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VARIETY, FLEXIBILITY, AND USE OF ABSTRACT CONCEPTS
A MULTIPLE GROUNDED PERSPECTIVE

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Abstract

The nature of concepts is a matter of intense debate in cognitive and neurosciences. While traditional views claim that conceptual knowledge is represented in a unitary symbolic system, more recent theories of Embodied and Grounded Cognition (EGC) submit the idea that our conceptual system is couched in our bodily states and dynamically influenced by the environment (Barsalou, 2008).

One of the major challenges for theories of conceptual knowledge, and particularly for EGC, is constituted by abstract concepts (e.g., *fantasy*) due to their detachment from physical experience. Recently, some EGC proposals have addressed this criticism, arguing that the class of abstract concepts is not a monolithic domain opposed to a concrete one but rather encompasses multifaced exemplars that rely on different grounding sources beyond sensorimotor one, including interoception, emotions, language, and social interactions (Borghi et al., 2018). However, little is known about how abstract concepts and their multiple dimensions vary as a function of life experiences and their use in communication.

This dissertation aimed to provide empirical evidence on multiple grounding of abstract concepts taking into account their varieties and flexibility. Therefore, the role of different semantic dimensions for specific kinds of abstract concepts was assessed in five studies.

Study I explored the fine-grained differences of a large sample of abstract concepts using separate ratings on 15 dimensions. Findings from principal component and cluster analyses indicate the existence of four distinct subclusters of abstract concepts characterized by different degrees of embodiment and of grounding in sensorimotor, inner, and language-based experiences. Study II validated this classification with an interference paradigm in which motor/manual, interoceptive, and linguistic systems were engaged during a word difficulty rating task. The results showed that interoceptive signals interfere with the processing of emotional abstract words; manual actions interfere mostly with concrete words of tools, and within abstract ones, with more concrete physical and quantitative words, while mouth actions reduce interference in processing of concrete words but not of abstract ones. Results confirm that different grounding sources are activated depending on the concepts kind.

Study III and IV examined the variability of institutional concepts in relation to individual expertise levels and situational contexts. A rating study revealed that institutional concepts were characterized by both physical/emotional and linguistic/social components, but concrete determinants were prominent for law experts. In a picture-priming study, the processing of institutional and theoretical concepts but not concrete ones was modulated by images depicting linguistic and social situations. Specifically, experts exhibited an advantage over non-experts in processing institutional concepts when preceded by social-cooperative situations, testifying a great individual variability in abstract domains.

Finally, in Study V, the content and conversational dynamics elicited by different kinds of abstract and concrete sentences were examined using a novel interactive paradigm. Analysis of language production showed that the level of uncertainty and interactive exchanges increases with abstractness, leading to generating more questions and requests for clarifications with abstract than concrete sentences.

The present results confirm that abstract concepts are multidimensional, heterogeneous, and flexible constructs differently employed and re-enacted depending on situations and prior individuals' knowledge and that social interactions and linguistic inputs are crucial dimensions to build or reshape their meanings. Investigating abstract concepts in real-time dialogues may be a promising direction for future research.

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“But words are things, and a small drop of ink,
Falling like dew, upon a thought, produces
That which makes thousands, perhaps millions,
think.” (Lord Byron, Don Juan, Canto III, 1821)

PART I

A FRESH LOOK AT THE ISSUE OF ABSTRACT CONCEPTS

INTRODUCTION

> . . . *Infinity*—that means what has always been. But what came before this? What is to follow? No, it's impossible to see this . . . What pointless images come up on account of a single word. Take the word *something*, for example. For me this is a dense cloud of steam that has the color of smoke. When I hear the word *nothing*, I also see a cloud, but one that is thinner, completely transparent.
> When I read newspapers, some things are clear to me. I have a good understanding of everything that has to do with economic affairs. But there are other ideas I can't grasp right away, ones I only get much later. Why? The answer is clear: I just can't visualize them. If I can't see it, it just doesn't penetrate… So where do I stand with regard to *abstract ideas*? When I hear the word *pain*, for example, I see bands—little round objects, and fog. It's the fog that has to do with the *abstractness* of the word. (Luria, 1987; *The mind of a Mnemonist*, pp. 131-132, p. 134, italics mine)

