratory), reminds us of how the intractable presence of meaning via

[155] Subsequently, we will discuss how this process may have therapeutic applications (**3.3b**).

perceptible signs within the *Mitwelt* shapes the PrCC of intersubjective bodily space. It also provides another example of how semiosis unites natural and cultural phenomena in perception (Eco, 1997/1999; Viola, 2015). Namely, the electrochemical organ of the brain responds to cultural carriers of meaning via semiotic processes in order to form an 'optimal grip' over the *Mitwelt*. For instance, the presence of political insignia on a person (e.g., the Anarchist 'A', the hammer and sickle, swastika or any political party logo) are rendered as informative signs as to the other's political or religious beliefs and, by extension, their moral principles.[156]

Many political insignia have no direct, iconic relationship to the ideas they represent. The rose-in-fist sometimes used to represent socialism must be learned empirically, as does the fascist *fasces*. Accordingly, such political insignia belong to the class of signs known as 'symbols', signs which bear no direct relation to their signifier, being connected only via convention.[157] Furthermore, while many individuals today would be greatly averse to seeing Nazi or Communist insignia, such reactions would be far less pronounced during epochs in which those ideologies were normative. Accordingly, the meaning of such signs (i.e., whether threatening or non-threatening) are often socio-culturally contingent and showcase how complex semiotic forms modulate 'low-level' sensorimotor cognition in a culture-specific way (Viola, 2016; Paolucci, 2021).

Finally, it is necessary to note that the present use of 'narrative' is distinguishable from capital 'N' Narrativity (see Paolucci, 2019). Narrative competence designates the generalised and cognitively foundational capacity by which some experiences are meaningfully grounded upon an ordering logic of action (Hutto 2008; Gallagher & Hutto, 2008). This is one means by which sensory impressions automatically present *as* meaningful experiences. Just as the paperback novel is not only ink blots on material paper, what we sense, think and do are not (only) mere data, biomechanical operations or neural excretions. Rather, both sense data and conceptual meaning co-constitute each other as a meaningful *Gestalt* that structures our embodied being-in-the-world (Paolucci, 2020; Fuchs, 2018). Accordingly, the kind of narrative employed in these studies displays a

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[156] See Iliopoulos (2016) for an important discussion on the perception of social signifiers from the perspective of enactive cognitive semiotics.

[157] However, if one knows what to look for, the relation between such political symbols and the ideas they represent may be iconic. For example, the rose-in-fist represents a better society after socialist struggle, the fasces represents strength in unity. However, one may have no knowledge of this relation, and still feature a PPS response upon seeing the political insignia worn by the other.

function somewhat diverse from that typically described by NPH. Specifically, while it shares several core features with NP, it operates solely within the confines of a particular event (i.e., a social interaction).

We might venture, then, that 'Narrativity' (Paolucci, 2019) can potentially be made analogous with an ontological category that structures consciousness *as such*, while, conversely, engaging a narrative is more like an ontic phenomenon, structuring or restructuring a particular situation. In fact, in the studies examined here, we see perhaps the most literal functional use of narrative: a story *proper,* capable of co-constituting acts of situated social-spatial interaction and disclosing a new situational logic that pervades the embodied social interaction. As somewhat analogous to an ontological structure such as temporality, Narrativ*ity* pertains to the deep structure of possible experiences. Nonetheless, we see how the power of narrat*ive,* even in its 'ontic' format, penetrates the agent's sensorimotor network, as measured in PPS alterations (Iachini et al., 2015; Pellencin et al., 2018; Fini et al., 2020). Learning that another person is immoral through 'narrative transportation' (Green & Brock, 2000; Fini et al., 2020) inhibits our incorporation of them into a joint enactive interface and, if they are extremely immoral, simultaneously presents them as 'nearer' than they otherwise would be so that we may 'keep an eye on them'.

Thus, the socially-powered sensorimotor phenomenon of bodily spatial inclusion vs. exclusion that undergirds the JEI's adaptivity essentially pertains to questions regarding the limits and boundaries of the (spatially) extended, *Mitwelt*-embedded social-bodily self (Fuchs & Froese, 2012). While this dynamic is largely an automatic phenomenon, we have seen how it is nonetheless profoundly influenced by moral factors, the automatic integration of which into social-sensorimotor processes bypass classic 'higher' and 'lower' dichotomies (see Kiverstein and Rietveld, 2014; Rietveld & Brouwers, 2017; Newen, 2018). However, the social-spatial dynamic discussed in this section thus far may also be subject to characteristic distortions in its proper functioning. As such, an explicit discussion of the JEI's clinical aberrations will feature as the third and final section of this chapter.

3.3 Social-Spatial Disruptions

The concept of 'boundary' in our discussion of embodied social spatiality has emerged as an important theme. We began with the idea that the lived body does not terminate at the epidermic layer but rather extends into a zone of world-interaction known as peripersonal space, the enactive interface where meaningful interactions with physical matter and co-specifics in space occurs. Throughout this section, we have examined how individual 'zones of interaction' sometimes blur their boundaries to merge with those of others during direct social engagements, entailing that the socially-extended lived body (Fuchs & Froese, 2012) does not always terminate at one's individual extended bodily presence, but is co-determined by the motivations, emotions, intentions and actions of others (see Fuchs, 2017, 2018). This phenomenon has been labelled here the 'joint enactive interface'.

However, social abilities and relationships are frequently the loci for symptom manifestation in various psychiatric conditions (Gallagher & Zahavi, 2012). The spatial dimensions of sociality are no exception here. Two psychological conditions in which self-other spatial boundaries manifest in a distorted format are autism spectrum disorder (ASD) and schizophrenia (SZ).[158] Furthermore, these conditions map onto our recurrent conceptualisation of social-spatial 'openness' and 'closedness', serving as extreme, 'polar' cases of each position. This classification was first articulated by Noel et al. (2017, p.9):

> Etiological and pathophysiological processes that define SZ and ASD may be founded, respectively, in an extreme shallowness or steepness [in the way that each condition] represents the *boundary between 'self' and 'other', as indexed by peripersonal space,* (emphasis added).

There is, therefore, a plausible way in which the more existential, intersubjective and pre-reflective dimensions of spatiality are measurably 'indexed' by peripersonal space in clinical research. This implies that, in accordance with the embodied-enactive theory of social spatiality formulated here, an ontological mode of spatial being-in-the-world has a measurable, ontic register in bodily space suitable for interdisciplinary analysis. Moreover, the intricacies of the JEI itself can be further mapped out by dissecting two of its extreme, polar manifestations as located at either end of an 'open' to 'closed' continuum, one side of which is typified by an extreme *openness* (SZ) and the other by extreme *closedness* (ASD), in relation to a pre-reflective tendency to spatially integrate with others. In this final section, I develop an account of ASD and schizophrenia in accordance with Noel et al.'s

[158] It is instructive to again consider the continuum between embodied-enactive cognition and traditional psychology. From a psychological standpoint, problems in self-other boundaries as manifest in clinical disorders might include violations of privacy or overidentification. However, these 'reflective' aspects are contrasted by the more deeply rooted, bodily and pre-reflective dimensions of consciousness under discussion here, though they may be linked in some capacity.

formulation that simultaneously grounds these conditions within the current conceptual framework of embodied-enactive, social spatiality.

3.3a Schizophrenia

Schizophrenia is a condition that has received considerable attention in phenomenology for a century (Sass and Parnas, 2007). Merleau-Ponty returns to the condition several times in *PoP;* crucially, he does so most often when explicating the phenomenology of embodied spatiality. Semiotics has likewise taken an interest in schizophrenia (Harrod 1986; Brandt, 2010; Lobaccaro, 2023). Prior research on how PPS disturbances specifically are implicated in SZ have already emphasised its embodied, phenomenological and/or pre-reflective aspects (e.g., Parnas, 2000; Legrand, 2007; Fuchs, 2005; Sass & Parnas, 2007; Gallese & Ferri, 2014; Nelson et al., 2020). In this section, we have correspondingly focused on how agents spatially unite or distinguish themselves from others at an embodied, pre-reflective level. Of relevance here is that one of the most characteristic symptom clusters of schizophrenia are classified as "blurred self-other boundaries" (Noel et al., 2017; Ferroni et al., 2022). This pre-reflective (and sometimes reflective) confusion as to where 'self' and 'other' begin and end may even be to the extent that people with schizophrenia temporarily lose the capacity to distinguish between themselves and others entirely (Ebisch et al., 2013; Gallese & Ferri, 2014).

The empirical literature showcases a variety of ways in which the boundaries between self and other are distorted in schizophrenia. Recently, Ferroni et al. (2022, p.1089) found shallower PPS boundaries in SZ populations, "suggesting weaker self-other differentiation". Both Ferri et al. (2014) and Ferroni et al. (2020) found higher PPS variability in SZ populations, suggesting both PPS size and shape is far less fixed and far more amenable than neurotypical subjects. In addition, Blanke et al. (2014, p.2684) claim that patients with SZ characteristically overestimate their body's presence due to mistaking the consequences of their own bodily actions for those of others, and that this may potentially contribute to hallucinatory content of mistaking oneself for another more broadly.

Furthermore, Holt et al. (2015) found an abnormally extended personal ('comfort') space, often linked to PPS, in schizophrenic populations, which may positively correlate with symptom severity in the social sphere (Schoretsanitis et al., 2016; Ferroni et al., 2020).

One explanation for such findings consistent with the literature may be that PPS is hypersensitive to normative social influences and so overreacts to mere 'hints' or 'suggestions' of bodily spatial integration that otherwise bypass those with normatively-attuned social-spatial cognition, possibly linked to 'aberrant salience' (Nelson et al., 2020). For our purposes, this suggests that clinical aberrations showcase an exaggerated version the otherwise normative merger between enactive interfaces that agents typically slip in and out of when acting alongside others in space.

Correspondingly, several studies have indicated that people with schizophrenia are significantly more susceptible to the rubber hand illusion (RHI) (Peled et al., 2000, 2003; Thakkar et al., 2011), which suggests that people with SZ are more prone to include external entities within their body image. Individuals with high-schizotypy, often viewed as a subclinical manifestation of schizophrenia have diminished capacity to distinguish between their own fingers when someone else touches them (Fotia et al., 2022). Moreover, Ebisch et al. (2013) found distinctions between SZ and control participants who observed an instance of both positive (caress) and negative (hit) affective touch applied to another's hand. Furthermore, the neurophysiological evidence in Ebisch et al. showed reduced activation of the ventral premotor cortex[159] and reduced deactivation in the posterior insular cortex in SZ participants. Accordingly, the disruption in SZ patients was predominantly found in the normative ability for a neural *suppression* of affective arousal , indicating problems with distinguishing between sensations applied to the other and those applied to oneself, which Ebisch and co-authors note explictly pertains to the pre-reflective level of self-other differentiation.

This collection of evidence strongly suggests that the pre-reflective, neurophenomenological profile of schizophrenia can enter reflective, conscious delusional content. This is because schizophrenic delusions concerning others are typically characterised by a sense of intrusion or diminished differentiation, which may proceed in either direction. Telepathy is one such paradigmatic example. Patients suffering from this delusion will either believe that they can either read the minds of others or that others can read their minds, or vice versa (Hoerl, 2001). 'Thought insertion' is a similar delusion whereby "patients suffering [from it] have a problem with drawing a clear boundary between themselves and the world" (Hoerl, 2001, p.191), believing that they can actively

[159] This is a brain area also implicated in PPS (Fogassi et al., 1996; Graziano et al., 1997, 1999; Bufacchi & Iannetti, 2018).

insert certain thoughts into the minds of others, or that others can insert thoughts into their minds. In such delusions, the boundaries separating oneself from that of the other appear drastically uncertain; even the most private aspect of oneself (e.g., one's thoughts) overlap seamlessly with others, whereby it appears self-evident that the typical borders separating oneself with the public world have disintegrated, often causing acute distress and self-identity dissolution.

This elasticity and shallowness of the spatial boundaries separating the self and other entities may also apply to objects. Frequently, schizophrenic delusions centre on the belief that one exerts control over objects or is controlled by objects in a manner that defies plausibility. A patient may believe that a household appliance is delivering them secret military codes, for example. This reflects how, at the level of lived space, clear demarking features between oneself and other entities may be disrupted. To be sure, in some sense, this same dynamic characterises typical manifestations of bodily spatiality, as classical 'subject-object' dichotomies dissolve during engaged activity between agents and objects and/or others. Yet, potentially due to the thin or overly flexible PPS boundary in SZ (Noel et al., 2017), this manifests in an amplified and consequently disorienting fashion for SZ patients. Further experimental research is therefore needed to ascertain whether or not schizophrenic patients are overly sensitive to tool-transparency. An interesting counter-example is the finding that tool-observation of the kind discussed above (**3.1**) was less pronounced in high-schizotypy subjects, though this was attributed by the authors to differences in the task employed (Ferroni et al., 2020).

Thus, if PPS indeed reflects the broader way in which one is spatially embedded in the *Mitwelt*, it is not surprising that we discover parallels in the neurophysiological and phenomenological planes pertaining to an excessive overlap in enactive interfaces as occurs between SZ patients and those whom they encounter. However, it is further unsurprising that more complex content of cognitive delusions (e.g., delusions of control or thought insertion) may stem from a more embodied, sensorimotor-spatial phenomenon in that the schizophrenic's enactive interface is constantly and involuntarily overlapping with those others around oneself. Such a continuum between the spatial phenomenology and neurophysiology coincides with body-centric accounts of language and metaphor

(Gallese & Lakoff 2005; Cuccio & Gallese, 2018)[160] that lend well to the idea that disturbances at the spatial-sensorimotor level apply to and co-determine the content of more abstract cognitive delusions. Whereas a fully-fledged unification of peripersonal spaces (i.e., the JEI) are situation-specific and require specific triggering conditions to emerge, a hypersensitive 'hair trigger' for this phenomenon's emergence, as found in SZ, can easily produce delusions that feature pathological self-other overlap as their primary content.

If bodily space in SZ is susceptible to a psychopathological overextension, in the manner that it unites too easily with the bodily spatial interfaces of nearby others, then it follows that SZ patients have difficulty in discerning where their bodily self begins and ends compared to the general population (Gallese & Ferri, 2014; Ferroni & Gallese, 2022). Indeed, in some sense, this is simply a realistic acknowledgement! A thinner, hypersensitive social PPS boundary (Noel et al., 2017) does indeed mean that the way in which bodily space manifests features impoverished self-other or self-environment differentiation within the experience of schizophrenic people. If we reconsider habit's central role in PPS (**2.3**), as many phenomenologists and cognitive semioticians insist, we can see how undergoing repeated experiences of the bodily spatial boundaries between self and other dissolving (caused by a pathologically frequent JEI formation with others) might leave a lasting imprint in the lived body and its neural correlates via neural plasticity. This may be why SZ patients often display long-term alterations in bodily space and recurrent delusions and hallucinations surrounding self-other differentiation (Hoerl, 2001).

To bring this all together, how then can ECS provide a theoretical treatment of bodily space and schizophrenia? Echoing Merleau-Ponty, Gallese & Ferri (2014, p.4) argue that "self and other are linked by a chiasmatic relation" and that deficits in social cognition may stem from the bodily dimensions of this relation instead of from social cognition modules *per se*. Indeed, in SZ, it seems as if this intersubjective point of contact with the other is blurred to the extent that it is difficult for some individuals with SZ to pre-reflectively discern where exactly the self-other bodily distinction begins or terminates. Moreover, as Ferroni & Gallese (2020, p.525) note in relation to the neural pathways that facilitate normative intersubjectivity: "the evidence of shared neural networks between self and

[160] Heidegger (1929/1984) deals with similar topics that were left partially open two years prior in *Being and Time (1927/2010)* and even explicitly deals with spatial metaphors (p.138).

other, possibly enabling to make sense of others' behaviours and feelings, could in principle lead to self-other confusion. This is obviously not the case". In fact, it seems that the specifically *partial* resonance and *asymmetrical* intensity of mirror-based neural activity in neurotypical subjects is precisely what renders others as *second* selves, not undifferentiated aspects *of ourselves*, thus giving birth to a *true* intersubjectivity (Gallese, 2014) and not just mere delusion.

This analysis provides an intriguing neuroscientific parallel to Heidegger's (1927/2010) previously cited notion that selfhood "is what maintains itself as an identity throughout changes in behavior and experiences and in this way relates itself to the multiplicity *(BT,* 115/112*)*. That is, we can relate to the multiplicity of others only by being minimally differentiated in some capacity and interacting with minimally differentiated co-specifics as individual agents sharing a *Mitwelt*. We can classify the exaggerated, 'open window' (Brandt, 2020) version of the joint enactive interface as found in SZ as a disruption - rather than a greater degree of - attunement and empathy with the other precisely *because* it interferes with understanding the other *qua* other. Accordingly, the idea of a minimal differentiation between self and other entities at a philosophical level, emphasised at the chapter's start, redemonstrates its importance here. Neural pathways that subpersonally distinguish between self and other, even while we are actively integrated in reference to tasks and co-embedded within an environment, permit authentically intersubjective interactions between differentially spatialised beings. Indeed, the clinical literature showcases how one possible misinterpretation of the enactivist framework of intersubjectivity actually more closely resembles a 'breakdown' of the intersubjective version of spatiality forwarded here rather than its normative expression.

Finally, schizophrenic symptomatology has previously been located both at the bodily, pre-reflective, largely sensorimotor domain (Parnas, 2000; Legrand, 2007; Ebisch et al., 2013; Noel et al., 2017) but also at the level of the temporally-extended narrative self (Gallagher, 2003; Northoff et al. 2006; Noel et al., 2017; Lobaccaro, 2023). Accordingly, since narrativity can inform sensorimotor spatiality, at least when applied to others (**3.2**), narrative interventions may be one potential therapeutic route for assuaging some of the social problems associated with SZ (see Gallagher & Hutto, 2019). Manipulating the morality of the other via narrative intervention, for example, may enable clinicians to fine-tune schizophrenic responses to others in space over a period of time. Nonetheless, the fact that symptoms of clinical disorders such as SZ are seamlessly implicated in social, sensorimotor and narrative domains itself speaks to the need for further research on such conditions' bodily spatial dimensions (further evidencing the interpenetration of said domains) and the consideration and inclusion of these spatial dimensions when developing diagnostic tools and therapeutic interventions. In what follows, we will analyse another condition in which spatiality seems deeply implicated but, interestingly, in a polar opposite way to that of SZ (Noel et al., 2017).

3.3b Autism Spectrum Disorder

If schizophrenia is characterised, in a semiotic sense, by excessively open windows (Brandt, 2020), ASD may be characterised by excessively closed walls. Noel et al. (2017, p.9) write: "a shallow self-other boundary gradient is indexed by the proneness to disembodiment, while a steep self-other boundary gradient [in ASD] is illustrated by an inflexibility in altering one's self-location". I wish to emphasise that this steep 'boundary gradient' manifests as the shape and size of their bodily space remaining pathologically fixed in place, pre-reflectively 'refusing' to merge with the enactive interfaces of others. As with SZ, this apparently engenders corresponding psychological and cognitive parallels, such as a feeling of isolation and abnormalities in personal space regulation (Candini et al., 2019); indeed, ASD children feel more comfortable at a greater distance from other people compared with controls (Gessaroli et al., 2013). Despite some variance in the ASD data generally, it has been noted in the literature that rigidity and inflexibility in one's spatial boundaries characterises the condition (Kennedy & Adolphs, 2014; Noel et al., 2017). As such, people with ASD are less phenomenally diffused in the *Mitwelt* and therefore are somewhat less amenable to the social sanctions existent there (Paolucci, 2019), as well as the fluidity that otherwise characterises successful social interactions.

Correspondingly, Fuchs (2018, p.178) invokes spatiality when describing successful 'primary intersubjective' interactions with infants thusly: "visual, proprioceptive, and motor modalities are integrated into a joint sensory space; there is an intermodal body schema that connects with the perception of others". Fuchs suggests that this dynamical interplay likely forms the basis of shared affectivity and, like Gallese (2011), also explicitly links this phenomenon with Merleau-Ponty's phenomenology of intercorporeality. By extension, ASD individuals experience problems in aligning with the motor potentialities of others in this 'joint sensory space', which has deleterious consequences for both primary motor, affective and attentional abilities as well as secondary narrativizing, cognitive abilities. It follows, then, that spatial disruptions within this dynamic of 'intercorporeal resonance' may contribute to the well-documented 'cognitive empathy' deficits in social cognition in ASD, rather than deficits in social cognition modules *per se,* in parallel with Gallese & Ferri's (2014) analogous claims regarding schizophrenia.

According to Gallagher & Hutto (2008, 2019) and Paolucci (2019, 2021), narrativity helps provide an ordering principle for human social interactions, endowing movements and utterances with comprehensible meaning, coherence and predictability. Paolucci (2021, p.65) adds that "with narrativity, the semiotic tradition means a prelinguistic skill able to shape experience through meaning". These social skills are sometimes labelled 'folk psychological' so that, when we engage our cultural co-specifics, we can intuitively understand what the other is doing, what they have just done, and we can skillfully anticipate what they are soon to do (Gallagher & Zahavi, 2012; Gallagher, 2020). Taking what we learned from the prior section on SZ, a deficit in bodily space may therefore cause or exacerbate deficits in narrative-based social understanding, and/or vice versa. Here, we encounter a bridge between the JEI and narrativity as previously discussed, since "in embodied interactions during primary intersubjectivity, a narrative competence (in the semiotic sense) is already at play" (Paolucci 2021, p.68).