Abstract ideas meant a round of problems and torments for Solomon Shereshevsky, the famous mnemonist studied by the neuropsychologist Luria. This man had flawless memory for details. In his world, each element was freighted with vivid sense impressions, which made it difficult to organize particularities of the external world into general pieces of knowledge. All his effort was expended in trying to convert everything into images, but when this proved impossible, he was bound to get confused. For him, any attempt to grasp the meaning of things beyond sensory experience remained a failure. This remarkable tale introduces the topic of this dissertation, namely *abstractness.* In fact, Shereshevsky seems to lack a crucial human ability: forming and mastering coherent abstract concepts. In short, he was unable to understand the meaning of words like “infinity”, “something”, or “nothing” that, by definition, refer to elements and situations detached from physical reality.

As a researcher interested in abstract concepts, it is fundamental to clarify what is the object of my investigations. If explaining the notion of *concept* can be hard work, defining *abstract concepts*, as we will see, is even harder. Let’s start with the first. Concepts, roughly speaking, are generalizations of relevant features of things we encounter in our everyday life that are collected into a single instance. For example, the concept of *tree* is what allows us to know that elms and lindens, inspective of their different size and shape, belong to the same category: the class of objects that have proprieties in common such as a trunk, branches, and leaves. As such, concepts are foundational elements of our thought, language, and communication, allowing us to understand and describe aspects of the world. While concepts can exist without words, researchers frequently study concepts by investigating the words used to express them. In more technical terms, concepts are an essential part of word meaning activated by words that stand for real-world entities (i.e., referents). Words themselves are not directly associated with specific entities which they denote but are only indirectly related to their referents by activating associated concepts, which, in turn, refer to the denoted entities. Thus, concepts and not verbal symbols (words) constitute meaning in verbal communication.

With this preliminary description of concepts in mind, now consider abstract concepts. The label "abstract" is generally used to refer to a class of concepts in which a physical and perceptual referent is missing. These kinds of concepts appear more ephemeral than concrete ones (e.g., infinity *vs.* tree) and yet are "real things" that exist as a fundamental part of human experiences. Even a few examples help illustrate the latter consideration: Our feelings and mental processes are conveyed by abstract words like *love*, *doubt*, *desire*; cultures and societies are built upon abstract constructs such as *civility*, *traditions*, *rights*; scientific research develops through ideas such as *events*, *causation*, *hypothesis*, that are abstract concepts; the word *concepts* itself is a completely abstract concept. This being said, the study of abstract concepts seems to set a footprint for understanding our most high-level behaviors and cognitive abilities.

Despite the efforts of the last 50 years of research in cognitive science, abstract concepts still pose a challenge to almost every theory of concepts, and especially those theories assuming a grounding of conceptual knowledge in perception and action, the so-called Embodied and Grounded Cognition approaches, which constitute the theoretical framework of this dissertation. The main questions animating the debate are: To what extent does the meaning of abstract concepts result from either symbolic or sensory information or a combination of both? If concepts are embodied, how can we provide a coherent account of abstract concepts whose referents have no physical form? What are the similarities and differences between abstract and concrete concepts? Do we need a single mechanism to explain them? The review of some of the most influential theories of concepts that have tackled these and other issues is the topic of the first Chapter of this dissertation.

The second Chapter, instead, covers various lines of research that have recently paved the way for a multiple perspective in the study of abstract concepts, partially overcoming traditional critiques advanced to Embodied and Grounded theories. Specifically, I will consider the role played by interoception, metacognition, language, and sociality as possible sources of grounding for conceptual knowledge and precisely for abstract concepts.

Even within this broader framework, the main concerns in studying abstract concepts lie in the difficulty of accounting for their heterogeneous and contextual nature. Indeed, abstract concepts seem to cover semantic domains that are very different from one another (e.g., numbers, emotions, social constructs, mental states). However, as long as abstract concepts have been treated as a unified class opposed to concrete ones, the differences between types of abstract concepts and their grounding sources have not been extensively investigated. Similarly, simply studying abstract concepts *per se*, omitting the context, does not inform on how their meaning varies across situations and individuals (e.g., *democracy* might refer to a political system, people’s active participation, or legal equality).

In an attempt to shed light on these issues, in the third Chapter I will analyze the distinctive features of some of the most salient domains of concrete and abstract concepts, showing that they should be considered neither as a sharp dichotomy nor as endpoints of a continuum but rather as multidimensional concepts whose boundaries are often nuanced. In the fourth and final Chapter, I will first present theoretical and empirical considerations on the conceptual flexibility of abstract concepts both at collective and individual levels. Afterward, I discuss the importance of integrating novel interactive paradigms for the study of abstract concepts, arguing that when they are embedded in interactive social contexts, it is possible to unravel their complexity.

In summary, the present dissertation aims to defend a multiple grounded perspective on abstract concepts addressing the following research questions: (a) How abstract concepts might be grounded? (b) What factors underlie the flexibility of abstract concepts? (c) What methods should be used to study them?

It should be noted that scientific research on abstract concepts is still flourishing and that the following discussion covers only a selected review of the literature. Nevertheless, I hope to show that through the lens of multiple grounding approaches to conceptual knowledge, we might dispel a bit of the fog in which abstract concepts are often wrapped and unfold their varieties and flexibility.

CHAPTER 1

GROUNDED COGNITION
AND THE PITFALLS OF ABSTRACT CONCEPTS

1.1 Concepts. A dispute in the cognitive sciences

Imagine for a moment to store in mind every single detail of the perceptual experience. The result would be a duplicate of reality so intricate, rich, and redundant that it would be impossible to manage the multitude of facts, objects, and people we encounter in our daily lives with order and relevance. If the human mind had to respond to each stimulus as new, it would be crushed by the infinity of perceptual and informational data, losing into chaos. Fortunately, the way humans experience the world is completely different, and each of us can attest to this firsthand.

The animal with the red fur meowing in front of me will never be the same as I see it now, under the same light, in the same position, etc. Yet, I know perfectly that it is Ginger, the cat who has lived in my apartment for three years, and that he is probably hungry because he hasn’t eaten yet. With a slightly different example: When I move into a new room and see a new bed, even though it is different in size and shape from what I had before, I immediately recognize that it is a piece of furniture to settle down to sleep or rest. One could continue with numerous examples across other areas of our experience. In all cases, however, we do not need to process every piece of information about objects or events to which we are constantly exposed as if we perceived it for the first time, because we are aware that the experience we are having is similar to the one we probably had in the past. In other words, we have implicit knowledge of the entities that populate the world: cats, beds, animals, furniture, and so on. What exactly is this knowledge? How is it formed? What is its specific function and structure?

These questions introduce an important topic that has fascinated scholars since ancient times, namely *concepts*. In common sense, concepts are general ideas about entities/objects in the world. These "ideas" are the result of a process of abstraction, that consists in extracting similarities across different occurrences of perceived stimuli and collecting them into a single instance. Through this process, we are able to simplify the structure of the reality forming categories, which include the class of entities sharing salient proprieties. For example, the conceptual category of "cat" is derived from repeated experiences with different examples of cats, and includes the information that a cat has four legs, is furry, meows, and can be petted.

Conceptual categories are generally referred to as the "building blocks" of our mental life, providing a means of understanding reality. They serve as a filter to interpret incoming stimuli by connecting to our prior knowledge in order to prepare us to enact appropriate responses to new instances. Better put, "concepts are the glue that holds our mental world together in that they tie our past experiences to our present interactions with the world" (Murphy, 2002, p.1). The ability to form and handle concepts is the heart of most basic functions of human cognition: We use concepts when formulating thoughts, drawing inferences, object recognition, action planning, remembering, learning, and communication. It should not surprise, then, that the conceptual representation has attracted a great deal of attention to the full range of cognitive sciences. The scientific literature covering the topic is overwhelming, spanning from philosophy (e.g., Margolis & Laurence, 1999; 2015) to psychology (e.g., Smith & Medin, 1981; Murphy, 2002), and neuroscience (e.g., Kemmerer, 2015). Illustrating the multitude of theories on concepts that have been proposed so far would be a captivating path, but is exceeds the purpose of this work (for a detailed review, see Margolis & Laurence, 1999). I will focus here on a more modest but no less exciting tale: the dispute over the format of concepts.