Indeed, it is telling that children with autism are potentially less capable of partaking in narrative interactions which, according to 'Narrative Semiotic Practice Hypothesis' (Paolucci, 2012, 2019), features both linguistic and motoric aspects, since the entrenched bodily spatial boundaries typical of ASD impede the development of primary intersubjectivity and thus secondary intersubjectivity also. According to Paolucci (2019, 2021), narrative competencies can assume two broad categories: deception and cooperation. The studies discussed in (**3.2**) seemingly cohere with deception, at least insofar as 'deception' falls under immorality, which, if detected, would likely prevent the JEI's formation during interaction. It is interesting to note that people with ASD often express a heightened sense of morality to which others often fall short (de Vignemont & Frith, 2008),[161] as if others are constantly kept at a distance, as seen in how neurotypical populations engage immoral others in space (Iachini et al., 2015). Recall that, in such studies, the participants 'sanctioned' the other at the sensorimotor level by not including

[161] Intriguingly, the authors of this paper use the spatial terminology of 'egocentric' and 'allocentric' to describe morality and empathy in ASD, noting that ASD subjects tend to view the world in egocentric terms but also understand social relations and normative conduct in a rules-based, highly abstract allocentric manner. This provides independent support that morality, sociality and spatiality are profoundly connected and should continue to be investigated.

them within the joint enactive interface (Pellencin et al., 2018). An exaggerated version of this phenomenon may thus be in operation in ASD.

Also reconsider the studies that showcase how co-operation fosters an automatic fusion between peripersonal spaces whereby agents' bodily spaces are temporarily bound together (Teneggi et al. 2013; Hobeika et al. 2019; Rocca et al., 2019), thus perceiving the world as meaningfully laid out on an intrinsically intersubjective and intercorporeal basis. Utilising this paradigm, Candini et al. (2019) tested the effects of co-operative tool-use in ASD infants and found that, while PPS extension following tool-use occurred normally, ASD infants did not undergo 'comfort space' expansion to include the other.[162] By contrast, neurotypical infants underwent a comfort space expansion following cooperative tool-use with an adult, including the adult within their spatial boundary. Future studies should aim to replicate these results by incorporating multisensory measures of PPS, perhaps in joint tasks as seen in Hoebeika et al., (2019) to further probe whether the enactive interfaces of ASD populations merge with those of others. Nonetheless, we know that bodily cooperation does not permit inclusion of the other within 'comfort space', which is a prerequisite and a potential marker of the JEI. This implies that cooperation has no effect upon the bodily spaces of ASD infants, potentially either causing or exacerbating related social-spatial abilities such as joint attention, narrativising and affective co-attunement (Fuchs, 2018; Paolucci, 2019).

Drawing on multi-sensory integration research, Mul et al. (2019) further speculate that errors in predictive processing may greatly contribute to ASD social deficits and that more attention is warranted regarding the parallels in the condition's temporal and bodily aspects. Crucially, Paolucci (2021) also links narrative-based social understanding with predictive processing theory (Clark, 2016). Accordingly, an explicitly social-spatial deficit may preclude the affected individual from certain types of social learning and shared environment-absorption and consequently social understanding generally, which highlights the importance of bodily space across multiple forms of social cognition. It is interesting to note in this context the well-documented preference that people with ASD display for objects over people. As the evidence shows that ASD individuals display normal PPS responses with object-use (Candini et al., 2019), it is unsurprising that people with

[162] Comfort space designates how comfortable subjects are to approach another and relates to personal space regulation. While it is undoubtedly linked to PPS, there is debate if each refers to a single construct. See Bogdanova et al. (2021) for a review and discussion.

ASD display a marked preference for entities conducive to normative spatial experiences. Likewise, it is also noteworthy that Cascio et al. (2012) found that ASD individuals do eventually experience the RHI; it just takes longer for the illusion to emerge. Interestingly, evidence also suggests high-empathy individuals are more sensitive to the RHI (Seiryte & Rusconi, 2015), whereas ASD populations often display reduced empathy by certain measures (Harmsen, 2019) (see also **3.2.3**).

In addition, Mul et al. (2019) acknowledged Noel et al.'s (2017) theory and sought to test susceptibility to the Full-Body Illusion (FBI) in ASD populations, which involves subjects wearing a VR headset and seeing a virtual body in front of them being stroked, while they themselves undergo the same stroking procedure applied to their backs. Mul and co-authors found reduced susceptibility to the FBI and also replicated findings that ASD individuals have a smaller PPS with a steeper boundary. They concluded that the reduced FBI likely pertains to a deficit in the capacity to flexibly switch from self-oriented to other-oriented bodily representations. Indeed, a fixed and immobile bodily space that does not easily slacken and incorporate external entities such as virtual bodies is likely to remain overly static during real social interactions, where joint enactive interfaces typically form.

Furthermore, it is interesting to note that cognitive inflexibility has been listed (albeit with some dispute) as a characteristic symptom of ASD (Leung and Zakzanis, 2014). Regarding such inflexibility, we again observe a parallel between the bodily-spatial and cognitive domains, encountering a synechism between the cognitive and spatial dimensions, traditionally considered. Merleau-Ponty's notion of *Praktognosia,* utilised in comparable enactive accounts (Gallese, 2011, 2018; Gallagher, 2017; Fuchs, 2018), may explicate some of the social deficits present in ASD. Namely, if one does not automatically become smoothly aligned with the enactive interfaces of others, whereby the world of intentional-objects suddenly assumes a new, intersubjective character, then the predictive aspects constituting spatial co-embeddedness that otherwise permit pre-reflective anticipation of others' actions, and thus social understanding, are impaired. It is as if those with ASD are inserted in the middle of a narrative without any orientation as to its beginning or likely end and cannot ease into the situation's rhythm.

However, the fact that the characteristic bodily spatial rigidity that initially resists the rubber hand illusion's emergence eventually loosens so that autistic people experience the illusion (Cascio et al., 2012), coupled with the fact that tool-transparency is retained in ASD (Candini et al., 2019), indicates that therapeutic interventions might do well to focus on embodied but co-operative tool-use. By beginning with a task that autistic people feel comfortable with and that produces normal spatial experiences (e.g., tool-transparency), clinicians and caregivers may then be successfully included within the JEIs of ASD populations by partaking in that action. Motor-intentionally, the object remains the primary intentional-referent, yet the other may be included into the JEI through the entry opened up via practical cooperation. Co-operative tool-use thus may be the key to helping ASD infants enter an ameliorated developmental trajectory with regards to social skills and understanding. While cooperation did not produce typical social-spatial merger effects in Candini et al. (2019), extending the activity's duration may, as in Cascio et al.'s (2012) RHI experiment, eventually produce a desired outcome.

At the opposite pole, examining the abnormally steep PPS boundaries in ASD may shed light on the way ASD populations find it difficult to resonate with others, find close personal contact uncomfortable, or feel highly attracted ('held') by physical objects. Spatial disruptions also shed light on normative self-other spatial interactions using a kind of 'breakdown' logic. If we contend that SZ is characterised by a *dis*embodiment of the self (Gallese, 2003; Fuchs, 2005; Stanghellini, 2009), ASD is thus characterisable as a *hyper*embodiment of the self; that is, the bodily self's boundaries are atypically fixed rigidly in place and thus not amenable to fluidly respond to the phenomenal bodily presence of others. Thus, since there is a mounting body of evidence implicating a bodily spatial dimension to several psychiatric conditions (e.g., Nandrino et al., 2017; Rabellino et al., 2020), employing the spatial terminology and neurophenomenological concepts developed in this chapter may prove helpful in detailing the ways in which clinical populations are spatially mis-attuned to their surroundings, as well as possibly pointing in the direction of possible interventions. Moreover, the conditions of SZ and ASD have helped us explicate the JEI's structure by witnessing disturbances in its regular structure in accordance with a 'breakdown' logic.

4. Chapter Summary

Combining resources from neuroscience, semiotics and phenomenology, this chapter has sought to explicate how agents spatially engage others from an embodied-enactive perspective, with a view to detailing the 'pre-reflective cognitive correlate' and 'motor-intentional profile' to intersubjective bodily space, alongside promoting the 'enactive interface' interpretation of PPS itself by integrating said resources. I have presented forms of evidence with the intention of demonstrating that social factors profoundly mould 'individual' sensorimotor-spatial cognition. Additionally, we have attempted to disclose space itself as an intrinsically social phenomenon; in other words, as a spatial instance of what phenomenologists have termed '*Mitwelt*'. In doing so, it has been emphasised that lived space is ultimately a relational, meaningful and public phenomenon, describable also as an instance of 'semiosis', that threads together the actions, words, gestures and motor potentialities of different agents acting within it against a meaningful, semiotic-cultural background.

Employing phenomenological resources, we began by first accounting for a minimal individuation of the self on social-spatial grounds, not dissimilar to the concept of a 'minimal self' (Zahavi, 2011, 2012; Lane, 2020), a notion which likewise boasts a phenomenological heritage. After sustaining the notion that there is indeed something like a 'bodily spatial self', we detailed the multitude of ways in which spatially individuated selves engage one another within shared space, ranging from comparatively simple cases of visually intending the other to cases whereby agents merge their spatial interfaces to become a unified, sensorimotor opening onto the world as a joint enactive interface. Moreover, the agent's capacity to use tools, learn habits, experience affective states and discover their surroundings are all implicated immediately in their being spatially co-embedded in a *Mitwelt*. In Heidegger's terminology, being situated with others in such a manner takes the form of *Mitdasein* or, more cumbersomely in English, 'being-there-with-others'. In this context, both ontically perceiving others practically engage tools, alongside witnessing, experiencing and simulating the intentional actions and emotions of those with whom we share surrounding space intrinsically shapes our own mode of spatial embeddedness so that the tool-using, expressive and interacting bodies of others fundamentally co-constitute one's own bodily space.

All this is to say that, if one never encountered others engaging with objects (or oneself), one's 'individual' bodily space would lack its actual instantiation in the world. This serves as negative evidence against the idea that others in the *Mitwelt* are completely sequestered, separate beings who exist for me as something comparable with objects in a spatially extended universe whose speech and behaviours I must cognitively interpret in order to make sense of (Dreyfus, 1990). We can, therefore, concur with Merleau-Ponty (*PoP*, p.521) in that: "The-other-as-object is nothing but an insincere modality of others, just as absolute subjectivity is nothing but an abstract notion of myself". That is to say, in the *Mitwelt*, bodily space is relationally co-constituted so that lived space does not arise from one's 'absolute subjectivity' but rather those encountered in space are perhaps just as responsible for its immediate character as my own bodily capacities are (see Maratto, 2012).

Conceptually, we should again lean on Peirce's philosophical synechism to conceptualise this self-other spatial relation. In our reading, the spatial agent is never a fully-circumscribed *Cogito* existing in the world only as a private, solipsistic perspective contained in space. But neither are they a completely disintegrated self, indistinguishable from others. As discussed, complete bodily spatial disintegration in the social world better describes psychopathological manifestations of spatiality than its normative version. Yet, as Heidegger noted, our individual selves always contain trace elements, even when alone, of that wider *Mitwelt* to which we belong. In our everyday activities, we thus oscillate across a spectrum of degrees of involvement with others, from staying alone in a room to actively co-operating, so that one's enactive interface seamlessly merges with those of others. Thus, the intersubjective constitution of lived space has several manifestations alongside neurophysiological and experiential correlates, that nonetheless always operate inside of an ontologically public *Mitwelt*.

More specifically, by initially expanding upon the previously described notion of 'tool-transparency' (**2.1.3**), the phenomenon of 'co-transparency' was subsequently proposed as its intersubjective variant. Co-transparency was uncovered as a second exceptional case departing from the typically observed lack of PPS expansion during the 'passive holding' of a tool, which otherwise manifests only during engaged tool-use (Iriki et al., 1996; Berti & Frassinetti, 2000; Maravita & Iriki, 2004). The intersubjective nature of spatiality was found to penetrate individual bodily space such that merely observing another using a tool can trigger tool-transparency in the passive observer via motor-intentional alignment. Developing upon the idea of minimal spatial individuation, it was emphasised that agents undergoing motor-intentional alignment need not isomorphically import the other's spatial perspective into their own but instead automatically account for their presence within their own enactive interface, irrespective of the semiotic schema (e.g., collaborative or competitive) of the interaction. Even when the other faces us in the format of an antagonistic relationship, their spatial perspective is still pre-reflectively accounted for in one's own enactive interface (Abrams & Weilder, 2015; Patane et al., 2021). This point is analogous to mirror neuron functioning whereby MNs map the intentionality of the other but do not confuse oneself with the other (Gallese, 2001, 2005, 2006; Tsai et al., 2011; Gallese & Sinigaglia, 2011b, 2018; Kiverstein & Rietveld, 2021).

As with objects (**2.2**), affectivity was also found to profoundly structure how individuals relate to one another in space. Indeed, enactive approaches to social cognition emphasise "intercorporeality and interaffectivity" from the outset, in both a situational and developmental context (Fuchs, 2017). Socio-affective intentionality- that is, how the other is affectively intended, or affectively intends us - has significant bodily spatial implications, such as when another looks at us with a fearful or angry expression. The spatial consequences of this influence include action-oriented dispositions geared toward possible escape or confrontation when facing an angry person (Ruggiero et al., 2017; Cartaud et al., 2018; Ellena et al., 2021) or a centrifugal attentional reorientation (Ellena et al., 2020).

We might view the relationship between the perceiver and a powerfully expressive face as another instance of 'hold', whereby the captivating presence of a fearful look produces a stronger spatial effect compared with other emotions. Moreover, even if the other is not the direct *cause* of one's dominant mood, we can nevertheless find ourselves oriented towards *all* nearby others in a kind of omnidirectional, affect-laden motor-intentionality in a manner disclosed by mood (see **2.2.3**). For instance, positive or negative music dictates whether we are spatially open or closed to all nearby others in surrounding space, as either 'open' or 'closed' (Tajadura-Jiménez et al., 2011). This finding suggests that one can be affectively embedded in a social world even by non-social factors (i.e., music), which nonetheless impact our tacit social-spatial relationships with others.

Moreover, just as contextual compatibility factors outlined above (**3.1**) modulate co-transparency, similar factors likewise co-constitute the phenomenon labelled 'affective co-attunement'. Affective co-attunement designates a phenomenon whereby two or more agents undergo an affective intentional relationship to one entity co-present within their surrounding space. Recall how, for co-transparency's emergence, the observer experiencing co-transparency was required to hold a similar tool and stand near to or opposite the observed tool-user (Costantini et al., 2011; 2014). In parallel, while at the ontological level, the affective presence of others might always scaffold our generalised mode of spatial being-in-the-world, it appears that bodily space is ontically most receptive to dimensions of affectivity that press upon one's immediate situation. The subdued facial expressions of those we pass by on a daily basis scaffold our generic, everyday way of being. Conversely, intensely emotive faces uniquely cause radical and sudden shifts in our global mode of spatial embeddedness, bringing forth a previously unseen aspect of the environment to prominence. Indeed, a similar reasoning was behind Peirce's emphasis on the power of surprise (West, 2021). Anger and fear *of the other* likewise seem to trigger sudden reorientations within surrounding space because these phenomena radically reorganise the dominant meaning of the spatial situation.

However, in distinction with perceived tools, an entirely unknown object of fear (or surprise, joy or anger for that matter) might come to dominate one's spatial situation in a manner only comprehended semiotically via the perceived other. Indeed, with 'affective co-attunement' (**3.2.2**), it was discovered that the 'embodied abduction' (Cuccio & Gallese, 2018; Cuccio & Caruana, 2023) incorporates what the other discloses about our environment directly into one's own enactive interface, producing appropriate spatial responses. This occurs due to the agent's constitutive co-embeddedness in contextuality, which provides an encyclopaedia (Eco, 1979, 1989) of situated world-information (Violi, 2017) from which to 'fill in the blanks' regarding ambiguities that lie at the intersection between conceptual and perceptual information (Viola, 2016).

However, because we are here talking of embeddedness of a sensorimotor variety, the procurement of such knowledge occurs automatically (Cuccio & Gallese, 2018; Cuccio & Caruana, 2023). Moreover, we also saw (**3.2.3**) that when the other becomes literally less accessible, such as with a translucent barrier placed between them, the other correspondingly imprints themselves less pronouncedly upon our situation (Gherri et al., 2020). Consequently, our automatic, physiologically-based capacity to empathise with them is dampened. Since people with ASD display difficulties in both social understanding and in merging spatial interfaces with others (Candini et al., 2019; Mul et al., 2019), this further suggests a link between bodily space and social understanding.

Affectivity can disclose the other in a particular intentional modality, facilitate social-spatial interaction or quickly realign bodily space into new affective logics brought forth by the other. Thus, affectivity both grounds our normative, pre-reflective ability to understand others, while co-constituting our own spatial embeddedness in the *Mitwelt*. Other modes of socio-affective intentionality, of which surprise and fear are paradigm cases, initiate a triadic relation that dominates the spatial situation via shared intentionality (Zahavi, 2015; Kiverstein & Rietveld, 2021) that instantly arises between two or more parties, uniting them in a shared, affectively-charged reference to a third entity (Fuchs, 2017, 2018). Like the term 'motor-intentional alignment', the term 'affective co-attunement' adopted above presupposes that two or more individuals are simultaneously attuned to the same entity in the public realm in a somewhat iconic fashion, and not each contained within a singular, solipsistic perspective.[163] Importantly, even in cases where the specificity of this mutual intentional-object is unknown to one party, the unknowing agent can 'fill in the blanks' through the embodied abduction, readjusting bodily space in accordance with abducted conceptual information while nonetheless displaying the same principles of pre-reflective, enactive cognition that typify PPS.

Indeed, a significant emergent theme from these analyses is how traditional distinctions between higher and lower-order cognition collapse when considering the phenomenon of bodily space in its social contexts. The enactive and pre-reflective aspects of traditionally reflective dimensions of consciousness - such as language and morality - were shown to play a pivotal role in sensorimotor, intersubjective interactions in space. In the meaningfully-structured *Mitwelt*, the phenomenon of language is neither just physical vibrations yet nor does it 'construct' a reality apropos of nothing. Rather, language is part and parcel of worldhood and of semiosis, interweaving action, movement, interaction and affectivity into a meaningful *Gestalt* (Paolucci, 2015; Violi, 2008). Evidence for language's influence over spatial-sensorimotor cognition is further uncovered in cases in which bodies interacting in space can undergo substantial changes (in both an experiential and neurophysiological register) without undergoing any changes within the objective-material domain. This capacity for language to remould bodily space can thus be capitalised upon in experimental conditions.

Recall that, in Patane et al. (2021), a singular schematic set-up between participants and objects (i.e., 2 participants facing an object placed in between them) was divided into two experimental conditions: one in which the object was 'shared' and another in which it was not. This instruction alone radically altered the spatial situation, producing entirely different bodily spatial profiles. As such, 'mere' verbal instructions, in a manner analogous with the other's gaze, automatically modulates one's sensorimotor opening onto the world so that our tendency for spatial engagement in the *Mitwelt* is informed by the meaning inherently present there, as disclosed linguistically (see Di Paolo, Cuffari & De Jaegher, 2018). Furthermore, the shared nature of the *Mitwelt* entails that aspects not directly

[163] However, while agents are never enclosed within solipsistic bubbles, interactive slices of shared space are frequently tinged with something of the personal. Indeed, a phenomenological distinction must exist between the space interact-able by me and the space interact-able by others that I cannot reach. This is why we began this chapter with an examination of minimal individuation on spatial grounds.

present to perception are automatically 'filled in' with the embodied abduction. Again, we see that 'higher' dimensions of cognition are implicated directly in the sensorimotor network and not first processed abstractly via a cognitive mechanism that must subsequently influence bodily space via a feedback network (Cuccio & Gallese, 2018). These studies showcase how the other can be an irreducible element, included within one's own perception of the spatial world.

Similarly, narratives were depicted as potent conduits for conveying socially-pertinent information (Hutto, 2008; Gallagher & Hutto, 2008; Paolucci, 2019, 2021), incorporating it within a brief but meaningful story. Importantly, narratives were also found to transcend the traditional categories of 'lower' and 'higher' cognition. That is, reading a narrative pre-reflectively modulates how agents relate to their co-specifics via bodily space. Additionally, narratives serve a predictive function akin to group membership categorisation (Gallese, 2003), facilitating insights into the other's most probable future actions, which circles back to the aforementioned spatiotemporality of bodily space (**2.3.2**). This specifically semiotic form of narrative competence is analogous to the embodied abduction phenomenon, wherein the sensorimotor system adapts to automatically inferred information gleaned from the concrete perceptions of others (Cuccio & Gallese 2018; Cuccio & Caruana, 2023). Narratively competent agents are thus equipped to see the 'token' of a moral/immoral person's actions within their corresponding moral category or 'type' (Paolucci, 2019). Thus, we found empirical support for Peirce's much earlier intuition that "abduction, even in its most explicit and conscious manifestations, always retains a perceptual element" (Viola, 2016, p.256).