When speaking about the "format" of concepts, it is generally referred to as the propriety of concepts to be represented by different codes. To make it clear, consider the example of the time in a wristwatch and a digitized clock on a smartphone: they have two different representational codes, despite encoding the same information. While there is a general agreement about the content of concepts (what they refer to, what information they include), the nature of conceptual representation remains a matter of considerable controversy. In particular, scholars contend whether the concepts exploit different or the same codes of perceptual and sensory representations.

Since the days of Plato and Aristotle, philosophers have speculated whether concepts are in some way dependent or independent of our senses. Theorists have been traditionally divided into two currents of thought. *Rationalists/definitionists* conceived concepts as ideal "Forms", namely innate mental ideas fundamentally independent of sensory impressions. Ideal forms capture the essence of the things in the world through a set of necessary and sufficient definitional features (e.g., the concept of bachelor is identified with the features: unmarried + adult + male). An illustrative example of how concepts are meant in this model is Plato's allegory of the aviary (*Theaetetus*, ca. 360 BCE): The human mind resembles an aviary full of birds, each of them representing different concepts or pieces of knowledge. When not in use, the birds are free to fly around in the cage of our minds. To possess and use a piece of knowledge, a person has only to grasp the right concept (and its definition), just as she has the power to catch one of the birds from the cage. On the contrary, *Empiricists* considered perception as the primary source of attaining knowledge. In particular, British Empiricists held that all concepts are built up from sense-based experiences. In Hume's words: "All our ideas are nothing but copies of our impressions" (1739).

A similarly fascinating debate is taking place in contemporary cognitive science, wherein in the last decades a divide has emerged between *amodal symbolic* and *grounded* approaches to conceptual representation (for a historical overview, see Prinz, 2002). Before discussing these two perspectives in detail, it would be helpful to point out that they start from a different perspective for studying cognition. Amodal Symbolic theories assume that cognition is an autonomous modular system able to perform complex operations over arbitrary, abstract, and amodal symbols (e.g., Fodor, 1975; Pylyshyn, 1984; Newell & Simon, 1976). In this view, symbols are amodal in the sense that they do not have any critical dependency on modality-specific information derived from the body and environment. In contrast, the so-called Embodied and Grounded Cognition (EGC) theories conceive cognition as a structural coupling of the physical world, brain, and body. This means that the type of experiences an organism has, as well as the activity of perceptual modalities and motor systems of its body, and the way the body is embedded in a context, profoundly affect its cognitive processes (e.g., Barsalou, 1999; Barsalou, 2008; Pecher & Zwaan, 2005; Pulvermüller, 1999). As will be specified below, while symbolic and amodal models of cognition have dominated the panorama of cognitive science in its early stages, the embodiment and grounding view bloomed in the recent 30 years mainly in response to the dissatisfaction with the standard paradigm. However, as noted elsewhere, these approaches are not mutually exclusive and are more likely to provide a complementary explanation of a given phenomenon (Zwaan, 2014; Matheson & Barsalou, 2018). For example, the symbolic and grounded approaches might find convergence in explaining language comprehension (e.g., Andrews et al., 2009; Louwerse & Jeuniaux, 2008; Davis & Yee, 2021).

In the first section of this Chapter, I will outline the theoretical debate on the nature of concepts. The literature review has purely expository purposes and is by no means exhaustive. Specifically, I will discuss accounts that have defended either an amodal or modality-specific format of concepts, showing how embodied and grounded theories have the most predictive power and potential to explain how concepts allow us to interact in, and experience, the world. The rationale behind this choice is that the dispute over conceptual format is also a core issue for the study of abstract concepts, which is the central theme of this dissertation.