Another example of how narratives can drastically reconfigure bodily space is by impeding or facilitating what we labelled the 'joint enactive interface' (JEI). The concept of the JEI, born mainly from an examination of the experimental data,[164] designates the most powerfully intersubjective version of the 'enactive interface', our working definition of PPS, in which the other functions as a constitutive (but transparent) element of this very interface. Evidence for the concept of the JEI was first provided in Teneggi et al. (2013), who discovered that, following cooperation, PPS expanded as to respond to stimuli near to the *other participant's body* how it otherwise reacts to stimuli at its *own* bodily location. Thus, bodily space expanded outwards to terminate at the other's spatial location, not the self, in what may be considered as essentially an intersubjective parallel of tool-

[164] But with several parallels and precursors in the philosophical literature, as highlighted.

transparency. Unlike tool-transparency, however, others always remain active participants in this unified spatial field (Fuchs, 2018). The JEI thus directly pertains to and expands upon what has been termed a 'we-centric shared space' (Gallese, 2003), the socially extended self (Fuchs & Froese, 2012) and serves as the spatial instantiation of so-called 'We-intentionality' (Tomasello & Carpenter 2007; Zahavi, 2015; Kiverstein & Rietveld, 2021), serving as its bodily spatial manifestation.

Perhaps worth underscoring here is that the motor-intentional and affective co-attunement detailed in **3.1** and **3.2** are not interchangeable with the joint enactive interface detailed in **3.3**. Neither affective co-attunement nor co-transparency necessitates any complete merger between bodily spaces, though each may potentially facilitate one. That is to say, you and I can be motor-intentionally attuned to the same teapot or feel pleasure from looking at the same painting without serving as a constitutive element of one another's bodily space. Whilst co-transparency dictates that our bodily spatial boundary extends to render the tool-in-hand transparent, by contrast, the JEI renders the *other* transparent and reforms the world according to a spatially intercorporeal 'horizon of possibility' made uniquely possible by two or more persons (Gallese & Sinigaglia, 2010).

Furthermore, the triggering conditions *for* and disruptions *of* the JEI in its various forms may have important implications for psychiatry. Noel et al.'s (2017) proposed dichotomy between an excessively rigid and open spatial buffer in ASD and schizophrenia respectively was further examined using the conceptual framework developed throughout this chapter. It was found that bodily space in ASD features a pre-reflective resistance to forming the JEI, while in SZ, it may form too easily. These bodily-spatial phenomena seemingly correspond in a 'bottom-up' manner with psychological-cognitive symptoms, such as cognitive inflexibility in ASD and thought control and telepathy delusions in schizophrenia. This suggests that future clinical research may benefit from paying greater attention to the bodily spatial dimensions of psychiatric conditions. Moreover, it implies that special attention to the character of lived experience in bodily space, as attempted here, is a crucial strategy for clinical research, as it is in the patient's experience that symptoms produce their most deleterious effects.

On a final theoretical note, I would here like to resurrect the Merleau-Pontian notion of 'intentional thread' discussed in **Chapter 2**, which can find application to all the concepts discussed here. By (re)applying this notion to the social world, we grasp that we are intentionally bound together with others, for better or worse, in the tapestry of the

Mitwelt. We might imagine that these threads are strengthened and weakened by a variety of factors, which perhaps even vary throughout a single social engagement, replete as they are with moments of pleasure, anticipation, relaxation, tension and surprise. The strength of an intentional thread exists and slackens or tightens, so to speak, at the levels of familiarity, distance, affectivity and saliency. The intentional thread is not necessarily predicated upon liking someone (i.e., strong positive or negative valence alike can strengthen it). For instance, the perceived morality of the other strengthens the intentional thread linking them to us, but so too does their immorality: the immoral other is brought closer even if they are morally more remote from us as a protective counter-measure (Iachini et al., 2015; Fini et al., 2020). In other cases, because the enactive interfaces of each party merge, the intentional threads linking them to each other dissolve, and new threads intentionally connecting them both to other entities emerge on the basis of the JEI.

Brief mention may be made regarding the limits of employing bodily space to understand social spatiality in its entirety. While I claim that bodily space is likely *necessary* for all forms of social spatiality - insofar as long as one must be a body to be-in-the-world, one must exist in space via bodily space - it may not be *sufficient* to disclose *every* manifestation of social spatiality exhaustively. Interpreted broadly, 'shared space' might also designate the space that dozens of people share on a sidewalk, that thousands share at a concert, or millions share in a nation-state, in which joint perception and/or action plays little to no role, despite surely counting as 'shared space'. At a more abstract level, technology has drastically reshaped spatiality; since one can relocate across vast distances or communicate over social media in a matter of hours, it should surely be included in a model of social spatiality. As such, the agent must always exist as a body in these places and thus is embedded via bodily space, but other frameworks can provide greater depth to these modes of social-spatial consciousness.

To recap, we have detailed a multitude of ways in which the other either directly impacts or even co-constitutes 'individual' bodily space: in the format of both dyadic and triadic (co-attunement) intentionality, via direct mirroring, by engendering co-transparency, or via the formation of a joint enactive interface, to name but some cases. While these examples broadly follow a direct social perception account (e.g., Kreuger, 2018; Gallagher, 2020), several social factors which are not directly perceptible are incorporated into sensorimotor cognition via the embodied abduction (Cuccio & Gallese, 2018; Cuccio & Caruana, 2023).

Moreover, in synchrony with the prior chapter, we discovered that, just as agents do not engage objects (only) as pieces of extended matter located in objective space, agents likewise do not relate to others (only) as physical-material bodies that happen to occupy proximate coordinate positions on a map. Rather, in the *Mitwelt*, our spatial existences overlap seamlessly with those of others in accordance with a variety of schemas: as colleagues, rivals, family, friends, enemies, lovers, etc., always embedded within a contextual, cultural background that confers a meaningful framing to our intersubjective interactions and to lived space itself. In sum, utilising our case examples of: 1) *Co-transparency and motor-intentional alignment*, 2) *Social Affectivity* and 3) *Interaction*, we have repeatedly witnessed how individual bodily space is always tethered somehow to the bodily spaces of others as fellow co-embedded beings within a public *Mitwelt*, whereby bodily space's 'world-embedded' nature entails that it always 'knows' how to react to the social situation's demands, automatically reflecting these demands immediately within its enactive interface. On this note, we might give the last word here to Merleau-Ponty:

> We must learn to find the communication of consciousness in a single world. In fact, the other person is not enclosed in my perspective on the world because this perspective has no definite limits, because it spontaneously slips into the other's perspective, and because they are gathered in a single world in which we all participate (*PoP* 411/369)

Chapter 4: Bringing It Together: An Enactive Account of Bodily Space

We began this journey with the proposition that the present account is poised to make a tripartite contribution to its antecedent literatures. Specifically, the present account contributes toward: *(1) Philosophical literature on lived space (2) Enactive Cognitive Science (3) The neuroscientific construct of peripersonal space.* Methodologically, this project has been conducted within the interdisciplinary purview of Enactive Cognitive Science (ECS), which permits one to draw freely on scientific and philosophical evidence - particularly of a phenomenological and pragmatist variety - to better understand the embodied human mind as situated in its ecological setting (James, 2020; Gallagher, 2023). ECS furnishes us with a coherent methodological framework suitable for integrating such varied discourses and data into a unified account. Spatiality was selected as the topic on which to conduct this analysis because there was a notable lacuna in ECS scholarship on this very theme. Peripersonal or bodily space was then selected as the more specific locus on which to conduct this investigation since, while there exists an ever-growing body of experimental scholarship on PPS, the construct itself remains plagued with conceptual and definitional issues (Bufacchi & Iannetti, 2018; Hunley & Lourenco, 2018), while simultaneously appearing highly compatible with pragmatist and phenomenological philosophy.

In what follows, this final chapter shall conclude our analysis by providing further detail on the ways in which our research findings have contributed towards outstanding issues in the philosophy (phenomenology and semiotics), enactive cognitive science and cognitive neuroscience of bodily space before providing a brief and final summary.

1. Phenomenology and Semiotics of Space

1.1 Phenomenology

At the outset, Heidegger animated our analysis by furnishing us with the conceptual tools to describe a fundamental ontology of lived space that diverged markedly from space as understood objectively. Heidegger's phenomenological investigations in *Being and Time* (1927/2010) thus provided the conceptual foundation for a spatiality that, broadly put, is structured qualitatively and not quantitatively. Such a move was indispensable for our subsequent discussions because qualitative factors were widely acknowledged as being the primary determiners of the ever-changing format of PPS (**Introduction**). Heidegger's disclosure of lived space brought with it several key notions that proved to be of significant utility, including (but not limited to): 'ready-to-hand', 'innerworldly entities', 'mood', 'de-distancing', 'directionality' and 'dwelling'. Each of these notions subsequently found interpretative value regarding empirical data.

Most prominently, Heidegger's phenomenological account of lived space showcased that, despite its fluctuating nature, there is nevertheless something like a 'deep structure' to the agent's spatial world-embeddedness. The details of such a structure might pertain to functionality (e.g., a tool's utility being highlighted by contextual locatedness) or, instead, serve as a fine-tuned description of the agent's phenomenal relationship to lived space. On a somewhat related note, several philosophical accounts distinguish between place and space, which might be simplified as corresponding to a qualitative vs. quantitative model (see Casey, 1997). Certainly, the presence of particular, contextual objects makes a place what it is. Nevertheless, we repeatedly maintained that a phenomenological account of spatiality does not implicitly reject objective space's existence or importance. This allowed even Heidegger's strongly phenomenological reading of space to merge with a scientific one, albeit with the caveat that scientific data pertain to the 'ontic' and not 'ontological' level of spatiality. Indeed, peripersonal space can and must be scientifically measured which, according to the current project's epistemology, simultaneously supporting a convergent phenomenological reading itself.

However, Heidegger's philosophy helps us underscore that whatever *correlates* to these quantifiable measurements of PPS at the cognitive-experiential level cannot borrow from quantitative or objective language. When some things are objectively measured, they lose their relevance to our lived projects, whereas it was precisely this 'relevant' way of engaging space that was required to account for bodily space. For instance, tools as bearers of utilities meaningfully present in a particular place co-constitute somewhere *as place* by enabling context-specific interactions to occur there. If one walks into a library and finds its shelves stocked with fish, one will conclude it is not a library, independently of its spatial layout or what any sign at the front door says.

While Heidegger is pivotal for building a pragmatic or enactive account of spatiality, at the same time, however, perhaps more than any other thinker, Heidegger reminds us that not everything in lived space comes down to brute functionality. 'Dwelling', for instance, unlike semiosis or even sense-making, brings forth the immediate, suprafunctional and experiential dimensions to what it means to exist in a space that is familiar. Even if this familiarity rests on the 'mechanics' of habit as explicated elsewhere, we shouldn't lose sight of the fact that dwelling manifests a distinct, phenomenological experience that reveals something unique about our spatial being-in-the-world (Blattner, 1999; Harrison, 2007; Malpas, 2008). Again, this does not neccesitate renouncing a corrolarly objective account of space. Heidegger (1927/2010, p.68/68) was thinking along similar lines when he claims that a room "is not just what is between four walls" but is "something useful for living". Note, he does not tell is it *not* what is between four walls, just that this objective analysis does not exhaust its character.

There is, arguably, risk of reviving a latent dualism arising here. Not a Cartesian dualism, but a dualism nonetheless. That is, when one admits that agents can engage space *both* as a field of meaningful experiences *and* as a metrically measurable zone, one may have to posit how and/or where these two planes intersect. In recent phenomenological scholarship and ECS, this has motivated the suggestions that the 'mind-body problem' has been supplanted by the 'body-body' problem (Thompson, 2004; Whitehead, 2015; Fuchs, 2018). This problem is at least partially overcome by adopting parallelism (Whitehead, 2015) and/or dual-aspect monism (Fuchs, 2018) in which both dimensions are retained and neither relegated to another 'world'. Moreover, as Moran (2013, p.294) writes: "One should not absolutize the contrast between Körper and Leib, since my living body is always physical body too, and thus Husserl speaks of Leibkörper of 'living-embodied egoity". Echoing Peirce, Moran then places the lived and objective body on a 'continuum'. Suffice to say that a spatial equivalent of an integrated, 'dual aspect' objective-lived space (as adopted here) is appropriate with a Heideggerian account.

While we can leave this question an open challenge, Heidegger is perhaps primary in convincing the modern reader that quantification does not exhaustively capture an account of space. Unlike Merleau-Ponty, Heidegger, aside from a brief period around 1929-1931 (Storey, 2016), viewed his philosophical undertakings as separate from developments in the sciences. Nonetheless, note how even in a purely philosophical account of space, Malpas (2000) uses terminology quite evocative of phrases that would later dominate discourse in 4E cognitive science, mirroring the present operational definition of bodily space. On Malpas' (p.328) account, Heidegger views spatiality as "an openness, an extendedness, a mode even of enclosedness, that is presupposed by the very possibility of the appearing of things". Indeed, the interdisciplinary analysis conducted here converged on the notion that bodily space is a sensorimotor opening onto space that extends into tools and others, and these capacities determine how space and things within space manifest at a fundamental level. Moreover, while Heidegger eventually abandoned such ambitions, Storey (2016, p.90) recounts how he briefly took great interest in Uexküll's theoretical biology, drawing parallels between von Uexküll's 'Umwelt' and his own notion of 'Dasein'.

Furthermore, the early Heidegger's emphasis on *temporality* also motivated us to ensure it an explicit role within our account. In turn, our analysis gives novel, further support for Heidegger's arguments for temporality's importance in virtually all domains. Malpas (2000, p.329) further notes that "Heidegger uses the term 'projection' to characterize that which enables this occurrence of world – 'projection', he says is 'world-formation'". This rather abstract claim was, I suggest, somewhat supported by the evidence presented in this project. However, we must be careful not to cloak this 'projection' with a Freudian garb or to mistake it for a species of constructivism. Projection instead denotes a pre-reflective launching of oneself into one's meaningful dealings in the world which defines one's present, not staring at it or measuring it as something present-to-hand, so that all of one's actions are teleologically sculpted. Consequently, the agent's present situation is always somehow shaped by its anticipated future. In this work, we encountered several occasions in which presently-situated bodily space was defined by its projection into future states. Aspects of protended tool-transparency (**2.3**) showcased (at the 'ontic-existentielle' level; see Aho, 2005) how Dasein engages the world by projecting forward into possibilities. This is why a neurophysiological profile of tool-use emerged in cases of passive tool-perception, providing that the agent was highly familiar with the tool in question, thus opening up its use as a pressing possibility.

In a notable parallel with ECS, the secondary literature on spatiality in Heidegger's phenomenology has also been comparatively scant, albeit with notable exceptions (e..g., Arisaka, 1995; Cerbone, 2000; Malpas, 2000, 2008, 2012; Harrison, 2007; Basak, 2016; Shepperd, 2016). This scholarly trend is less perplexing and pronounced than in ECS, however, since Heidegger explicitly subordinated space (alongside other topics addressed in *Division I*) to 'Care' and 'Time' in *Division II* of *Being and Time*. But let us never forget that space remains crucial to Heidegger's goal of overcoming Descartes' famous severance of the *res extensa* and *res cogitans* (Arisaka, 1995, Cerbone, 2000, Malpas, 2000, 2008). After all, Heidegger leaves no room for ambiguity when he writes in *Being and Time* that "Dasein is spatial in a primordial sense" (p.108/112). Heidegger may, therefore, be plausibly said to agree with, and have pre-empted, a conclusion reached in this study, namely, that the embodied agent is intrinsically a spatio-temporal entity, due to bodily space's habitual and protensional character. Such a conclusion entails that any completely comprehensive account of human existence must include both dimensions. How to optimally achieve this remains open, even if the early Heidegger clearly opts to approach it by explicitly subordinating Dasein's spatiality to temporality. Whether this remains the right strategy for ECS remains an open question worth pursuing.

Finally, taking all of this into consideration, I posit that there is ample reason to continue to forge closer dialogue with Heideggerian and embodied-enactive accounts of spatiality, as the topic of space has been previously understudied in both discourses and thus will benefit from further study as neuroscience and phenomenology provide mutual illumination and constraints (Varela, 1996). While this project has mainly focused on space as treated in *Being and Time*, Heidegger's later work may form the basis of productive future studies in which spatial notions become increasingly salient (Malpas, 2008). Finally, it has been noted that the spatial notion of place characterised by what some Heideggerians term the third (and final) phase of his career, following ECS, thus shall likely benefit from further engagement with Japanese philosophy, in which space assumes a more foundational role (e.g., Nishida, 1970).

Turning now to Merleau-Ponty, we can be more confident that the early Heidegger's worries that emphasizing human embodiment in an account of lived space resurrects Cartesian problems were, ultimately, unfounded (Cerbone, 2000; Malpas, 2000; Ha, 2005; Storey, 2016). If Heidegger confers a foundational structure for spatiality as a qualitative phenomenon at an (arguably) somewhat abstract and disembodied level, Merleau-Ponty serves to draw out the lived body's role in its concrete engagement with space and spatial entities. A good case example here would be Merleau-Ponty carving out a more explicit role for the body regarding Heidegger's orientation-themed notions of 'de-distancing' and 'directionality', which became 'hold' and 'spatial level', respectively.[165] Indeed, we have previously highlighted how Heidegger's notion of 'worldhood' found a more explicitly embodied expression in the phenomenology of Merleau-Ponty (**1.1b**), which helped us develop a model of world-embedded bodily space.

[165] However, notably, Merleau-Ponty does not cite Heidegger's writings on space during these sections. It is unclear if Merleau-Ponty was inspired by the section on space in *Being and Time* or if simply he converged on similar phenomena independently.

Throughout *PoP*, Merleau-Ponty repeatedly returns to how one's most immediate perception of space (from which all objectifications of space are derivative) is structured in a manner emphasising the harmony and compatibility between organism and environment, a notion that subsequently would heavily characterize foundational works of enactive cognitive science (Varela et al., 1991; Thompson, 2007; Chemero, 2009). Indeed, these theoretical tenets found further elaboration and confirmation in this project. Merleau-Ponty furnished us with several phenomenological notions highly useful for recounting the 'deep structure' of embodied spatiality, such as 'spatial level', 'motor-intentionality', 'intentional threads' and 'optimal grip' as well as phenomenological rereadings of spatial concepts such as depth and movement. Merleau-Ponty summaries his position by arguing that body has something like a originary 'pact' with space, perhaps mirroring Heidegger's emphasis on time. This notion underpins the present work.

For Merleau-Ponty, this 'structural coupling' (Varela et al., 1991) does not condemn lived space to 'mere subjectivity'. If one names a fundamental thread running through Merleau-Ponty's rich spatial phenomenology, it is that one's experience of space emerges from their direct bodily engagement with real entities encountered therein. If we were not inherently mobile beings who meaningfully engage their surroundings from a litany of particular standpoints, lived space would be bereft of its inherent, manifest structure. Lived space obtains its structure in alignment with the human form that engages it yet it is no less 'real' than the organic, measurable brain or physical body that facilitates such experiences. A key phenomenological tenet shared by Heidegger and Merleau-Ponty (and adopted here) is that quantitative measurement is not the sole way of ascertaining a thing's reality. Due to this reciprocity between the body and its surrounding space, bodily space is, in Merleau-Ponty's words, tantamount to a "pact" or "communication with the world more ancient than thought. And this is why [space and perception] saturate consciousness and are opaque to reflection" (302/365). Providing further corroborating evidence for Merleau-Ponty's 'pact' was one of the goals of this project.

Merleau-Ponty was also perhaps the first philosopher to have consistently emphasised that the body's space is not limited to the epidermis.[166] Even if one limits bodily space's extension to the 'scope of one's actions', one cannot comprehensively account for bodily space while imagining that it terminates at the extremities, as Merleau-Ponty foresaw while expanding upon Husserl's notion of *Leib*. Bodily space extends further than the

[166] This is not explicitly noted by Heidegger until two decades later in the *Zollikon Seminars* (1964/2001).

Korper's outermost boundaries and is, therefore, inconceivable *sans* the area of surrounding space in which it is embedded. Further still, as we learned not only from Merleau-Ponty but also from von Uexküll and Heidegger, areas entirely external to perception can still directly impact upon bodily space. The entire area of space available only to perception ('extra-personal space') can be equally constitutive of bodily space's form. For instance, what one hears in extra-personal space can cause a fear-based expansion in PPS. In the PPS literature, the same point was reached, using 'walking' as the case example (Vignemont, Serino, Wong and Farne, 2021, p.10), complementing Merleau-Ponty's depiction of the lived body (see also Marratto, 2012).

As Merleau-Ponty often emphasised, what remains invariant throughout the variations in life that one undergoes across situations is the lived body as a concretization and 'memory' of the organism's being-in-the-world (Talero, 2005), which always takes its place within the world via its interface or opening *as* bodily space. Accordingly, while we might limit bodily space to the area that is neurally mapped as 'peripersonal space', bodily space always, in some sense, is imprinted by the totality of one's world. An implication of this is that a culture's religion, architecture, myth, morality, technology, medicine and so forth all eventually find their way into bodily space one way or another because bodily space belongs to its total world. Even communicating with a spatially distant collaborator via technological means (Rietveld & Brouwers, 2017) has an impact on bodily space, even if bodily space has a less pronounced role compared with face-to-face interaction. As Rietveld and Brouwers suggest, such examples bypass a dichotomy between 'higher' and 'lower' cognition, a claim Merleau-Ponty no doubt would have approved of.

As such, Merleau-Ponty's greatest utility here is that he essentially unified Husserl's *Leib* with Heidegger's *being-in-the-world,* showcasing how the spatialised lived body is meaningfully embedded in an interreferential spatial world (Carman, 1999; Aho, 2005; Moran, 2013). As in Heidegger's account of lived space, things within this world do not merely 'sit around' or feature uniformity in relation to that into which they are 'contained'. Indeed, for Merleau-Ponty, space "is not a relation between a container and its content" (290/253). Accordingly, "rather than imagining space as an ether in which all things are immersed, we must think of space as the universal power of their connections" (291/254). In the spirit of Merleau-Ponty, I have aimed here to showcase *how* agents and entities in space are not just 'contained in a container' but meaningfully co-exist in the qualitative powers of their spatial connections, brought to life by the lived body. In doing so, I attempted to provide both novel scientific examples (unavailable during Merleau-Ponty's era) as well as reinvigorated laborations of existing ideas found in Merleau-Ponty's seminal writings on bodily space.