1.1.1 Mind as Computer. Amodal Symbolic approaches

A key impetus for the idea that cognition is a symbolic system and that cognitive processes are symbol manipulations was the spread of Artificial Intelligence studies in the early 50s. Fascinated by the ability of machines to process information (even before by the mathematical model of the "Turing' machine"; Turing, 1936), several scholars began to see the analogy between minds and computers as a powerful tool through which to study cognition. Among others, Newell and Simon (1976) heavily contributed to formalizing the hypothesis that mental processes are ultimately computations run on physical symbols that can be accurately interpreted by means of explicit syntactic rules. Roughly speaking, the human mind was conceived as an information-processing device, much like the software of a computer that performs symbolic computations according to a set of instructions.

The computer metaphor of the mind constitutes the core of the theories and accounts sometimes grouped under the label of *cognitivism* or Computational Theory of Mind (CMT), which have profoundly inspired the research in the field of cognition until the mid-twentieth century and are therefore now understood as the traditional paradigm.

Excited by the success of computer science, cognitivist scholars postulated that knowledge in our minds must be organized in symbolic-abstract structures, rather than in raw images or sensory patterns (e.g., Pylyshyn, 1973; Fodor, 1998). The argument advanced can be summarized as follows: Each concept actives an infinite number of mental images – just as the word "rectangle" is applied to an infinite number of rectangles of different shapes, sizes, colors, etc. – Thus, a direct association between a verbal label and mental images would require an unlimited storage capacity (one for each possible instantiation of the concept). But, since it is reasonable to assume that the brain can only store a finite subset of information, there must be a more abstract representation, such as "rectangleness", that goes beyond the single occurrences, and thus operates on "type" rather than "tokens". As Pylyshyn puts it: "There must, in other words, be some common format or interlingua" (Pylyshyn, 1973, p. 5). In this view, conceptual representations, which are just the result of perceptual processes, are intended as symbolic descriptions that have similar qualities to propositions in natural language. In this sense, knowledge is said to be propositional: It contains symbols for objects and attributes and their syntactic relations act like rules for combining these symbols into new thoughts. For example, the word "bat" could be combined with the word "mammal" to execute the inference "the bat is a mammal".

Notably, in this view, symbolic representations resemble spoken language but do not coincide with any of them. Rather, they are constituted by what Jerry Fodor, in his Representation Theory of Mind, explicitly calls "the language of thought" (Fodor, 1975; 1998). Once again following the computer-mind analogy, Fodor claimed that in order to process information, our cognitive systems must rely on some kind of innate language in which computations are carried out in the same way that computers have a “machine language” that operates with binary representations in the form of zeros and ones. Importantly, both the computer and human symbols were seen as arbitrarily (i.e., by convention only) related to their referents. Hence, just as in a computer the string combinations of 1 and 0 could give as output, say “cat”, in human cognition the mental symbol “X” can represent the concept of “cat”, but neither of them symbols shows systematic similarity to a real cat.

Framed in these terms, the explanation of conceptual representations does not directly concern their semantic content, and thus how symbols designate an external entity; rather, concepts are determined solely by their combinatorial syntactic rules. To deal with this issue, Fodor (1998) extended his earlier proposal by advocating the thesis that has come to be known as Conceptual Atomism and can be summarized with the claim that since “mental representations have no structure, it is reasonable to suppose that they are atoms” (p. 22). This implies the existence of simple, primitive constituents of thought, the symbols, which are correlated with the entity in the world in virtue of a causal-nomological relation.

The arbitrariness and the anatomical architecture of conceptual representations are what ensure the internal consistency of a symbolic system and satisfy the two fundamental properties that any conceptual theory must account for, i.e., the systematicity and the productivity of language. Cognitive symbols, operating exclusively with their own propositional forms, guarantee the ability to produce a potentially infinite number of linguistic expressions starting from a finite set of elements, and to understand logical-systematic relations between symbols (e.g., John loves Mary – Mary loves John). Ultimately, in a symbolic system the mental representations have a combinatorial syntax and semantic structure in which complex representations are systematically built on primitive atomic constituents. Hence, the semantic content of a complex representation is conceived as a function of its parts, together with their combinations (see also Fodor & Pylyshyn,1988).