On this note, I would add that, as discussed, Merleau-Ponty (1945/2012) provided a replicable methodological template that even today remains suitable for interpreting a vast array of empirical studies through a phenomenological lens (e.g., Stratton 1899; Head & Holmes 1911; Wertheimer, 1912; Goldstein & Gelb 1918; 1921). In keeping with Merleau-Ponty's vision for phenomenological research, numerous studies were filtered through a similar phenomenological lens and their implications dissected above. This strategy simultaneously yields evidence for specific phenomenological claims while uncovering overlooked theoretical implications from the experimental data (Sykes 2021a).

Specifically, several experimental studies noted above uncovered a coherence between object-affordances and bodily location or posture based on distance (Cardellicchio et al., 2011; Waiman et al., 2016), state of usability (Bucccio et al., 2009; Costantini et al., 2010) and the ability to move one's arms (Iachini et al., 2014). All such relational factors serve to modulate bodily space and the enactive perception of innerworldly objects, as Merleau-Ponty already intuited. Additionally, it was consistently discovered that there are intersubjective parallels to pre-reflective object-interaction (e.g., Costantini et al., 2011; 2014; Teneggi et al., 2013; Pellencin et al., 2018; Patane et al., 2021), that supports Merleau-Ponty's famous notion of intercorporeality (Marratto, 2012). Moreover, with the JEI (**3.3**), we encountered a yet more striking example of intercorporeality that, once again, bolstered a much earlier claim by Merleau-Ponty.

Thus, Merleau-Ponty's pioneering interdisciplinary methodology mounts a plausible case for considering him as the *de facto* father (or at least grandfather) of 4E cognitive science. Indeed, Merleau-Ponty was probably the philosopher who most strongly inspired the conceptual outlook found in *The Embodied Mind* (Varela et al., 1991) and has been regularly cited by several notable neuroscientists (e.g., Varela, 1996; Rizzolatti et al., 1997; Cole, 2008; Gallese, 2001, 2014, 2016). The present project has faithfully followed Merleau-Ponty's epistemology in that experimental investigations were filtered through a phenomenological lens. In addition to those mentioned, perhaps the most compelling exemplar of this methodological assertion was the striking correspondence uncovered between Merleau-Ponty's account of habit and cane-use and subsequent experimental investigation (Serino et al., 2007). To paraphrase, Merleau-Ponty claimed that, for habitual cane-users, their body 'ends at the tip of the cane' insofar as it serves as the point of world-interaction whereby habit enables the user to navigate with it pre-reflectively like one's own body and not via computation and conscious decision (see **2.3.1**).

Until recently, such comments may have been seen as vague or borderline mystical to most scientists. Yet, over 60 years later, convergent empirical evidence was provided seemingly by accident by Serino and co-authors (see also Hunley and Lourenco, 2018). To my knowledge, while this study is itself over a decade old, its remarkable compatibility with Merleau-Ponty's account had previously gone unnoticed. This begs the question as to how many more of Merleau-Ponty's other phenomenological insights might find support in both existing and future neuroscientific research or theoretically enrich such results. Undoubtedly, Merleau-Ponty would have welcomed the kind of interdisciplinary approach adopted in ECS since he believed that phenomenology was uniquely poised to uncover interpretations of data that might otherwise be confounded by inherited conceptual errors regarding the nature of consciousness (Dreyfus, 2002; Marratto, 2012; Sykes, 2021a).

Thus, it appears that incorporating empirical (experimental and clinical) literature opens up novel and illuminative pathways with which to (re)consider phenomenological accounts of space. At the same time, phenomenological accounts provide fresh and unique ways to draw theoretical conclusions from empirical evidence. Additionally, Merleau-Ponty's noted insights into developmental psychology, neuropsychological disorders and clinical disorders (e.g., schizophrenia) entail that he shall likely remain of continued utility in mapping out enactive spatial cognition and its clinical aberrations as new empirical evidence is collected. Further attention to the spatial phenomenology of clinical disorders shall likely prove useful in diagnosing and understanding a litany of clinical disorders, as was provisionally attempted with ASD and schizophrenia above. While such interdisciplinarity was far more welcomed by Merleau-Ponty than by Heidegger, so long as one avoids an overtly naturalistic metaphysics and leaves the door open for a possible fundamental ontology of space *without* the contribution of the sciences, there is every reason to believe that this productive dialogue will continue apace between the phenomenology and neurophenomenology of spatiality.

In conclusion, this thesis has attempted to serve as a humble contribution to the phenomenological study of space by contributing to secondary scholarship on Heidegger and Merleau-Ponty both as individual scholars and comparatively while comparing their insights with several posthumous scientific findings as well as key figures in the disciplines of biosemiotics and cognitive semiotics. Developments in neuroimaging alongside creative experimental design and increased philosophical competency on the part of experimentalists seemingly furnish us with a roadmap for building a non-reductive neuroscience. Such an approach should give lived experience a primary role without impeding scientific credibility and should, where possible, feed back into experimental design. This may pave the way for a reinvigorated neurophenomenology and even to new, non-reductive theories of consciousness (Froese & Sykes, 2023).

Looking ahead, it may also prove fruitful to place recent technological developments in which spatiality takes a central role (e.g., AI, virtual reality, robotics, bioaugmentation) into dialogue with relevant Heideggerian scholarship on technology and postphenomenology (e.g., Ihde, 2010). In turn, Heideggerian accounts may again be synthesized with Merleau-Pontian accounts of embodiment, serving to enrich interdisciplinary approaches to technology studies. All this is to say that we must remember that phenomenology generally, and Heidegger and Merleau-Ponty especially, have been crucial for the scientific study of peripersonal space since the earliest days (Rizzolatti et al., 1997) and that the present work has far from exhausted the way in which this relationship may be studied in the future.

1.2 Semiotics

In **Chapter 1**, we identified the fields of biosemiotics and cognitive semiotics as the semiotic subdisciplines most conducive to our current research aims and to integration with biological, psychological, and neuroscientific evidence. The figures of Jakob von Uexküll and Charles Sanders Peirce were selected as the respective figureheads for these approaches since they set the theoretical and methodological tones for subsequent research conducted in biosemiotics and cognitive semiotics. In addition, we found that several of their concepts found support in much more recent empirical accounts of bodily space, retroactively supporting the validity of some of their theoretical claims and philosophical outlook.

Jakob von Uexküll's foremost importance lies in his seminal exposition of the notion of *Umwelt*, a spatial concept of indispensable utility for detailing the coupled agent-environment relation in a manner avoidant of mechanist or reductionist terminology. We noted that enactive approaches to cognition are often defined using some variant of Varela et al.'s (1991) term: 'structural coupling' which harkens to Uexküll's pioneering approach. Likewise, Hunley & Lourenco (2018, p.2) explicitly note that PPS can find an antecedent in Uexküll's philosophical biology. Expanding this line of thought, therefore, necessitated an in-depth analysis of Uexküll's (1934-1940/2010) rich theoretical biology, which also heavily utilised contemporary scientific findings and philosophical concepts of his era. In parallel, '*Umwelt'* alongside related concepts (e.g., functional cycles, effect marks, meaning-carriers) set the tone for our subsequent analyses of empirical data. Moreover, Uexküll represented an important perspective for this project since he was a trained biologist. Indeed, as well as serving as a conceptual cornerstone for our project, the harmonic alignment between body and *Umwelt* (as structured by meaning-carriers and functional-cycles) depicted by von Uexküll was demonstrated to have a measurable imprint in the PPS network on several occasions.

Thus, Uexküll's notion of *Umwelt* both helped us lay the conceptual groundwork for our treatment of organism-environment relations as well as better deal with specific topics as they arose in the analyses of the empirical literature. For instance, Uexküll's theory helped showcase how organisms unite with their environments via functional cycles, which forms the basis for the *Umwelt*. This emphasis on the interdependence on perceptual 'input' and motor 'output' clearly pre-empted embodied-enactive approaches (e.g., Froese, 2010; Feiten, 2020). Uexküll routinely emphasised that 'perception' and 'effect' marks determine the organism's perception of 'meaning-carriers' (i.e., useful objects) so that perception is constituted by the meaning of the thing perceived in an enactive, body-centric way. Clearly pre-empting the notion of 'affordances' (Gibson, 1979), the functional perception of meaning-carriers is based on the organism's current goals (sometimes termed by Uexküll a 'tone', 'mood' or 'schema'). Indeed, somewhat like Heidegger, Uexküll thinks that dynamic 'mood', allows the 'objective' environment to show up according to 'subjective' properties.

Furthermore, that the *Umwelt* is relationally structured on the basis of the 'meaning-carriers' that enter into the sensorimotor organism's functional cycles certainly corresponds with several of our analyses of bodily space, most notably (if not exclusively) the notions of 'spatial affordances', 'hold', 'affective intentionality' and 'affective state'. Most strikingly, when Uexküll (1940/2010, p.191) attends to human manifestations of this phenomenon, he provides the (proto-affordance) example of the coffee cup: "A coffee cup with a handle shows immediately the contrapuntal relation to coffee, on the one hand, and the human hand, one the other". This is one of Uexküll's numerous examples intended to showcase the spatial complementarity between organism and object. Interestingly, TMS studies on micro-affordances between the hand and cup (Buccino et al., 2009; Costantini et al., 2010) showcased that hand position, MEPs and motor system recruitment generally are all directly related to the position and usability (i.e., reachable or unreachable; broken or unbroken) of the coffee cup's handle in exactly this 'contrapuntal relation' to the hand. Thus, Uexküll's conceptualisation of the *Umwelt* continues to hold water insofar as this coupling exists at both a 'macro' level (organism-*Umwelt* spatial coupling) and a 'micro' level (hand-tool spatial coupling), today termed a 'micro affordance' (Ellis & Tucker, 2000).

Additionally, while the study of PPS is, of course, enriched by understanding its metric and psychophysical properties, Uexküll consistently emphasised that the language of mathematics, physics or stimulus-response may apply to mechanistic, context-less *physiology* but not to life-centered *biology*. By formulating the *Umwelt* as largely unrestrained by strict physical or geometric constraints at the level of its structure, Uexküll helps us see how qualitative space bypasses the limits of the 'here', and 'now' for the individual organism. It also helped us see the *Umwelt* bypasses the 'me' as a social phenomenon, belonging to a species or community. Two specific examples to note here are 'territory' and 'the flight path', both of which proved useful to our subsequent analyses. The concept of territory denotes a space without precisely clear borders but that modulates entities based on whether they are in or outside this zone, a distinction which pertains to a large amount of the object-interaction literature.

Territory can, of course, also be a socially emergent (and not only individual) phenomenon, operating as a larger-scale version of the JEI, as noted above. It remains to be seen if the JEI as described here might extend to a third party or even further, as in a tribe, though future experimental investigations can empirically test the metric limits of this phenomenon. Secondly, Uexküll's notion of 'plan', as embodied in (but not limited to) the 'migratory flight route' found several applications here, particularly when synthesised with phenomenological accounts of time (**2.3**). The flight path is 'magic' or 'suprasensory' in Uexküll's terminology since it allows the organism to sense-make on a large spatio-temporal scale that beckons the organism in space as it progresses through passages until the completion of the meaningful course of action. In essence, this pertains to the future-directed, protensional aspects of PPS, alongside the fact that PPS automatically updates itself at each moment of the act's progression because the organism *is* in space in the enactive interface of PPS. Always ready to avoid connotations of mechanism, Uexküll claims that such acts are better termed 'plan' rather than the more mechanical term 'instinct'. Interestingly, Peirce (1903/1998) uses the term 'instinctual' to refer to how agents typically engage in semiosis (though typically in scare quotes, presumably for comparable reasons) also reverts to using ‘instinct’ to articulate what is now termed the ‘pre-reflectivity’ of habit, action and even belief (**1b.2.2**).

On that note, our second semiotic figurehead (and widely considered the founder of semiotics), Charles Sanders Peirce, despite not thematising bodily space directly, provided several crucial concepts that guided our analysis, including ‘synechism’ and ‘pragmatism’. Peirce can plausibly be said to be a forerunner of embodied cognition (Violi, 2008) and direct perception (Viola, 2016; Paolucci, 2021). Alongside Merleau-Ponty, Peirce also helped us understand the crucial role of ‘habit’, which pertains to how repeated actions render a particular mode of comportment automatic (Legg & Black, 2022) and thus sediment into the fabric the agent’s relation to space. This entailed that the aforementioned ‘abduction’ (one of his key contributions to logic) can be a perceptual act (Viola, 2016), thus bridging ‘higher’ and ‘lower’ cognition. More recently, Peircean abduction has been rendered compatible with the neuroscientific framework of ‘embodied simulation’ (Cuccio & Gallese, 2018; Cuccio & Caruana, 2023). Applying this reworked conceptualisation of the ‘sensorimotor’ or ‘automatic’ abduction, we were able to develop the notion of ‘affective co-attunement’, using the sensorimotor abduction to better understand how agents automatically engage in adaptive responses to aspects of the world inferred from the expressions of co-specifics.

Additionally, the Peircean concept of ‘Synechism’, a philosophical position favouring the continuum over the dualist dichotomy, formed something of a conceptual backbone to this project as we continually assessed both theoretical statements and empirical evidence through the prism that adhering to substantive, fixed dichotomies (e.g., between nature and culture, human and animal life, and science and philosophy) were ineffectual for properly disclosing bodily space in its multifaceted richness. This Peircean insight facilitated our interdisciplinary, methodological angle that one can freely recruit both human and animal literature in addition to philosophical theory and phenomenological description alongside data-driven experimental and clinical literature as and when such resources appear conducive to one’s current aims. Because bodily space is locatable within several such continua, discrete approaches can independently uncover different but ultimately convergent aspects of this interconnected whole even without prior knowledge of such convergence. Combining them, however, can facilitate a more comprehensive model of the research topic in a manner demonstrative of the methodological applicability of the Peircean synechism.

We also assessed the recent branch of semiotic research that engages heavily with cognitive science - which acknowledges Peirce as its intellectual forebear - known as 'cognitive semiotics' developed by Dadessio (1995) and Eco (1997/1999). While CS has inherited the term 'cognitive' in its title, embodied processes of mind may be better described by the Peircean term 'semiosis' (Kull, 1998; Paolucci, 2021; Jappy, 2023). While we have used the term 'cognition' on occasion throughout this text, reflecting our interdisciplinary orientation, we have noted that 'semiosis' might be thought of as the more accurate term for embodied spatiality, particularly in light of enactivism's conceptual preference for 'sense-making' over computation (Weber & Varela, 2002). I claim that bodily space as divulged here is a prime contender for why 'semiosis' may plausibly substitute oversaturated terms like 'mind' or 'cognition' insofar as these terms bring with them unhelpful conceptual baggage.

With semiosis, we emphasise the pre-existence of systems of meaning and their discrete sources and locations (e.g., affective, linguistic, symbolic, etc.) which are then actively 'linked together' by the spatially situated meaning-maker according to context and circumstance (Violi, 2008; Paolucci, 2018). Due to its strong ties with pragmatism (Mounce, 2002; Johnson, 2016; Paolucci, 2018, 2021), the concept of semiosis enables simultaneous understanding, sense-making and appropriate (re)action to signs that, as we saw, might encompass motoric, linguistic, social and affective domains in a single sense-making act. Thus, semiosis designates a non-privative, meaning-making *process* that, unlike a computation, emerges as a public, even external entity from out of the interrelated sources of meaning present within an *Umwelt* and thus pertains closely to how bodily space actively makes sense of its surroundings.

Finally, the philosophies of Pierce and Uexküll can be made mutually informing, with each picking up the slack regarding gaps in the other in formulation a contemporary semiotic account of bodily space. For instance, as discussed (**1b**), Uexküll explicitly sought to link his ground-breaking biological theories with Kantian philosophy. The highly embodied and social nature of Uexküll's philosophical biology, however, made this a somewhat awkward union, at least on one possible interpretation. The *Umwelt* structures the possibility of all biological sense-making (Kull & Favareau, 2022), yet, even in Uexküll's neoKantian account, it exists 'out there' as the other half of a structural coupling and given meaning by one's community, bodily capacities and physical environment; it is not contained within the organism's intellectual apparatus. Peirce picks up the slack here in providing a semiotic framework more in keeping with ECS than the Cartesian-Kantian tradition, though he certainly had a great estimation for Kant. Peirce achieves this by emphasising that learned networks of meaning-associations structure thought and action. Perhaps more importantly, he also does so by adopting an explicitly anti-Cartesian account of mind that places semiosis *qua* mind in the public realm and not a private, inner theatre (Eco, 1997/1999; Paolucci, 2019, 2021; Jappy, 2023).

Furthermore, while Uexküll provided the backbone to biosemiotic research with his notion of 'Umwelt', Kull & Favareau (2022) noted that an account of 'learning' is largely absent in his description of how the organism develops in tune with its environment. In fact, Kull and Favareau (2022) write that being situated in an *Umwelt* is prior to all subsequent associative learning. With the added help of Peirce, we can better understand bodily space as a particular kind of semiosis that occurs within an *Umwelt* bridging Peircean semiotics with biosemiotics. While organisms always have an *Umwelt* no matter what, they increasingly gain knowledge and competence with it over time. Uexküll's functional cycles gradually become subordinated to Peirce's notion of habit, so that, as an organism ages, it typically (at least up until a point) engages in functional cycles pre-reflectively. On this note, Kull and Favareau link the temporality of the *Umwelt* to the 'specious present'. However, following Gallagher's (1997) discussion of the phenomenological failings of the specious present compared with Husserlian and Heideggerian accounts of temporality, I argue that, as has been indicated, the biosemiotic notion of the *Umwelt* is optimally connected with a phenomenological understanding of time and can act as the focal point ot unify all three.

Finally, Stjernfelt (2006, p.21) claims that the *Umwelt*-embedded body is a "semiotic device" whereby it is "an intrinsic property to a body to perceive the surroundings through signs and act constitutively through signs". Critiquing Uexküll's emphasis on the perfect compatibility between body and *Umwelt*, Stjernfelt then argues that the semiotic body in the *Umwelt* is better described as a constantly recalibrating attempt at optimisation. Accordingly, Stjernfelt (p.24) argues that Uexküll's "perfection" be supplanted by a kind of local optimum, spurred by constantly changing environmental conditions, which he explictly links with Merleau-Ponty's phenomenology. Correspondingly, we have often noted that bodily space continuously readapts to reflect the global spatial situation of the agent; it is like this that PPS can respond adaptively and automatically to changing situations. This echoes Peirce's later philosophy which sought a continuum between mind and matter (Paolucci, 2018, 2021; Jappy, 2023), the latter of which we can, as we shall see later, take to include 'world'. This all to say that, as several leading scholars have shown, themes surrounding bodily space are the perfect locus on which further to research phenomenological and semiotic convergence can take place (Kull, 1998; Stjernfelt, 2006; Violi, 2008; Kull & Favareau, 2022; Jappy, 2023).

In conclusion, while semiotics has always contained the antecedents of ECS (Violi, 2008; Paolucci, 2021), it has only been within the last 15 years that it has explicitly incorporated embodied-enactive approaches. During Eco's (1997/1999) pioneering semiotic foray into the cognitive sciences, cognitive science was almost exclusively dominated by computational and cognitivist models, which reflected the dominant intellectual tendencies of the era. Such an approach was perhaps exemplified by the work of Marr (1985), a researcher whose work Eco regularly engaged. In today's cognitive science, however, computationalism no longer enjoys the same dominance. Reflecting this state of affairs, cognitive semiotics is incorporating theories and frameworks from the Enactive tradition which, to reiterate, is quite conducive to its earliest research output. One of the first instances of this turn towards embodied-enactivism in CS is in Violi (2008), who emphasised how Peirce carved out a unitary role for affect, body, and intersubjectivity in his philosophy.

More recently, Brandt (2020) and Paolucci (2021) have provided book-length treatments of cognitive semiotics. Once again, however, despite spatiality being central (albeit often in an implicit way) to key concepts in cognitive semiotics, it was not explicitly thematised in Paolucci (2021) and was not linked with embodied accounts or biosemiotics in Brandt (2020). Therefore, in this thesis, I collected evidence to support an enactivist-friendly semiotics of space that attempted to vindicate Peirce's approach to mind and Uexküll's account to life, using examples in the experimental literature published around a century subsequent to their original writings. Accordingly, I have attempted to position the current thesis within the wider bio and cognitive semiotic scholarship with the hopes that it may spark greater interest in the semiotics of space from an embodied-enactive perspective.

2. Enactive Cognitive Science

2.1 Motor-intentional Profile and Pre-reflective Cognitive Correlate

This thesis has proposed that two modes of analysis and conceptualisation greatly augment an interdisciplinary discussion of bodily space: a) 'motor-intentionality' and b) the 'pre-reflective cognitive correlate'. This is because a guiding principle adopted here is that spatiality is a relational phenomenon but that the way in which agents relate to spatial entities is via immersion in meaningful space, not by abstractly thematising external spatial properties 'in the head'. In most cases, agents do not engage their surrounding space or entities within space in any consciously explicit manner but instead find themselves automatically moulded by, directed towards, and fluidly engaging with, surrounding space and innerwordly entities found therein as a part of broader projects, goals and forms of life (see Rietveld & Kiverstein, 2014; & Kiverstein & Rietveld, 2015, 2018). For these reasons, a large swathe of experimental studies was interpreted through the lens of the so-called 'motor-intentional profile' (*A*) (MiP) and 'pre-reflective cognitive correlate' (PrCC) (*B*), which pertain to the third-person and first-person dimensions of bodily space, respectively. The foregoing analysis was thus proposed as a paradigm case for demonstrating how these two frameworks contribute to ECS at the methodological and metatheoretical levels, using bodily space as a vehicle to do so.

A) Motor-Intentional Profile (MiP)

Adopting motor-intentionality as worked out in the phenomenological tradition (Merleau-Ponty, 1945; Dreyfus, 2000, 2007), with occasional assistance from compatible notions found in von Uexküll (1934/2010), served to clarify agent-object and agent-other relationships by allowing us to pinpoint *what* the embodied agent is relating to in space and *how* they are relating to it. The experimental literature was thus clarified through a specification of both the intentional-referent and the modality in which this referent was actively intended by the brain-body in space.

In **Chapter 2**, we analysed spatial interactions with objects. Following a literature review, it was found that agents typically intend objects as useful pieces of equipment, labelled 'tools', as related to specific tasks and goals, the meanings of which are typically grounded within a pregiven, cultural lifeworld. That is, I see a fridge for *storing-food* and its handle *for-opening* because I am acculturated to its use and because, *per* Uexküll, these uses align with my anatomy and physiology. It was further added that, when the brain-body perceives a tool, the content of its motor-intentionality is determined by that tool's use-value, oftentimes according to a gradation of intensity via the phenomenon of 'hold'. 'Hold' thus determines the strength of an 'intentional thread'. When agents merely look at objects, their body is prepared for action with them (albeit at a level small enough to only be detectable via MEP measurements (Cardelecchio et al., 2011). Action is thus deeply interconnected with spatial perception in the manner of 'projective anticipation' (Di Paolo, Buhrmann, & Barandiaran, 2017). As a [motor]intentional-object, the perceived tool thus assumes a greater presence within their situation whereby task-relevant body parts display muscle activity while action-related neural pathways are activated (Serino, 2019).

Detailing the MiP helped distinguish the above account of tool-*perception* from the profile of tool-*use*. A tool's affording features are usually accessible via visual intentionality (as a directly perceived *for-something*), but this perceptible 'for' aspect must necessarily recede as the dominant referent of motor-intentionality whenever one acts upon an affordance and uses the tool. Thereafter, using a tool in service of a goal triggers tool-transparency, causing bodily space to temporarily expand and include the tool as bodily space's shape and size reflects the task that it is currently engaged in. As newly-transparent, the tool temporarily becomes a constitutive component *of* motor-intentionality, no longer its demarcated intentional-referent. Only following tool-transparency, whereby this tool is integrated into bodily space, can a specific task-dependent affordance show up, rendering previously unavailable action-possibilities suddenly available.

Consider, for example, an area of floor when wielding a vacuum, the nail while wielding a hammer, the basketball hoop when wielding a basketball, etc. Each of these tasks or spatial zones becomes the dominant intentional-referent whenever the agent purposefully wields the tool associated with their enaction. Consequently, tool-using agents can be motor-intentionally oriented towards intentional-objects other than the tool, such as a nail when practically wielding a (transparent) hammer or the hoop into which one throws the ball. Thus, the open spatial dynamic grounded on potentiality that characterises tool-perception (where one typically faces numerous action-possibilities to the extent that there are tools) recedes during active tool-use, whereby the agent is fully absorbed in performing one particular action that dominates their spatial situation.

After detailing tool-transparency, we turned to a seeming violation of its logic, as visibly manifest in several experiments; namely, that passive holding of a tool does not trigger its withdrawal into transparency (Iriki et al., 1996; Berti & Frassinetti 2000; Costantini et al. 2011). While purposefully using a tool is typically a prerequisite for its functional pairing with the task-at-hand, there are, however, exceptional cases that involve highly habituated tool-users. Here, the role of habit came to focus on two major themes in semiotic (esp. Peirce) and phenomenological (esp. Merleau-Ponty) literature since habituation with a tool can trigger its transparency even when it is merely held passively. An agent's motor-intentional orientation toward innerworldy entities in space is thus infused by a future-facing protension that is detectable in multisensory PPS measurements (Serino et al., 2007; Bassolino et al., 2010). Agents can therefore be motor-intentionally directed to entities in a futural (or modal) sense, by which their *potential* use inhabits *presently-situated* motor-intentionality.

After detailing how agents differentially intend objects during tool-perception and tool-use, we transitioned into detailing social spatiality first through the phenomenon of observed tool-use, in which a singular tool serves as a joint motor-intentional object. This phenomenon was termed 'motor-intentional alignment'. Thus, two nearby agents can each be motor-intentionally oriented to a singular object yet retain a unique spatial perspective, all while remaining co-embedded within a shared spatial situation. Broadly, this can take the shape of a competitive or collaborative semiotic schema (Brandt, 2020), whereby the object/tool serves as a *mutual* intentional-object, allowing the participating members of the interaction to undergo diverse spatial experiences based on their role (Bloesch et al., 2012; Abrams & Weilder, 2015).[167] Agents can thus be 'united' at the motor-intentional level but otherwise maintain idiographic motivations and perspectives, a phenomenon clarified by the framework of motor-intentionality.

Affectivity was also identified as a major factor in several forms of motor-intentionality. Object valence (**2.2.1**) was found to structure the way things in the surrounding environment manifest on the basis of the affective disposition that they evoke. This affective phenomenon typically unites with a capacity for practical engagement with that same object; i.e., a disgusting carcass that makes us step over it. Moreover, it was found that a more wide-reaching state or mood (e.g., anger, joy, grief or fear) can temporarily determine the agent's mode of intending all surrounding entities in a way analogous to Heidegger's and Uexküll's discussion of *Stimmung*. This 'state' can also be elongated into a trait, showcasing how individual differences can have a permanent impact on bodily space (Sambo & Iannetti, 2013).

Moreover, how the agent is themselves affectively intended by the other was found to be important for bodily space. An angry face elicits skin conductance (Cartaud et al., 2018) because the angry other who looks at us is likely to be a threat within our immediate spatial situation. The angry other taking us as their affective intentional-object causes us, reciprocally, to intend *them* as a threatening intentional-object. Subsequently, in sections **2** and **3** of **chapter 3**, we discovered how content from 'higher-level' cognition

[167] See our discussion on social role in **1b.2.3**.

automatically informs situated motor-intentionality. Fear, for instance, can drive perceptual intentionality *away from* the fearful face, yet still produce increased skin conductance despite no directly perceived fearful object (Ellena et al., 2020, 2021). Utilising the concept of embodied abduction (Cuccio & Gallese, 2018; Cuccio & Caruana, 2023), it was proposed that these results emerge because the situated sensorimotor system abducts the presence of a fear-producing nearby entity and automatically includes its presence within its spatial opening onto the environment. Thus, affective intentionality features an intentional-object (the fearful thing), yet this intentional-object is semiotically mediated via the other, in absence of its direct perception.

In the context of social spatiality, it was further found that tools are not the only thing that can be rendered functionally transparent when engaging the world. When included as part of the JEI, the other is likewise rendered a transparent element of one's social-spatial situation. One's motor-intentionality thus automatically figures in the other's potential influence and automatically recharacterises all nearby intentional-objects on such an intercorporeal basis. Thus, most intentional-objects engaged in the format of the JEI are differentially registered compared to when encountered alone, and the framework of motor-intentionality helped clarify the difference between individual and group-level spatial sensorimotor cognition.

In conditions such as schizophrenia and ASD, there can be a respective heightened or weakened disposition toward forming the JEI, thus contributing to a correspondingly misattuned motor-intentional orientation (Noel et al., 2017; Mul et al., 2019). In some cases of SZ, there appears to be a tendency to avoid keeping the other as a distinct intentional-object but instead to form a JEI too easily, which may lead to delusions and experiences of pathological self-other overlap. A similar pathology of spatial over-integration has also been observed with objects (Peled et al., 2003; Thakkar et al., 2011). In ASD, by contrast, while the motor-intentional capacity to render tools as transparent appears entirely normative, there is a notably reduced capacity to form the JEI, causing the other to remain a distinct object *of* motor-intentionality rather than co-constituting motor-intentionality *as* a socially unified entity. This implies that spatial motor-intentionality likely contributes to other well-known social deficits in ASD (De Vignemont & Frith, 2008; Maise, 2013; Canidni et al., 2019).

While motor-intentionality finds its origins in phenomenology, it has been previously noted to share distinct similarities with Uexküll's concepts of 'schema' and 'tone'. I claim that motor-intentionality is also friendly to a semiotic depiction involving a Peircean 'thirdness' (Jappy, 2023), particularly in its embodied format (Stjernfelt, 2006). Indeed, for Peirce, behaviour is not the currency of consciousness, yet neither is a substantial *Cogito*. Instead, 'mind' operates via semiosis, which incorporates *both* cognition and action traditionally conceived and is remarkably akin to what is currently called 'sense-making', another candidate to replace terms like 'mind' and 'cognition' (Paolucci, 2021). A motor-intentional relation is also founded on a Peircean "network of habits" (Colapietro, 2021) whereby the habituated, tool-wielding interpretant is unified with the tool. This is particularly salient in social situations, as the spatial schematic can be defined by two agents each being motor-intentionally oriented to a separate, third entity which, for Peirce, is the basis of communication and, as noted by Eco (1975, 1989), enables human communication's more complex examples, such as deception.

Therefore, we can claim that the MiP in social contexts (relating two or more parties to an object) functions in a manner that is triadic and not dyadic. Moreover, such a framework permits a third-person depiction of Agent-Object and Agent-Agent spatial interactions in third-person terms (e.g., *X* is engaging *Y* in *Z* way) while simultaneously avoiding the language of representationalism and behaviourism, which remain highly controversial terms in ECS (Cappuccio, 2023). Indeed, in many cases of motor-intentionality, there is no behaviour present to even describe, despite crucial differences in motor-intentional structure. In **2.3**, for instance, we found that habituated agents undergo tool-transparency while merely holding a familiar tool. Behaviourally, however, both the habituated and non-habituated populations exhibited no discernable differences when holding the cane.

Yet this apparent homogenity conceals a remarkable difference at the motor-intentional (as well as experiential and neurophysiological) plane. Namely, the habituated tool-user's motor-intentionality made the tool transparent. The forthcoming action is protended, directed towards imminent interaction with their environment thereby sculpting bodily space. While this certainly has a register in first-person experience (the PrCC; see below), its third-person correlate can be formulated with the MiP by interrogating the type of relationship between the enactive agent and the thing interacted with.

In sum, the extant experimental literature on peripersonal space, above divided into studies pertaining to 'Objects' (**Chpt. 2**) and 'Others' (**Chpt. 3**), was refined and explicated in several ways by incorporating the terminology and conceptual framework of motor-intentionality as pioneered by Merleau-Ponty (1945/2012). This mode of analysis was also found to cohere with select semiotic accounts of sense-making. Furthermore, this *third-person* framework was integrated with a *first-person* account of pre-reflectivity, which shall now be described below.

B) Pre-Reflective Cognitive Correlate (PrCC)

The PrCC was proposed as a means of accounting for the first-personal domain of spatial cognition as it coheres with measurable and discrete patterns of neural activity. Using phenomenology (and, in many cases, semiotics), philosophy helps provide a human-centered account of space which is informative to the empirical findings of the neurosciences. This was concretely instantiated by disclosing what I label the 'pre-reflective cognitive correlate' (PrCC). The primary implication here is that what neuroscientists observe at the neurophysiological level does not correspond exhaustively with scientific or even computational models of space at the cognitive-experiential level (Sykes, 2021b). Again, 'Hold' is one such prominent example. The concept of hold denotes how agents pre-reflectively cognise usable objects. Muscle activity in the hand indexes the body's anatomical preparation for appropriate action, which correlates with the experiential imprint of the tool's specific utility enjoying an increased presence within its observer's spatial situation. Yet, in both domains, we are typically scantly aware of the presence of hold. Consequently, researchers require specific measurement devices *and* phenomenological methods to capture and articulate it.

Developing a language to account for the cognitive correlates to select neuroscientific experiments conducted on PPS is often tricky because many ways of being in space and relating to spatial entities occur prior to conscious awareness. For example, the layperson is not aware that vRFs in their brain expand towards the tool's tip during engaged action with it and so cannot report it (Iriki et al., 1996). Surrounding space pre-reflectively manifests on the basis of a task-at-hand opened up by the tool. Yet, several decades before this finding was made, Heidegger and Merleau-Ponty pre-emptively described essentially the same phenomena. This heavily implies that, at a pre-reflective level, such neurological changes are also present within experience. But this phenomenon is itself transparent in the agent's experience because we are highly accustomed to such phenomena in the background of our daily lives. Therefore, we may not be fully cognisant of the experiential and neurophysiological changes that arise when potential pathways of action are pre-reflectively laid out when holding highly familiar tools. Nonetheless, this does not mean that such phenomena are *not* experienced; simply that they are not experienced *reflectively*. As such, a specific framework is required to describe the cognitive-experiential correlates to this neural activity.

In a similar vein, without phenomenological training, we are unlikely to be reflectively aware of phenomena such as co-transparency (**3.1**); that is, that one's bodily spatial boundaries extend while watching another individual use a tool similar to one held by the observer due to motor-intentional alignment. But the fabric of social-spatial reality is such that we pre-reflectively experience the other's task-at-hand almost as if it was our own, a phenomenon with detectable neurophysiological consequences. Indeed, in examining social spatiality, we found that even relatively nuanced means of social understanding (e.g., the other's moral status) are accomplished pre-reflectively (**3.3.2**). The content of an automatic abduction that (among other functions) helps us label a person as immoral due to their behaviour, penetrating pre-reflective cognition so fully that appropriate (if invisible) sensorimotor responses to that other become almost instantaneous. Indeed, immorality was found to be a condition of exclusion from the JEI's formation, an undeniably sensorimotor phenomenon that agents also experience at the pre-reflective level.

Upon becoming part of a successfully-built JEI, we are, of course, to some extent, aware that a change has occurred. We know that a long piece of furniture now has the quality 'movable', whereas before it did not. Yet we probably remain ignorant of how far this change has penetrated our neural pathways, reflecting how our spatial boundaries now overlap with the other's, forming a singular, social-spatial entity. Several studies show that responses typically around one's own PPS now occur around the body of the other (Tenneggi et al., 2013; Pellencin et al., 2018; Hobeika et al., 2019; Rocca et al., 2019). This entails that pre-reflective experience is now directly infused with the other's social influence so that the world suddenly shows itself to one as a socially unified entity; this is not the result of any choice, but rather a consequence of the shift in spatial embeddedness that has automatically accrued.

At this juncture, after having reiterated some prime examples in which the PrCC proves informative, it appears prudent to contrast neuroscientific experiments in which participants reflectively thematise spatial properties with the *pre-reflective* account of spatial cognition outlined here. An exemplary case of reflective spatial cognition are spatial rotation tasks (e.g., Bricolo et al., 2000; Bernadis and Shallice, 2011), in which participants mentally manipulate the position of three-dimensional objects. Arguably, spatial rotation tasks using non-tool-like objects are comparatively reflective and abstracted from everyday circumstances. To spatially rotate a shape, one must thematise its Euclidian properties in an abstract manner that typically remains relatively independent from any pragmatic situatedness in the world.

Undoubtedly, such tasks are profoundly revelatory of the brain's understanding of space. Moreover, in their most complex manifestations, such abstract intellectual capacities allow scientists, mathematicians, and engineers to achieve outstanding intellectual feats and accomplishments. But, notwithstanding their impressiveness, all such endeavours are nevertheless placeable within the domain of *reflective* spatial cognition which ultimately rests on, and is conditional upon, a prior and more primordial *pre-reflective* embeddedness in the spatial world.

Accordingly, there is no tension in recognising that discrete methodologies and terminologies are required to showcase how agents are spatially embedded within their environments in lieu of how they thematically represent spatial properties as cognisers, acts which are easier to measure directly by asking experimental subjects to thematise spatial properties in de-contextualised laboratory settings. For this reason, we here distinguished between a *reflective* (e.g., rotation tasks, ratio scaling) with a *pre-reflective* cognitive correlate (e.g., affordance-perception, spatial interaction) and propose that this distinction likely applies not just to bodily space, but to other or all themes in ECS.

However, this is not to imply that reflective and pre-reflective cognition operate in wholly different realms. From the perspective of his collaborative work, Tim Shallice (Bricolo et al., 2000; Toraldo & Shallice, 2004; Bernadis & Shallice, 2011) agrees that "reflective and pre-reflective spatial cognition (as proposed here) are different but not in conflict and believes that they are probably connected in some capacity".[168] Indeed, bodily spatial skills can also feature reflective dimensions, especially during the skill acquisition phase. It is important to add that several instances of motor-cognitive acts hitherto categorized as 'pre-reflective' may have begun their lifespan as reflective forms of cognition since most skills are learnt deliberately. Indeed, there is something like a phenomenological transference of skill from inhabiting reflective cognition into scaffolding pre-reflective cognition when it becomes fully absorbed into one's sensorimotor opening via habit (Cappuccio, 2023), which is a pivotal notion for enactivism more generally.

[168] Personal communication.

To give a common example, during the reflectively-managed learning stage of skill acquisition, say, of learning to ride a bicycle the agent has not embodied the transportation 'tool' in the same manner as the habitual bike rider (Dreyfus, 2005; Cappuccio, 2023). Whilst the learning phase is underway, the would-be cyclist must concentrate on every muscle exertion, carefully balancing a moment-to-moment coordination between his feet on the pedals, his hands gripping the handlebars, the eyes on the road, etc. At this stage, cycling thus has a reflective experiential and neurological register. In some sense, the bicycle is rendered transparent when the skill of cycling is mastered, which is likewise the case for learning to drive a car as noted in both the phenomenological and PPS literature (Ratcliffe, 2012; Graziano, 2018).

The logic of 'tool-transparency' is again at play here: the cycle path ahead dominates the agent's global motor-intentional orientation, not the bike itself, but all the actions required to ride the bike are present in pre-reflective cognition. The task is the intentional-object and the bicycle is a transparent facilitator of that task. Tying one's shoes or driving a car are two more well-known examples here. In such cases, one can perform complex actions, to borrow the colloquial term, 'on autopilot'. For instance, it is probable that learning to use a tool is a reflective procedure with distinct neural correlates, but these are replaced by the PrCC when habit enables participants to pre-reflectively engage space as disclosed by the familiar tool that they hold. Further scholarship should focus on when and how reflective and pre-reflective spatial cognition intersect and interact (Newen, 2018; Cappuccio 2023).

Finally, following Heidegger, we might claim that the 'worldliness' characteristic of pre-reflective spatiality truly unfolds when our modes of *Umwelt*-interaction become fully-integrated into the transparent background of our everyday being-in-the-world and are thus always 'at-hand' at the appropriate time (Wheeler & Cappuccio, 2010). That is, when we are spatially well-oriented, capable of immediately recognizing objects via their use-values and wielding them skillfully on demand (perhaps even while getting on with other business), then we might truly consider ourselves as *part of* our environment. The truly skilled chef navigates around the kitchen with ease and proficiency just as the elite football player navigates the pitch and the teacher their classroom. The enactivist definition of cognition *qua* agent pre-reflectively immersed in their environment as an ongoing process (Thompson, 2007; Kiverstein, 2018) thus seems reliant upon the accumulation of habits and skills as exemplified in the phenomenon of bodily space, which has been found to feature unique kinds of neural correlates. It follows, therefore, that being part of one's environment has, at least on the basis of certain tasks, a distinct PrCC.

Thus, the present thesis plausibly serves as a case study for delineating between reflective and pre-reflective cognition as related to spatiality and its corresponding neural correlates. We have sketched some provisional guidelines regarding how neural activity may be effectively connected to the latter, considering that the transparency of pre-reflectivity may render it even harder to individuate PrCCs than 'regular' reflective cognitive correlates (Sullivan, 2015). To avoid a resurrected dualism, we also considered that reflective and pre-reflective spatiality often intersect and briefly considered some ways in which they interpenetrate each other in ecological settings, although further research is required here. Additionally, further scholarship is likely required regarding both how to further describe pre-reflective cognition as well as how to continue to relate it to other forms of neural activity from the perspectives of philosophy of science and epistemology.

2.2 Spatiality and the Enactive Approach

Further motivating this project was the fact that 'spatial cognition', while a lively and enduring research area in the fields of computational neuroscience and cognitive psychology (see Burgess, 2008 for a review), it has received surprisingly scant attention in enactivist literature. At the time of writing and to the author's knowledge, there are currently no doctoral theses, academic monographs, or popular books on space from an enactive or 4E perspective. In Gallagher and Zahavi's 'The Phenomenological Mind' (2012), often viewed as a textbook of ECS, space does not have a chapter devoted to it. While spatiality has obtained some notable mentions in several research papers (Gallese & Sinigaglia, 2010; De Preester, 2012; Jackson, 2014, Gallagher, 2018), thematic investigations of spatiality in ECS are few and far between if compared to topics such as embodiment, action, intersubjectivity, affectivity and temporality. Further amplifying this problematic is the fact that foundational figures in the neuroscience of peripersonal space had long ago highlighted its compatibility with phenomenological approaches to mind (Rizzolatti et al., 1997). As such, this project aimed to address this lacuna in the ECS literature by bringing spatiality to renewed thematic attention.

Upon deeper consideration, moreover, spatiality seemingly proves useful in providing a more comprehensive formulation of several 'canonical' topics already existent in Enactivism. Thus, in this subsection, I aim to add further detail to this claim. Certainly, the lived body engaged in the world as oft-described in ECS never occupies a placeless void; no matter the bodily act, one always encounters a lived body that moves through and acts within a qualitatively-structured space. On this note, consider Kiverstein's (2018, p.37) definition of (radically) extended enactive cognition as "extended cognitive systems [are] perception-action systems on the basis of which the person or animal is adapted to its environment and so be able to deal adequately with its affordances". Since this statement is purportedly definitional of extended or enactive cognition, expounding the most fundamental structures underlying this kind of relationality thereby proves instrumental for better understanding other key domains of enactive cognition that are of interest to 4E theorists, such as embodiment, tool-use, affectivity, temporality, intersubjectivity and language.

As such, bodily space fits neatly into the lacuna left open by accounts of other core themes of ECS. Let's first consider the theme of intersubjectivity. As discovered in this work, intersubjectivity and spatiality are deeply unified phenomena. It was noted on several occasions that mirror and peripersonal neurons shared various properties in relation to both their location and function. Peripersonal neurons were first hypothesised in Rizzolatti et al. (1981) before Rizzolatti and colleagues discovered mirror neurons (Rizzolatti et al. 1996; Gallese et al., 1996). Indeed, as foreseen by Merleau-Ponty and Uexküll, there is compelling evidence that one's own capabilities dictate one's capacity for understanding the other's actions in space (see Gallese & Sinigaglia, 2018).

Likewise, when we engage and interact with others in face-to-face settings, in the bodily manner typically highlighted by enactivists (Froese and Fuchs, 2012, Froese, 2018, Gallese & Sinigaglia, 2018, Newen, 2018; Gallagher, 2020), we always do so within a shared space. Indeed, it seems that the joint enactive interface is an exemplary application of radically extended cognition (Kiverstein, 2018) to the social domain. In the JEI especially, the other truly becomes an extension of oneself whereby, as a socially unified entity, the entirety of one's spatial surroundings manifest on a fully intersubjective basis.

The connection between time and space, while arguably less immediately apparent than that of embodiment or intersubjectivity, may likewise prove crucial to providing a full account of either. In fact, our enactive account of bodily space may join some prominent theories in physics such as special and general relativity (Einstein, 1984) that maintain that space and time are fundamentally united (Rovelli, 2006). Broadly put, the agent's meaningful actions enacted within the *Umwelt* and *Mitwelt* always feature temporal signatures. Certainly, such acts feature a duration, but measurable duration pertains more to a linear and chronometric model of time, something viewed as wholly unsuitable for the reality of experienced time (Bergson 1910/2014; Husserl 1921/2001; Heidegger 1927/2010; Gallagher, 1997; Varela, 1999; See **2.2.3**). In fact, Heidegger's (1927/2010) complaint regarding the dominance of linear time was precisely that it was reliant upon spatiality as its conceptual basis!

In line with phenomenological accounts, however, how *lived* space and time intersect in our account is notably diverse from their objective counterparts. Pre-reflective spatial perception hinges on the perception of a variety of potential near-futures that can be taken up, so that one's spatial here and temporal now is always co-constituted by a corresponding 'there' and 'then' (Talero, 2005; Gallese & Sinigaglia, 2010). We encounter bodily space's dynamic, non-linear temporal signature even more pronouncedly when considering habit, where it also served an explanatory role in relation to experimental evidence (e.g., Serino et al., 2007; Bassolino et al., 2010; Zanini et al., 2021; Fossataro et al., 2023). This is because habit demonstrates that know-how acquired in the agent's past has direct bearing on their present, which, in itself, is co-constituted by a future-directedness. Accordingly, one's most immediate manifestation of surrounding space depends on the skills one has learned and habits acquired, which, in turn, is grounded upon whichever cultural milieu one has been born or socialized into. This is why the Amazonian tribe *sees* the Amazonian rainforest differently from the explorer who has just arrived.

Even studies operationalising emotion (e.g., fear) appear informative of the agent's temporality. In an affective state of fear, for example, external entities are processed more quickly compared with other affective states (Vangoni et al., 2012; Taffou & Viaud-Delmon, 2014; Ferri et al., 2015). It is almost as if the bubble of space surrounding the body emits a stronger gravitational pull in spacetime, by which nearby entities enter the agent's world faster and with greater impact. Accordingly, the agent does not exist in a grid that can be uniformly mapped out, nor does he journey through metric space and chronometric time like a dot traversing a 2-D plane. Rather, in addition to having a trajectory, the agent's existence in time and space is meaningful, dynamic, non-linear and constantly updated by situational factors. However, third-order cybernetics, with its leading notions of recursivity and non-linearity (Froese, 2010; Colombetti, 2018), may be appropriate to describing lived spatio-temporality in third-person terms, which remains an open question. The present account of spatiality may thus be construed as an account of spatio-temporality and future research on temporality from an enactive perspective may benefit from taking spatiality into greater consideration than it has done thus far.

Even language, perhaps the domain most intuitively remote from spatiality, has been found to mould bodily space, while, reciprocally, manipulating bodily space itself alters participant's language use, such as one's usage of locative adverbs (Coventry, 2008, 2014; Rocca et al., 2019). Language thus clearly co-constitutes normative bodily space, as each domain reciprocally co-constitutes the agent's situatedness, as shown in the several studies listed above (e.g., Pellencin et al., 2018; Rocca et al., 2019; Patane et al., 2021). Indeed, to give but one example, Patane et al. (2021) employed identical conditions when measuring PPS reaction to an object placed in the middle of participants, albeit with one change. Namely, in one condition, the object was explained to be 'shared'. This simple verbal instruction automatically engendered changes in PPS responses during the task in reference to both the object and the other participant. Correspondingly, Gallese and Sinigaglia (2018, p.422) claim that EST, a framework that has been regularly utilised here, can encompass both language and spatiality "within a theoretically unitary framework".

Thus, we have seen how thematising spatiality expands and enriches several popular discourses and research directions within enactive cognitive science. Another prominent theme underlying essentially all accounts in ECS is the inherent situatedness of sense-making acts (e.g., Chemero, 2009; Kiverstein & Rietveld, 2014, 2015; Rietveld, Denys & van Westen, 2018). Certainly, emergent from our own assessment of the current empirical evidence is the notion the PPS network is inherently a contextually-situated phenomenon. Once more, it should be emphasised that the mainstream scientific literature, while arguably missing some of its philosophical implications, is highly cognisant of this fact (see **Introduction**). For example, De Vignemont, Serino, Wong, and Farne (2021, p.3) highlight this same phenomenon when claiming: "Depending on context, the same area of peripersonal space can be processed as peripersonal or not". This clearly implies that PPS, while undoubtedly bounded, has no permanently fixed location or size due to its embeddedness in a contextual frame; its topography is always situated and context-dependent.

This finding may naturally lead us to ponder what exactly 'context' is and how such a supposedly nebulous concept can directly and automatically influence the brain-body at a 'lower' sensorimotor level. Does the brain-body compute 'context' as an adjacent factor? Following the enactivist tradition, I would claim it does not (Heras-Escribano, 2021;

Cappuccio et al., 2021; Gallagher, 2023). In showcasing how bodily space is contextual, we also see how it interfaces with the concept of ‘situatedness’ prominent else. Such considerations also position bodily space as interpreted here in relation to a pivotal concept found throughout enactivist literature: that of ‘frame’ (Dreyfus, 2007; Froese, 2007; Kiverstein, Miller and Rietveld, 2019; Cappuccio et al., 2021). Frames were instrumental in dethroning ‘classic’ models of Artificial Intelligence, and by extension cognitivism, and had predictive validity regarding failures in AI research (Dreyfus, 2007). To make a huge topic rather brief, AI research has continued to find that AI systems that must depict their environment and knowledge of the world in the format of logic trees fall into infinite regress, as one frame must always be invoked to explain another frame, *ad infinitum*. As Cappuccio et al. (2021, p.10) succinctly summarise one variant of the problem:

> The computational limitations of which the system suffers prevents the robot from exhaustively analysing the logic of values and the overwhelming complexity of the real-life scenarios in which values are relevant, as such analyses typically require massively interconnected causal relations, further complicated by fuzzy, holistic, and modal properties.

To give further conceptual grounding to these observations, we can again lean on Heidegger’s technical usage of ‘world’, which inspired the conceptual usage of frames as first articulated by Dreyfus (1996, 2002, 2007). The so-called worldliness of the world (*die Weltliekeit die Welt*) denotes the phenomenal world’s ability to scaffold Dasein’s intrinsic capacity for absorbed, meaningful and non-theoretical engagement within it. This notion has already made the leap into cognitive science to serve an explanatory role (Dreyfus, 2000, 2007; Wheeler & Cappuccio, 2010; Kiverstein, 2012; Malpas, 2012). Taken as such, it provides theoretical support to the way that the brain-body is automatically attuned to environmental demands in a manner describable as intelligent yet non-conscious. This continual readjustment to contextual demands manifests as absorbed engagement with tools that occurs prior to or without reflective cognition (Dreyfus, 1999; 2002; Kiverstein & Rietveld, 2015, 2018; Cappuccio, 2023).

The conceptual stipulations we have outlined here directly apply to the ‘worldliness’ of peripersonal space, whereby we routinely discovered that its contextual grounding entails that certain objects automatically show up as useful in accordance with situational demands. Moreover, we frequently saw how a qualitative place frames appropriate action whereby a change of context might entail that a previously useful object is now rendered useless. For example, a keyboard on the ocean floor does not afford *for-writing* when encountered during scuba diving, just as my nearby water bottle is less salient when I’m not thirsty. Such a change can occur even with minimal alteration in the 'objective' location. A context automatically elicits appropriate and skillful action from the agent because it relinquishes the agent of their need for cognitive reflection and guidance (Dreyfus, 2002, 2007; Rietveld & Kiverstein, 2014; Cappuccio, 2023). As such, the framed and habitual character of bodily space permits it to interface with the spatial world of which it is part. These themes will be expanded upon below when we are in a section dedicated to providing a definition of PPS (**4.3.2**).

In summary, we have witnessed how both foundational and ongoing research topics in ECS, such as embodiment, affectivity, intersubjectivity, language and temporality, productively intersect with and mutually enrich spatiality, so that bodily space as a research theme may potentially even operate as something like a 'missing link' in relation to certain prominent debates and discussions due to its prior underdevelopment. We have also seen how fundamental and ongoing theoretical cornerstones of the enactive approach, such as 'frames', 'situatedness' and 'habits', found reaffirmation in the current analysis. A rigorous theory of bodily spatiality thus enriches some classic theories prominent in ECS while introducing spatiality to a litany of parallel research areas, the continued inclusion of which will help researchers to build a more comprehensive picture of sense-making from an embodied-enactive perspective. Finally, the notion that bodily space is profoundly interconnected with several other cognitive domains, including the notion that it is always framed by its situated context, leads directly onto the next section, in which I examine in greater detail a proposed operational definition for PPS that foregrounds these factors, in addition to detailing how PPS might be distinguished from a highly similar construct.

3. Cognitive Neuroscience of Peripersonal Space

3.1 Disaggregating PPS from a Related Construct

We have elsewhere emphasised how tightly related bodily space is with other key constructs in cognitive science and the neurosciences, as noted by numerous scholars (e.g., Holmes & Spence, 2004; De Vignemont & Iannetti, 2015; Hunley & Lourenco, 2018; Serino, 2019). But this similarity also entails that a common problem permeates the empirical literature, a validity concern that has elsewhere been labelled the 'individuation problem' (Sullivan, 2015). The individuation problem pertains to the difficulty researchers face in differentiating between closely related and oftentimes functionally interdependent cognitive capacities and their associated neural correlates. It was claimed above that a framework capable of detailing the pre-reflective cognitive correlate makes explicit otherwise unnoticeable cognitive correlates to neuroimaging data.[169] But, just like their reflective counterparts, these pre-reflective domains may overlap in a manner that impedes investigation. In fact, this problem may be even more pressing for ECS, which tends to emphasise holism and downplay the existence of discrete modules (Gallagher, 2023).

Peripersonal space has not escaped this dilemma. In the scholarship, numerous figures have called attention to how PPS relates to other constructs, with on-going debates pertaining to the differences and similarities of such constructs (Holmes & Spence, 2004; Cardinali et al., 2009, Hunley & Lourenco, 2018; D'Angelo et al., 2018). Perhaps the most prominent of these debates pertain to 'body schema'. In what follows, I will apply the findings from the embodied-enactive analysis presented here in an attempt to shed light on whether these constructs can be disaggregated despite their common phenomenological heritage.

In brief, we learn from Merleau-Ponty that body schema is neither (just) an intersensory unity nor even a global awareness of posture (129/101). Nor is it merely a copy or representation of the body because *qua* schema there is no superordinate entity to which it can be copied or represented to (Carman, 1999). For Merleau-Ponty at least, a schema is no more a representation than the consciousness itself is a representation. Even in traditional cognitive neuroscience, we rarely hear of 'conscious representations' because consciousness itself is not considered to be a representation. We understand the world through our body to the same extent as through our consciousness. Thus, if neither consciousness nor cognition are themselves representations, neither is the body.

We can now return to the relevant empirical literature. Among the first to explicitly link body schema and PPS was Holmes and Spence (2004, p.104), who claimed that "the 'body schema' and 'peripersonal space' are both emergent properties of a network of interacting cortical and subcortical centres". For the same reason, this proposed similarity seemingly holds up two decades later. However, they phrase the question thusly:

> Is it appropriate to say, for example, that the tool is literally incorporated into the brain's 'body schema' (Head and Holmes 1911–1912), which is used for maintaining and updating a postural model of the body in space? Or is it rather a remapping of extrapersonal visual space as peripersonal space?

[169] Indeed, this notion underlies the research programme of neurophenomenology, with which ECS is intimately connected (Varela, 1996; Thompson, 2007; Froese & Sykes, 2023).

However, we know from Merleau-Ponty (1945/2012, p.129/101) that the body schema is not actually a 'postural model'. Thus, the second option appears more accurate: extrapersonal space is remapped as peripersonal (bodily) space via a withdrawn tool, reflecting the body's changing position in the spatial situation. Seemingly, what we have labelled 'tool-transparency' impacts both bodily space and body schema. Cardinali et al. (2009) further highlight the tight convergence between the notions of 'peripersonal space' and 'body schema':

> Tool-use does indeed change what we have so far called the body schema. Even more intriguingly, the effects of this plastic modification in the body schema seem to last long enough to be detected after the change itself has occurred, most likely during the tool-use phase. We believe that it is when the consequences of using a tool affect the representation of our acting body that the tool "becomes a part" of the body.

Thus, a tool both becomes part of the body's schematic while *also* becoming part of the body's space. D'Angelo et al. (2018) likewise contribute to this discussion by experimentally testing whether PPS and body schema change in the same way following a task in which agents assume control over a virtual hand. Namely, they found (p.7) that "the sense of agency for a virtual hand projected in the far space extends both the body schema and peripersonal space". This study thus assumes that peripersonal space and the body schema are genuinely distinctive constructs, yet each respond to the same experimental manipulation identically. Body schema and bodily space can thus plausibly be distinctive yet mutually influenced by an effect due to their profound overlap.

As such, while all of these accounts are informative and well-developed, I will argue that they nevertheless leave open the question as to whether body schema and bodily space are identical. Indeed, every way that one can define the function of PPS seems also to apply to body schema. By attending to the MiP however, I aim to repeat the method that previously successfully disentangled body image and body schema (Merleau-Ponty, 1945/2012; Gallagher, 1986, 2005) and provide some suggestions and apply it to body schema and bodily space. My proposed solution can be foreseen in De Vignemont and Iannetti (2015), who forward a tripartite division between peripersonal space, bodily space and extrapersonal space. Of note here is the proposed distinction between 'bodily' and 'peripersonal' spaces. Obviously, this is clearly different from the proposed identicality of PPS with 'bodily space' as adopted here or in comparable interdisciplinary PPS accounts (e.g., Gallese & Sinigaglia, 2010; Jackson, 2014) which also reflects how 'bodily space' is employed by Merleau-Ponty. However, we should retain the core idea that there is a space inside PPS that pertains to the body proper or to motor-intentional acts either directed to or very close to the body, such as readjusting one's tie or pressing a number on one's phone.

To recap, the body schema is an inherently spatial entity and included within its spatial schematic are the things that it is motor-intentionally attuned to. The inherited, pre-phenomenological conceptions of body schema that Merleau-Ponty took to task (e.g., intellectualist, empiricist, and Gestalt) had all missed this crucial dimension by marking the schematic components only as those body parts themselves, thus 'de-worlding' the world-embedded body schema and treating it as something present-to-hand (i.e., as *Korper*). Instead, the body schema earns its structure via the motor-intentional objects that it engages, particularly if with frequency. But, while differentiating it from the body image, this description makes it difficult to separate it from peripersonal space. Namely, this is because both constructs:

1. Are constitutively receptive to, and sculpted by, external entities.
2. Extend beyond the body surface into the space surrounding it.
3. Feature temporary alignments between tasks and task-relevant body parts.

How, then, can we disaggregate these remarkably similar constructs? I claim that this confusion, if it cannot be resolved experimentally may be approached conceptually. To do so, we must locate a role for the body schema that is not also accomplished by bodily space, despite their significant overlap in most areas. First, recall that bodily space enables agents to incorporate tools into their space/schema or, alternatively, determine how other entities in space are perceptually encountered in alignment with one's spatial situation. Regarding tool-transparency, it was key that other entities were made accessible via the withdrawn tool, causing the characteristic expansion of bodily space. Bodily space might also dictate the degree and type of salience of a perceived tool (e.g., hold; affective intentionality), allowing a future action to 'open up' within one's present spatial situation (tool-protension) or expand following observation of another's tool-use (co-transparency). So far, however, these descriptions might plausibly apply to body schema also.

However, within each of these situations, there exist adjustments and movements of one's body parts that are seemingly unrelated to bodily space; i.e., that do not pertain to a situation-dominating spatial connection between agent and object or alter the spatial size of the lived body's envrionmental presence. For instance, if I slightly adjust my hat while looking at a painting, or close a short button that came undone, bodily space has not undergone any significant changes following these actions. Essentially, these are goal-directed actions that are not directly linked to the task-at-hand of admiring the painting. This gives us an indication as to how to differentiate these two constructs. The key difference, I claim, is that intentional actions conducted intra bodily space that facilitate the proper use of the tool-in-hand but do not pertain to the primary task-at-hand may belong solely to the body schema.

Some examples would surely help clarify this proposed distinction. To offer a personal anecdote, I spent some months at a Japanese university, and living in Japan meant improving my proficiency with chopsticks. When one holds chopsticks, one should continually readjust them in their fingers to dynamically adapt to the process of eating the (quite delicious) food. After some embarrassing learning moments, one eventually increases one's skill at letting the chopsticks roll in the hand and readjust between one's fingers as one eats with them. This example applies to 'standard' chopstick-use but, but for this example, let's consider the long, metallic chopsticks used in barbeque restaurants in Japan ('yakiniku'). These metallic chopsticks, sometimes 40cm in length, enable one to pick up raw meat and place it on the coal barbeque that may sit in the middle of a large table, often in extrapersonal space.

Thus, with these withdrawn tools, innerworldly entities in extra-personal space (e.g. food, the coal BBQ) are pre-reflectively experienced as more accessible. This is due both to their position (in the middle of the table) and the inability to handle them without a tool (raw meat; a high flame). If one uses one's chopsticks to manipulate foodstuff on a plate located at a fair distance away for more than a couple of minutes, it is entirely plausible that one would observe a PPS expansion. One's mode of spatial situatedness would thus readjust accordingly: bodily space expands to incorporate the (transparent) lengthy tool so that otherwise inaccessible intentional-objects suddenly appear accessible. However, these processes might apply to both the body schema and bodily space (though perhaps more so to bodily space). The crucial difference, however, is that the small but necessary adjusting movements enacted by the hands and fingers required to hold the chopsticks in place are accomplished solely by the body schema rather than by bodily space.

Returning to Heidegger's famed example of the ready-to-hand hammer might also reveal something that serves our current purposes. As with the chopsticks, certain aspects of hammering might only be accomplished by the body schema even though bodily space is also required as a constituent component of the act. Specifically, tiny muscular movements of the fingers around the hammer's handle while hammering are not accomplished by bodily space, even if they certainly facilitate its enaction. Rather, small micro-actions such as shifting the fingers, loosening or tightening one's grip, or moving one's hand higher or lower on the handle are all bodily schematic actions, and may also become sedimented into background 'know-how' for expert builders. Yet these kinds of pre-reflective, skillful bodily adjustments are accomplished by the body schema though even if they almost certainly have a secondary effect on bodily space. For instance, a failure in the body schematic grip on the hammer may sever the intentional thread between the hammer-tool and the nail-object or prevent it from withdrawing in transparency.

Finally, consider driving a car. After acquiring the correct habits, the gearstick and steering wheel become on-hand for adjusting the car's movements. Bodily space has undergone a shift so that it has 'wrapped around' these objects (Graziano, 2018) and enactive spatial perception has radically altered on this basis of the new spatial situation. By expanding, bodily space has facilitated the incorporation of intra-bodily spatial objects, enabling a global alteration in the spatial situation, altering one's relation to other entities as is appropriate when driving. Namely, the speed or trajectory of surrounding entities (pedestrians, other cars) external to the car are not tagged as 'near' or 'far' or 'dangerous' or 'safe' in the same way as they would be for the agent walking down the street. Thus, while bodily space has expanded while operating the car, most movements inside this expanded space are then taken over by the body schema. Flicking the indicator switch, changing gear, or slightly moving the steering wheel to the right are all activities accomplished by the body schema which only involve bodily space indirectly as their precondition, if at all. Bodily space instead pertains to the ability to make these items withdraw and the adjustment of one's relationship to surrounding space outside the car and the entities found there

Thus, the fine-tuned conceptual analysis of bodily space attempted here has potentially furnished us with the requisite tools to distinguish between two highly similar constructs, a problem repeatedly noted in the PPS scholarship, in which there has been a longstanding inability to differentiate bodily schema and bodily space. By strategically emphasising the divergent motor-intentional profiles of bodily space and body schema, we understood that intentional-objects inside one's own bodily spatial zone that are subject to small, calibratory movements pertain more closely to the body schema than bodily space; e.g., adjusting one's grip on a hammer or flashing an indicator light in the car or putting pressure on the accelerator with the foot, even if both of these tools have been incorporated into bodily space. Bodily space typically does not 'point inside itself' so to speak; rather, it reflects, indexes and facilitates the global spatial situation and enables the body to interface with that which is outside of the body, even if this means incorporating things into bodily space. This stands as at least one highly salient difference between these constructs.

3.2 PPS as 'Enactive Interface'

Settling on an adequate definition of PPS has plagued the literature (De Vignemont & Iannetti, 2015; Hunley & Lourenco, 2018; Bogdanova et al., 2021; De Vignemont et al., 2021). This derives from the vast number of functions and situated variations that shape the multivariate manifestations of PPS. Indeed, De Vignemont & Ianetti (2015, p.5) claim that "An urgent question is indeed to what extent those functions require distinct types of representations of PPS". The staggering heterogeneity and occasional paradoxical responses of PPS motivated the division of PPS into 'defensive' and 'non-defensive' PPS (de Vignemont & Iannetti, 2015). Subsequently, Hunley and Lourenco amend this by forwarding a "unified network" of PPS responses that collectively make up a total PPS. Bufacchi and Iannetti (2018) instead propose that there is no 'single' PPS but rather an intersection of action fields. Perhaps the most recent proposal is Serino's (2019) definition of PPS as a 'multisensory-motor interface', which takes its heed from the earlier definition in Brozzoli et al. (2011) of PPS as a 'multisensory' interface.

One stated aim of this research was the provision of an operational definition of PPS In this project, I have forwarded a definition of PPS that is not substantially different from some alternatives, particularly that of Hunley and Lourenco (2018) and Serino (2019). However, while I retain the term 'interface' (Brozzoli et al., 2011; Serino, 2019) I propose that foregrounding the term 'enactive' contributes towards a more comprehensive definition insofar as it encompasses certain key aspects of peripersonal space otherwise overlooked by competing definitions. Instead of defining PPS as a multisensory interface, I have claimed that PPS is most comprehensively defined as an '*enactive* interface' (EI). Certainly, this is not to deny that PPS is dependent upon processes of multisensory integration (Serino et al., 2015). However, by substituting 'multisensory' with 'enactive' when defining what this interface is and does, we expand our definitional borders to domains of consciousness that are not necessarily encompassed in multisensory-motor cognition.

Interpreted broadly, *both* 'multisensory-motor' and 'enactive' imply that the agent is grounded in a meaningful spatial environment whereby their embodied existence is infused with possibilities, affordances, movements, and actions that confer to this organism-environment coupling its definitive qualities. However, enactive spatiality is not limited to these *purely* sensorimotor capacities. 'Multisensory' (Brozolli et al., 2012) or even 'multisensory-motor' (Serino, 2019) implicitly excludes or underemphasizes key factors such as language, morality, and lived temporality, which have all been demonstrated as equally co-constitutive to bodily space as sensory information and motor output (e.g., De Vignemont & Iannetti, 2015; Iachini et al., 2015; Patane et al., 2018; 2021). Crucially, however, unlike many cognitivist accounts, enactivism does not relegate these 'higher' and 'lower' cognitive domains to separate modules that only interact on occasion in the format of concurrent representations (see Rietveld & Kiverstein, 2014, Kiverstein & Rietveld, 2015, 2018; Rietveld & Brouwers, 2017; Newen, 2018).

Rather, at least in many cases, sensorimotor cognition is *co-constituted* by such higher-order factors and vice versa. Indeed, as repeatedly shown here, there exist several ways in which 'higher-order' cognition automatically impinges upon its 'lower-order' counterpart, so that these two levels cannot be neatly separated while still leaving normative spatiality intact. As described above, the 4E tradition already provided several detailed accounts of how such factors constitute cognition and we have here attempted to showcase how spatiality fits alongside them. For example, in how domains such as language and sociality are intertwined with sensorimotor cognition (Di Paolo, Cuffari & De Jaegher 2018) or how conceptual content is abducted from the other's visage (Ellena et al., 2020; Cuccio & Caruana, 2023). Since enactivism provides a plausible cross-disciplinary framework for integratin these various domains under a unified banner, 'enactive interface' serves as a more encompassing definition for PPS.

Furthermore, we have repeatedly emphasised the non-interchangeability between qualitative and quantitative models of space. That is, theoretical models well-suited for describing physical and geometric space do not directly transfer over to describing the way that the brain-body immediately engages lived space. For instance, when holding a hammer, one can feel its weight and material composition while also experiencing it as a ready-to-hand tool directed toward a task. Here, it has instead been claimed that the *primary* relationship between agent and space is one of embeddedness rather than of representation or analysis. The enactive interface itself reflects these qualitative aspects of the spatial world via its embedded nature, and it is precisely in its pre-reflective attunement to such aspects that PPS can fluidly react to contextual changes within and across spatial environments and contexts.

Another way of describing this agent-environment interface in line with a phenomenological heritage is that of a 'sensorimotor opening' (see Dreyfus, 2002, 2005, 2007), in that the spatial world automatically manifests on the basis of one's bodily structure in relation to bodily tasks and activities that can be plausibly conducted within that space (Gallese & Sinigaglia, 2010, 2011). At the broadest level, the enactive interface is essentially synonymous with a sensorimotor opening onto the environment *qua* world as articulated in the phenomenological tradition. Both 'environment' and 'world' here designate a meaningful background that confers form and structure to bodily space.[170] Synonymous with such an 'opening', the enactive interface is that which permits the brain-body's meaningful and automatic interaction with this background in specifically spatial terms. This idea was already implicit in Gallese's (2018, p.33) claim that "the functionality of the motor system literally carves out a pragmatic *Umwelt*, dynamically surrounding our body". I would add that, as emphatically noted by Zlatev (2018), we can also conceive of this 'openness to the world' as the embodied agent making sense of their surroundings via semiosis. Specifically, Zlatev (2018, p.14) bridges phenomenology with semiotics to form a "general notion of meaning as a value-based relationship between the subject and the world" that he likewise characterises as an "'openness to the world' through which both the entities in the world and the subject become co-constituted".

Furthermore, this 'sensorimotor opening', like semiosis, further implies that the emergence of meaningful spaces is not constructed by the agent but nevertheless requires the existence of one in order to be concretely actualised. Accordingly, world-embedded bodily space can be described as an instance of semiosis because the agent does not himself construct *ex nihilo* these spaces of meaning that he interfaces with, yet they require him *qua* interpretant to manifest (see also Eco, 1997/1999, pp.62-70). Because agents are spatially embedded, the structure of semiosis entails that agents neither construct nor contain space within their own intellectual capacity. Indeed, we should recall here Eco's own elaboration of semiosis:

> (it) is not transcendental in the Kantian sense, it does not come before but after the semiosic process; it is not the structure of the human mind that produces the interpretation but the reality that the semiosis builds up, (Eco 1997/1999, p.12).

[170] Although environment is implicitly more constrained than world in that environment is merely one aspect of world. For Heidegger, non-human animals are allegedly 'poor in world' precisely because they are much more constrained to their immediate environment (Storey, 2016). For von Uexkull, there is a stronger human-animal continuum but, nevertheless, humans are still defined as a species by their access to a far greater number of sign-systems.

Since being embedded in lived space is immanently contextual and qualitative, tools, others and place all intertwine to co-constitute the EI's ever-changing structure. When our body is contextually aligned with the kinds of activities appropriate in a particular place, the enactive interface becomes responsive to select affordances (see Rietveld and Kiverstein 2014). Additionally, as we saw in **Chapter 1**, a tool may confer a different PPS response depending upon where the agent encounters it. As embedded, the EI already takes the tool's contextuality into pre-reflective consideration. Structurally, what makes a kitchen a kitchen or a gym a gym is disclosed by the kinds of tools and activities available there. In the kitchen, there are kettles to boil and pans to cook with whereas at the gym there are kettlebells to lift and treadmills to run on. Heavy objects will rarely seem '*for-lifting*' in the office, nor will the gym receptionist's computer offer the same '*for-typing*' affordance as my office computer, independent of how close it is to my hand. PPS must therefore be constitutively sensitive to the environmental contexts which automatically modulate its automatic, situated responses. Indeed, in the empirical studies in which participants could not claim ownership over the tools presented in the experiment, PPS demonstrated a markedly different form (Fujii et al., 2009; Abrams & Weilder, 2015; Patane et al., 2021), which, in ecological settings, will largely be determined by contextuality (e.g., discrepancies in seniority, status of familiarity, level of intimacy, strength of friendship, etc).

As well as its contextuality, our definitional and conceptual clarifications can better account for the intelligent automaticity of peripersonal space. Throughout the array of studies dissected above, it was repeatedly discovered that nuanced PPS responses were rarely the results of decisions or choices but immediately reflected situational demands that the lived body found itself in; this was even the case for classically 'higher-order' phenomena such as moral judgements (Iachini et al., 2015; Pellencin et al., 2018; Fini et al., 2020) and co-ownership of objects (Patanè et al., 2021). This is because PPS always facilitates a broader mode of spatial being-in-the-world, for which PPS features as this relationship's ontic, neurophysiological register. As discussed, 'worldhood' in Heideggerian phenomenology is a technical term that highlights how the automaticity, fluidity, and pre-reflectively of complex, contextual actions are achievable without recourse to theoretical thought (Dreyfus, 1990, 1996, 2000; Wheeler & Cappuccio, 2010, Froese, 2011; Kiverstein, 2012; Fuchs, 2018; Cappuccio, 2023, Gallagher, 2023). The notion of 'worldhood' is theoretically important for the account of pre-reflective spatial cognition developed here, as it applies directly to bodily space's ability to pre-reflectively mirror whatever situation the agent faces, including a situation's more complex conceptual elements.

Therefore, one function of a well-adjusted enactive interface is that agents need not consciously decide, say, which utility a seen piece of equipment has, or choose for it to withdraw into transparency or protend an action when holding a familiar tool. For instance, when using a tool, PPS extends to embody it, whether I want it to or not. As world-embedded beings, the EI responds appropriately to *inner*wordly entities without requiring reflective cognition to interfere (**1a.1.1**), aside from in 'surprise' or 'breakdown' instances of recalibration (Dreyfus, 1999, 2002; Cappuccio, 2023).[171] Indeed, as spatially-embedded agents, a conscious decision is rarely required to elicit the practical know-how necessary for successfully engaging one's spatial surroundings. Such processes are always already caught up in the engaged involvement with the world. Rather, an intimate absorption in the lived situation elicits appropriate multiscalar reactions, temporarily bringing to the foreground task-contingent behavioural and neural states (Gallese & Sinigaglia, 2010; Wheeler & Cappuccio, 2010; Cappuccio, 2023, Gallagher, 2023). When such direct access is untenable, the cognitive semiotic notion of embodied abduction (Gallese & Cuccio, 2018; Cuccio & Caruana, 2023) allows for more conceptually complex factors to automatically update the EI, which again occurs below reflective awareness.

Furthermore, the enactive interface emphasises, in the manner of the later Merleau-Ponty's (1968/2004) notion of 'flesh' [*la chair*], that bodily space is essentially of the same substance of the world in which it is embedded, and, as such, exists in consonance with the entities encountered within this world, albeit one that must frequently 'retune' (Stjernfelt, 2006). Peirce likewise viewed mind and world as a continuum, with the logic of mind essentially conforming to the logic of the world, at least in an optimal scenario (Paolucci, 2018). While some semioticians, notably Umberto Eco (1990, 1997/1999), disagreed with Peirce here, citing the fallibility of human reason, I want to emphasise that this epistemologically harmonious continuum holds when concerning the *world,* not necessarily the objective universe as studied by science (see Dreyfus, 1990).

While 'Universe' designates the objective phenomena disclosed by science, 'world' designates the interreferential totality of meaning in which Dasein is absorbed (Casey, 1997; Dreyfus, 1990, 2007). The enactive interface, as embedded in such a world (if not the

[171] As noted previously, 'breakdown' functions very similarly to the role that Peirce carves out for the emotion of surprise.

Universe), can thus partake in intelligent actions and reactions fluidly there on a timescale much faster than that found in reflective decision-making. Indeed, most agents are wholly unaware of the cascade of neural changes occurrent in the brain in response to spatial phenomena. While agents certainly can be in error (e.g., mistaking the distance of an item, abducting incorrectly) even in this format, they intuitively make sense of their surroundings and gain familiarity with the worlds in which they are part automatically simply by near-instantly recalibrating when necessary. Moreover, when this otherwise stable structure in the agent-world interplay is impeded by clinical disruption such as in SZ and ASD (Noel et al., 2017; **3.3.3**), it induces profoundly deleterious consequences that seemingly have a bottom-up influence over other aspects of cognition (e.g., delusions and social understanding deficits).

Accordingly, the way in which agents are world-embedded via the EI allows for instantaneous, adaptive and sophisticated sensorimotor and (some) higher-order reactions to meaningful phenomena encountered therein. Worldhood thus carries explanatory weight in helping explicate how PPS always readjusts to situational demands prior to conscious deliberation, exemplifying Varela et al.'s (1991) pioneering definition of sense-making as 'structural coupling' between organism and environment. Alternative interpretations of the heterogeneity and adaptability of PPS that are somewhat compatible yet distinct with that proposed here have emerged within the PPS literature. De Vignemont and Iannetti (2015), for example, famously proposed a dual system (i.e., defensive and functional) model to account for the vastly different types of PPS responses as found between object-approaching, functional responses and object-retreating, defensive responses.

However, some scholars have suggested modifications to this conceptualization which seemingly may support the EI hypothesis. Hunley and Lourenco (2018), for example, arrive at a very similar interpretation to the EI hypothesis, though with a slight albeit noteworthy difference. Hunley and Lourenco aim to avoid a 'hard version' of a discrete systems definition, instead showing the interreferential nature of all PPS systems at a higher level of integration. In alignment with our discussion, they claim (p.8) that a "unified network" modulates the way that objects are processed in an integrated PPS, albeit one that integrates diverse systems. While objects in space share a "common coordinate structure", the multitude of diverse spatial interactions one may engage might imply that different PPS systems are at work; as such, a 'multiple systems' model might be proposed, whereby every peripersonal function corresponds to a unique system. However, Hunley and Lourenco (p.8) cast doubt on the veracity of a strong version of this interpretation because “this coordination may be possible within the PPS network itself”. However, they also question whether or not it manifests in the form of multiple, discrete ‘systems’ and instead speculate that PPS may be a high-level integration of systems into a unified network:

> Although defensive and non-defensive pathways are accompanied by distinct neural regions, they likely represent the locations of objects using a common coordinate structure. A multiple systems account would likely posit that other, relevant systems might be recruited to accomplish the coordination between defensive and non-defensive behaviors. However, we propose that this coordination may be possible within the PPS network itself because the structure of the different representations or “maps” (de Vignemont and Iannetti, 2015), which reference the body, likely support similar computations. Evidence for such a possibility comes from much research showing that defensive and non-defensive behaviors demonstrate common forms of plasticity (i.e., expansion and contraction) and that defensive and non-defensive behaviors are impacted by common variables such as body size and trait anxiety…. Distinct pathways of defensive and non-defensive functions may exist in a unified network.

Adopting a situated perspective helps avoid what I claim are errors in the conceptualisation of PPS stemming from a cognitivist inheritance. Namely, that the remarkable adaptability and heterogeneity of PPS implies the existence of hundreds of different peripersonal spaces or sub-systems. Similar variables impact ‘diverse’ bodily spatial ‘systems’ because, in a sense, bodily space is a dynamic response to situational demands. From this perspective, defense and function are not sharply distinguishable, at least not to the extent of being a ‘different’ bodily space. Of course, ‘defense’ is plausibly ‘functional’ also, since it is goal-directed and features a delineated motor-intentional profile. Defense and function are thus subsumable under the category of ‘situated responses to the spatial world’, a category inclusive of responses at the social and/or affective levels too. Again, what we actually observe are different manifestations of embedded bodily space in adaptive, contextual attunement with its situation, which gives it its multivariate form. Accordingly, a singular influence might impact upon functional, social, defensive or affective space together or independently, depending on how the agent must acquire an ‘optimal grip’ over the spatial situation because all such domains belong to the totality of bodily space and to being-in-the-world generally.

However, there might be, in a limited sense, two different spatial profiles operative in a single moment, pertaining to two separate body parts. For example, the part of PPS surrounding the face can measurably expand while that around the hand does not

(Gentilucci et al., 1988; Sambo and Iannetti, 2013; Serino, 2019). Certainly, it can likewise be practical to prefix PPS with its current, online function, i.e., 'defensive peripersonal space' (Sambo & Iannetti, 2013). But this must always be understood as situationally grounded and not a discrete system. Just as we need not propose hundreds of different bodies when discussing the body in action instead of simply emphasising that *particular* body parts come online during certain tasks, in parallel, certain parts or manifestations of bodily space are particularly 'online' during certain tasks without diverging from bodily space generally. The innumerable manifestations of the body and of bodily space in accordance with the logic of its current situation render it a singular phenomenon, whose structure is always adaptive and contextually-mediated.

However, I think that the implication to draw here is *not,* as Hunley and Lourenco (2018) and arguably Bufacchi & Iannetti (2018) seemingly do, that there exist several or even several hundred discrete systems subserving all of these possibilities because, at that point, it becomes unclear at which juncture one must draw the boundary for where one system ends and another begins. We are again threatened by the spectre of the infinite regress as articulated in the frame problem (Dreyfus, 1992, 2007; Cappuccio et al., 2021). This problem essentially asks us (with an eyebrow crooked): is there *one system* for a functional reaction to an affordance, *another* for when we are defensive, *another* for when we are uncertain, *another* for when we are in the presence of a hostile other, but *another* for a neutral other, *yet another* for when we are interacting with a co-specific, and so forth? Indeed, each of these 'systems' could be subdivided into further, discrete subsystems, since we have shown elsewhere that each spatial relationship is beholden to several conditions and variants that influence its current manifestation. For these reasons, positing a unitary, homogenous peripersonal space appears incompatible with the experimental data, yet positing the existence of hundreds of separate systems for every simulated or actual spatial interaction appears redundant, if not unwieldy.

Taken thusly, as Hunley and Lourenco (2018) speculate, any intentional-object is, in some sense, always the same object; yet what genuinely differentiates these objects is perhaps not being intended by discrete PPS systems but rather the manner in which it is presented in relief against a background logic of situation. It is this logic of situation that unifies the enactive co-ordination between brain-body, object and the space in which their interaction takes place, encompassing and unifying these elements into a singular, meaningful *Gestalt*, emergent simultaneously at the behavioural, experiential and neurological levels. Indeed, while each specific profile may be detected and transcribed separately in the appropriately domain-relevant terminology, the spatial Event is most comprehensively disclosed if correlated in all three domains simultaneously. And since agents partake in an enormous number of actions in space in accordance with a myriad of situational needs every day, the relationships between even a single agent and intentional-object are potentially innumerable.[172]

As already noted, these considerations evoke the famous 'frame problem', which has been well discussed in phenomenological scholarship. It has also received some attention in cognitive semiotics also. For instance, Violi (2017) explicitly references the frame problem when expounding the usefulness of Eco's theory of encyclopaedic knowledge. Indeed, PPS serves as a contrast case to the problems of infinite regress faced by a disembodied computing machine required to act fluidly across fluctuating spatial situations. As a world-embedded phenomenon, however, the EI is not impeded by any frame problem: it is always already contextually situated inside a frame which entails that its size, form and contours are typically aligned with this contextual frame's demands. This is why the interface continuously shifts in adaptation to, or anticipation of, situational demands automatically; there is no need to redivert to reflective cognition to update it. When an angry other appears (to take but one example) PPS may expand (to react more quickly to the threat) or, alternatively, solidify its boundaries, preventing the JEI's emergence. Either way, the meaning presented by the other triggers automatic bodily spatial responses which can then rapidly alter if the other's expression is then seen more clearly as happy rather than angry. Moreover, because the other co-constitutes this frame, they cannot be, as Merleau-Ponty emphasised, a mere epiphenomenon of my private Ego.

By reconceptualizing bodily space as an inherently 'worlded' phenomenon, we avoid any need to postulate hundreds of 'systems', while simultaneously accounting for the pronounced plasticity and contextuality exhibited by PPS that motivated their proposal initially. Because the enactive interface is always embedded in a world, as the dynamics that underlie being-in-the-world continuously shift, so too does bodily space in lockstep. And because the brain-body is embedded in space through this enactive interface, the mind does not need to represent innumerable aspects of the world before purposefully aligning its own sensorimotor capacities to them. Rather, its *de facto* pragmatic

[172]As emphasised in innumerable semiotic accounts (e.g., Peirce 1903/1998; Eco 1997/1999; Colapietro, 2021; Cuccio & Caruana, 2023) habit sharpens this wide field of possibilities that the potentially unlimited is limited to a manageable way of engaging the world (Jones, 2002).

attunement to worldly demands enables bodily space to remain largely responsive to the entities encountered within it, which are automatically and pre-reflectively encountered in terms of what they mean for the situated agent. This is why disciplines dedicated to uncovering the structure of meaning were useful in developing a definition of PPS.

Interestingly, we can take this opportunity to reiterate that some acts feature only a phenomenological and neurophysiological register, not a behavioural one. This helps distinguish ECS from behaviourist models, which ECS is sometimes accused of veering dangerously close to (Block, 2005; Di Francesco and Tomasetta, 2021). In some cases, it appears that distinct neural pathways are activated in accordance with the way that an object is presented via the perception of its use-value, even if not subsequently engaged with behaviourally. For example, the action-possibility that is opened up whenever habituated agents passively hold familiar tools (**2.3**) can be transcribed neurophysiologically and phenomenologically while, behaviourally, no change is detectable. Objectively, all that commences behaviourally, in each case, is the fact that an agent is holding a tool. However, as already intimated, a behavioural homogeneity conceals a pronounced heterogeneity at the experiential, motor-intentional and neurophysiological levels. The EI is, therefore, a definition uniquely poised to incorporate all of these domains too. Moreover, attending to the pre-reflective domains of embodied spatial cognition assist the practice of cognitive neuroscience by assuaging validity concerns. That is, further emphasizing these dimensions augments the 'construct validity' and 'content validity' of the construct of peripersonal space (see Sykes, 2021).

Thus, these three tightly interrelated terms: 'enactive interface', 'sensorimotor opening' and 'spatial embeddedness' all aim to showcase that bodily space is something immutably connected to a meaningful world from which it derives its manifest form. Because we can only ever artificially separate mind from world, spatial-sensorimotor responses must always be properly located within the meaningful environments from which they arise. Due to its inherently relational structure, we have labelled PPS a 'worlded' or 'semiotic' phenomenon: its existence coheres with a contextual, pragmatic and sociocultural framing that accompany every act of spatial sense-making. At a less abstract level, this definition has clear functional implications. The speed at which PPS responds to changes in context in experimental conditions, coupled with the lack of conscious awareness or explicit decision-making accompanying such changes, are all explainable by the 'enactive interface' interpretation. Undergoing tool-transparency, hold, co-transparency, affective co-attunement, or unifying with the interfaces of others in the JEI are not processes that the agent chooses to undertake or is even necessarily aware of. Agents simply interface with a world that is spatial and meaningful because they themselves are spatial, sense-making beings and space is, ultimately, a space of meaning.

In sum, we have discovered how objects and others determine the structure of the agent's relation to the *Umwelt* and *Mitwelt*, which in turn frame bodily space at the foundational level. This distinction between *Umwelt* and *Mitwelt*, however, is only a stopgap for practical purposes. In reality, *Mitwelt* and *Umwelt* overlap and interpenetrate one another at multiple levels so that one cannot exist without the other in a unified, meaningful, spatial *Welt*. As we have attempted to show, the way that the spatial brain-body is physically inserted into this meaningful world is via the enactive interface of bodily space. However, precisely because bodily space is an enactive interface, it is *de facto* a phenomenon that, at its very fundaments, is changeable and adaptive because the situations one typically finds oneself in are constantly changing, if nonetheless still following a discernable structural logic. Because of the dynamic nature of this structural coupling, the EI typically mirrors whatever changes occur in the spatial world in which it is embedded, entailing that bodily space is pre-reflectively (re)configured by every emergent spatial situation without conscious deliberation because, at one level, it is nothing but an extension and expression of this very spatial world.

Chapter Summary

We have here synthesised the findings of our prior 3 chapters, to emphasise what was discovered or to add further analytic detail. We began by showcasing how this project has contributed to its philosophical antecedents: phenomenology and semiotics. In phenomenology, we both contributed to secondary scholarship regarding the role of space in the major phenomenological works of the early Heidegger (*Being and Time*) and Merleau-Ponty (*Phenomenology of Perception*). Where prudent, we compared the two accounts, often emphasising that what was proposed in a somewhat disembodied way in Heidegger's ontological account often found expression, in an ontic and embodied form in Merleau-Ponty's (see Aho, 2005; Viljoen, 2010; Ha, 2016). We saw how several phenomenological descriptions proposed by both thinkers found support in experimental studies published several decades subsequent to their intitial proposal.

We subsequently recounted how our project has contributed to the semiotics of space. We began by recounting in detail Uexküll's seminal theoretical biology, with particular focus on his notion of the *Umwelt*, which we noted is prolific in ECS literature yet is rarely thematised in its own terms in any great depth. We noted how 'functional cycles' form the base structure of the *Umwelt* (see also Froese, 2010; Di Paolo & Froese, 2011; Feiten, 2020). Perhaps above all, Uexküll demonstrated that a life science such as biology (and related disciplines) must have, as he put it, "meaning as its pole star" (p.162), and not a mechanist framework of cause and effect or stimulus-response. Peirce likewise furnished this account with the notion of 'synechism', in addition to a theoretical means of grounding bodily space in pragmatism terms. Additionally, the Peircean notion of semiosis was even proposed as an occasional substitution for 'cognition' itself. As with phenomenology, we were both able to contribute to the semiotic study of space as well as compare and contrast the semiotic philosophies of Uexküll and Peirce. In addition, we were able to compare semiotic and phenomenological accounts of space, noting their similarities and differences.

Thereafter, we reviewed how this project contributed to the field of enactive cognitive science, which has framed our overall methodological outlook. It was noted that, by combining resources across disciplines, we have developed an enactive account of bodily space that has aspired to achieve greater comprehensiveness than any single discipline might have done alone. ECS provided the theoretical terrain on which to conduct such an approach. Throughout this thesis, I have often utilised the terms 'motor-intentional profile' (MiP) and 'pre-reflective cognitive correlate' (PrCC) to describe neural processes in third-person and first-person terms and the behavioural, cognitive and experiential levels. Here, I fleshed out with precise examples in greater detail, what function these two frameworks serve recounting some of the issues that they addressed. I claim that the present thesis serves as to showcase the utility of the MiP and PrCC.

However, while the theme of spatiality was demonstrated to be an understudied and underdeveloped topic within ECS, it is implicitly entangled with several highly prominent themes in Enactivist literature. Above, I briefly outlined how spatiality enriches and reciprocally informs prominent research avenues such as embodiment, intersubjectivity, language and temporality. As such, I have showcased one means by which space (via PPS) can reunite with over topical, more studied themes as well as how it can continue to be integrated into more dominant discourses within ECS. My hope is that the paucity of explicit research on spatiality in ECS is rectified by invigorating a renewed interest in space with this discussion.

Finally, we recounted how this project has contributed to the cognitive neuroscience of peripersonal space. I applied this project's findings to the problem of disaggregating the tightly related notions of 'body schema' and 'bodily space'. To do so, I drew on the philosophical and scientific resources that were examined in this thesis. In particular, I drew attention to the discrete motor-intentional profiles operative in the body schema as compared to bodily space. Subsequently, I highlighted that small calibratory movements in task-related body parts (i.e., tightening a grip on a handle, applying more pressure to a foot pedal) can be achieved by the body schema without directly recruiting bodily space. I encourage future debate and criticism to see if this proposed distinction stands up to further scrutiny.

Furthermore, I provided a more detailed explanation in an attempt to justify my proposed operational definition of PPS: that of an 'enactive interface'. I briefly discussed some recent attempts to operationally define PPS (e.g., De Vignemont & Iannetti, 2015; Bufacchi & Iannetti, 2018; Hunley and Lourenco, 2018), debates which partially motivated the current thesis. I noted that, while contributing to our understanding of the construct of PPS, such accounts share a problematic in that they:

A) Implicitly overlook non sensorimotor aspects of bodily spatiality, such as language, morality and temporality.
B) Evoke the 'frame problem' by which multiple PPS are proposed, running the risk of an infinite regress when attempting to number these different systems.

By contrast, the 'enactive interface' interpretation is proposed to account for peripersonal space's marked contextual, heterogeneous, even 'paradoxical' nature (Masson et al., 2021) in which it responds adaptively and automatically to the fluctuating demands of the dominant situation. Thus, the EI interpretation can be assessed and debated to ascertain its validity as an operational definition of PPS.

Conclusion

We have thus seen how the foregoing interdisciplinary account has introduced the previously understudied theme of spatiality into enactive cognitive science and elaborated a theory of bodily space in alignment with the principles that animate Enactive Cognitive Science. Moreover, aspects of the present account potentially serve as a standalone theory of 'lived space' that contributes to the secondary scholarly literature of its antecedent disciplines in both philosophy, as well as to cognitive neuroscience of spatial cognition.

A prominent motivation for this project was the fact that it was repeatedly noted throughout the relevant empirical literature that peripersonal space was highly responsive to, even constituted by, experiential sources of qualitative meaning present within the brain-body's surrounding environment. Yet, these aspects had yet to be explicated in significant detail with compatible conceptual sources. In doing so, it would become clear that peripersonal spatiality was not (only) structured quantitatively and positionally but qualitatively and meaningfully. Accordingly, as phenomenology and semiotics are disciplines designed to uncover and catalogue meaning in their various guises, they were chosen to fulfil this explicatory role. In addition, this thesis also compared the theoretical treatment of space and spatiality in the fields of both phenomenology themselves and semiotics, as such a comparison was also absent in the extant scholarship.

In the **Introduction**, without negating or diminishing quantitative models of space, we noted that a terminology appropriate for comprehensively disclosing qualitative, situational space appeared comparatively underdeveloped, nor could such an account have been simply imported from quantitative or computational accounts. Therefore, we began with an overview of peripersonal space before highlighting its incompatibility with objective models of space and cognitivist models of spatial cognition. The primary problem was that, with some notable exceptions (see Jackson, 2014), such accounts were grounded, explicitly or implicitly, in abstract or quantitative models of space. Qualitative space, by contrast, appears to be structured according to contextuality, which necessitated the development of an account of lived space.

Thereafter, we forwarded a qualitative model of spatiality by way of a close reading of philosophical texts that deal with the exposition of meaning, i.e., semiotics and phenomenology. In **Chapter 1**, the necessity of developing a comprehensive model of qualitative space (already indicated by the experimental data) motivated the recruitment of philosophical resources to formulate such an account. Four paradigmatic thinkers were chosen as representative of these disciplines: Charles Sanders Peirce, Martin Heidegger, Jakob von Uexküll and Maurice Merleau-Ponty. The resulting analysis provided several key concepts that would guide our subsequent reinterpretations of the experimental literature, alongside the notion that space is an inherently relational phenomenon. Building upon this idea of relationality, we were able to strategically divide the scientific literature on bodily space into two broad categories: 'Objects' and 'Others'. These categories corresponded to the spatial '*Umwelt*' and '*Mitwelt*' (structured by bodily space's relationships to said objects and others, respectively). However, this thematic subdivision comes with the important caveat that these *'Welten'* are only separated for purposes of analysis; in real-life, ecologically-valid spatial sense-making, they profoundly interpenetrate one another.

Chapter 2 thus examined how agents meaningfully engage with inorganic, non-living beings (i.e., 'tools') dispersed throughout their environment via the interdisciplinary lens described above. Broadly, we focused on the role of affordances in space and how this relates to the distinction between tool-perception and tool-use. Thereafter, we focused on the role of affectivity in object-interactions and how certain modes of object-interaction become sedimented by habit and allow the agent to face the *Umwelt* in a protensional capacity. This was achieved with the help of phenomenological accounts of temporality and the neuroscientific theoretical framework of 'Embodied Simulation theory' (EST).

In **Chapter 3**, we explored how agents spatially engage their co-specifics in an intersubjectively-constituted space. This complemented the prior chapter by retaining several core themes and enriching them by showcasing their social dimensions (e.g., tool-transparency and co-transparency), as well as highlighting the unique ways in which human beings engage with others like themselves. Once again, we saw how the affective dimensions of the social world and social interaction itself deeply impact bodily space. Finally, we assessed perhaps the most substantial evidence for bodily space being a truly intersubjective phenomenon in the so-called 'Joint Enactive Interface' before using this model to shed light on clinical disorders known to feature disruptions in bodily space, such as schizophrenia and ASD. In each chapter, a litany of new concepts was introduced in which clear areas of mutual support were discovered between the relevant conceptual and empirical literature. This supported our notion that bodily space is relational, and to describe bodily space necessitates the inclusion of those things with which it interacts in space.

Finally, in **Chapter 4,** we underscored in greater detail how this analysis has contributed to philosophy and cognitive neuroscience as well as the interdisciplinary field of enactive cognitive science itself. Threading together these various disciplinary approaches to spatiality independently arrived at the idea that qualitative space cannot be adequately captured by abstract, physical or metric models of space where the position of things in a uniform space are essentially interchangeable. It was precisely in this way that one may conclude (as many philosophers already had) that, for living organisms, space is, indeed, always equivalent to a lived space constituted by meaning.

On a final theoretical note here, it is interesting how etymological connections seem to support the interpretation promoted in this work. 'Peripersonal space' was, of course, the name elected by Rizzolatti and colleagues (1981) to designate this uniquely embodied kind of spatiality, who subsequently noted that this concept was strikingly compatible with phenomenological accounts of space (Rizzolatti et al., 1997). The philosophical history of the Greek term 'peri' yields some thought-provoking results. As Casey (1997, p.55) notes:

> 'Surround' translates [the Greek] *periechein*, which means 'to hold' (*echein*), 'around, (*peri*- as in perimeter). As a vessel holds water or air within it, so a place holds a body or bodies within it in a snug fit.

Indeed, we have concluded that peripersonal space is the enactive interface encircling the body, invisible to the naked eye but detectable neurophysiologically and experientially. But bodily space does not *just* surround the body. Nor is it itself merely contained within a wider space (Sloterdijk, 2012). Rather, it is dynamically and qualitatively linked to its surrounding space via the presence of meaning, allowing the agent to fluidly act there. This insight disclosed the reality of bodily space as a species of lived space and even its neccesary condition. The surrounding 'peri' aspect of bodily space itself, therefore, unites the agent(s) with the wider spatial reality in which it is meaningfully embedded. Indeed, Casey (p.90) later notes how:

> To be unified with (*sumphues*) is to be dynamically linked with something – to make a difference not just to its shape or form but in its very being or reality (*ousia*). Place is thus 'never separate from [a body's] first entrance into existing things and from principal reality'.[173] Through place, reality is reached. Through reality, place is maintained.

Thus, 'peri' denotes something that surrounds the lived body which is itself dynamically tethered (*sumphues*) to its world so that its size, shape and general form always cohere with that very world. A place's meaning concretises itself in the lived body. And by always

[173] Here, Casey is quoting Sambursky (1977).

being part of this spatial reality, the brain-body always 'has' a peripersonal space or better: it is always embedded in the world *via* its peripersonal space. Each implicates the other. In a certain sense, then, our theoretical treatment of peripersonal space and its relationship with space coheres with prior and contemporary philosophical conceptions in the history of philosophy. Indeed, Casey's impressive historical account, after noting the gradual disappearance of qualitative space in favour of its quantitative counterpart, explicitly notes that one way in which qualitative space is returning is "by way of the body" (p.202). This contention, while perhaps surprising, has independently found expression in neuroscience and therefore within this work too.

Of course, the present contribution to the scholarship stands as only one possible means of theoretically expanding upon the intriguing notion of peripersonal space, which, by all accounts, appears set to remain a lively topic of experimental and theoretical investigation in the years and decades to come. My own contribution to this field has been to provide a literature review of PPS from a consistently enactivist perspective, to offer conceptual clarifications directed at outstanding issues and to propose an operational definition of PPS in coherence with enactivist principles and the extant empirical data. However, much more research is required not only regarding peripersonal space's conceptual implications but, of course, also on its neurophysiological properties. However, in the spirit of Varela (1996) and his collaborators and successors, I have hoped that this exposition of the experiential and meaningful dimensions of bodily space have conferred "mutual illumination" and showcased "mutual constraints" regarding the construct of PPS that might guide or inform future empirical work.

As such, it may be the case that some of the ideas presented in this work might, in turn, aide the development of future experimental designs. For example, testing how participants react to affordances in different contextual (i.e., congruent or incongruent) places, testing if there are individual differences based on differing expertise relating to tool-protension, if the embodied abduction applies to emotions other than fear, or if the joint enactive interface can include three or more people within its borders are but some of the possible testable hypotheses generated by this research. Moreover, it may also be the case the future data might be interpreted with the help of the present account, as the studies included in this study were not preselected due to any particular compatibility and thus should be applicable to any future result.

Furthermore, I have often noted how the theme of spatiality had been quite inexplicably understudied within 4E or embodied-enactive approaches to cognition. While I will not reiterate these arguments again here, suffice it to say I hope that this work may somehow contribute toward continuing to rectify the issue or even inspire future research on closely related themes. Certainly, my own exposition of bodily space does not come close to exhausting the potential scope of this research avenue. Other dimensions of bodily spatiality may find articulation within subsequent research, as well as accounts that may focus in greater detail on the more specific intersections between spatiality and other themes (e.g., linguistic, affective, narrative-based, temporal) or, alternatively, the interplay between reflective and pre-reflective spatial cognition, as well as demarcating their differences.

In addition, peripersonal space is likely not the only neuroscientific construct that is appropriate for such a detailed assessment from within an enactive account of space. To give but two examples, this thesis has not dealt at all with grid cells (Haftin et al., 2005) or place cells (O'Keefe, & Burgess, 1996; O'Keefe & Krupic, 2021), two important findings which have birthed their own wide literature on the cognitive neuroscience of spatiality. What is the relation between these cells and peripersonal space? How should ECS incorporate them both within a unified account of spatiality, if at all? Thus, the questions surrounding spatiality and what it entails for the field ECS has only been tentatively opened and by no means answered.

Moreover, there are cultural aspects of space that might be considered in future research that this thesis has not yet considered. We might reconsider how certain modes of spatial being animate particular cultures or epochs. For instance, notions animating particular cultures and epochs (Dreyfus, 1990), such as 'harmony', 'grandiosity', 'collectivism' or 'individuality' all have a spatial register, which might entail that such concepts interface with bodily space in a meaningful way (see Lefebvre, 1991). On a more local level, certain qualitative manifestations of social bodily space have not been assessed much in the philosophical or scientific literature. For instance, people who know each other for a long time may display a comradely or romantic embodied spatiality, qualitatively distinguishing their intersubjective mode of bodily space. All of these factors may arguably, at least for now, escape measurement with current scientific techniques; yet this may not be the case forever. Just as Merleau-Ponty's claims regarding embodied cane-use could not be tested until Serino (2007), several other more nuanced aspects of space may be ripe for interdisciplinary examination in the future following the development of more sophisticated neuroimaging or other measurement tools.

On a similar note, in two recent literature reviews, both Serino (2019) and De Vignemont et al. (2021) explicitly probe the relationship between PPS and emerging forms of technology and note that the nature of this relationship remains an open question. As our shared life-world is updated with the addition of new technological artifacts, so too must our PPS network update alongside it. Already, inventions such as the computer, car, smartphone or surgical robot are built on top of our more ancient tool-use neural systems. It stands to reason, then, that PPS will adapt to the new modes of technological being that will almost surely emerge in the coming decades perhaps even changing the nature of bodily space itself, for better or for worse. In the near-future, it seems likely that virtual reality, bioaugmentation artifical intelligence as well as new means of transport, architecture and social organisation will become more present within everyday life. Indeed, Serino (2019) states that the plasticity and adaptivity of PPS make it an excellent locus to study brain-body-machine interfaces in near future, which by all accounts seems to be a well-justified assertion. Moreover, in a recent paper on bioaugmentation by a wearable supernumery robotic digit, Rossi et al. (2021) note how such augmentation devices directly impact upon PPS.

Indeed, this sentiment, far from taking bodily space away from philosophical terrain, also present another possibility to unite with an enactive, philosophical account of bodily space. For instance, the field of 'Postphenomenology' (e.g., Ihde, 2010) almost exclusively focuses on an embodied phenomenology of technology and technics. Certainly, applying an enactive account of spatiality would prove fruitful here. We thus return to our aforementioned Peircean semiotic notion (elaborated by Eco, 1979, 1989) of 'infinite semiosis': because a sign can always produce another sign *(ad infinitum)* we cannot hope to know the vast amount of sign-systems that will emerge (nor can we know the vast amount that was known to prior civilisations). As such, the door thus remains wide open regarding the different configurations that bodily space will take in alignment with as-yet unseen cultural forms and artefacts, or, alternatively, even understanding those that existed in the archaic past (Iliopoulos, 2016).

Thus, there remain a substantial number of open research questions spanning several disciplines that have yet to be thoroughly explored. However, above all else, I hope to have forwarded a persuasive case (following several predecessors analysed in this text) that, for human beings, or perhaps living organisms more generally, quantifiable and physical models are not the only game in town when conceptualising space. Accordingly, this thesis may be positioned within wider and ongoing attempts to carve out a role for distinctly human modes of being (in space or in other domains) that are not pigeonholed to the status of 'illusion' in reference to an abstract reality exclusively and definitively disclosed by quantifiable measurement. Taking this wider philosophical aim into careful consideration, we see that there still remains a staggering multitude of ways in which we can discover that bodily space is, ultimately, a space of meaning, and further integrate spatiality with ongoing discourses.

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