Over the years, cognitivist and computational theories have been pervasive in cognitive science leading the background for many models for representing semantic knowledge. Given symbolic thought is assumed to be similar to language, theorists have typically described concepts in terms of words associations. In feature lists (e.g., Smith et al., 1974), each concept is comprised of a set of features, which code its basic aspects, for example, the words “round”, “smooth”, “sweet”, “red” etc. are features of the concept “apple”. Likewise, in schemata and frame models (Barsalou & Hale, 1993) the predicate calculus is used to associate words with a set of attributes, relations, and values to represent an event (e.g., WIN; agent = Meryl Streep; Object = oscar). Perhaps, one of the better attempts to explain the symbolic conceptual structure is represented by the semantic networks (Collins & Loftus, 1975; Collins & Quillian, 1969) in which concepts are organized in hierarchical propositional models: Each concept is displayed as a node related to other nodes based on specific semantic relations (such as Car-is-vehicle; Plants-has-roots). The symbolic model of the mind was reinterpreted in a strong form by theories whose agenda consists of providing a theory of brain function, based on distributed connectionist schemas (e.g., PDP, parallel distributed processing; Rumelhart et al., 1986; McClelland & Rogers, 2003). According to this approach, cognition relies on the associative and statistical structure of causal interactions in a dynamic system. A possible implementation of dynamic systems is the neural networks, in which concepts stand for the nodes or units of a multilayer feed-forward network of weighted interconnections, simulating the functions of neurons and their synaptic connections. In these models, the conceptual representation is not given by the single units, but it is the result of a progressive adjustment of all neuron-link units and their propagation activity after the repeated exposure of inputs (i.e., backpropagation mechanism).

Connectionist models and traditional symbolic theories of semantic representation, despite diversity, share some basic assumptions about the *amodal* format of concepts that have been critically contrasted. Below, I will generally outline the main tenets of this view and then move to the most compelling set of arguments that contributed to the partial disclaim of the classical approach to studying concepts.

1.1.1.1 Where do symbols come from?

Arguing that cognition acts as an engine operating on arbitrary symbols, cognitivist and connectionist scholars have typically stated that the investigation of cognitive processes does not directly correlate with the physical substrate that instantiates the computations (for a different perspective that links connectionist modeling and neurobiology, see Elman et al., 1996). Traditionally, cognition, far from being intertwined with a particular body or environment, has been viewed as the product of an autonomous module in the brain. According to the proposal submitted by Fodor in his famous essay *The Modularity of Mind* (Fodor, 1983), our mind is composed of innate structures or modules that are computationally autonomous and differentiated based on domain-specificity. Although modules interact somewhere, the internal information flow in a module is encapsulated, so it has no impact on other modules. In this way, Fodor draws a distinction between “high-level” systems responsible for reasoning, decision making, or thinking and “low-level” systems for sensory modalities that operate separately and independently of the former. In this perspective, perceptual systems simply serve to provide inputs to central cognitive modules, and motor systems simply serve to get information out, without playing a critical role in the symbolic computations.

The basic assumption underlying traditional approaches is that a *transduction* process occurs to transform external signals captured by sensory-motor systems into a new representation format that is inherently nonperceptual, i.e., *amodal symbols* (e.g., Pylyshyn, 1984). In the course of the transduction, every link with sensorimotor experience in the environment is lost. For example, in the representation of the concept “flower” the propositional feature of “have petals” is included, but not the olfactory information of smelling a flower, or the motor experience of picking it up. That is why the traditional approach of concepts is referred to be *symbolic* and *a-modal*, in the sense that symbols do not have any associations with modality-specific features.

The idea that concepts are generated by arbitrary, abstract, and amodal symbols leads necessarily to conceive concepts as stable and context-invariant mental knowledge entities. Although the stability assumption is not always explicitly claimed in these models (for example, in distributed semantic networks the contribution of single nodes varies as a function of inputs and other nodes), the stable character of concepts is directly implied by the premise of the existence of innate, primitive symbols that stand for entities in the outside world through a causal connection. To use the above example, the concept of “flowers” is assumed to elicit the same meaning and features irrespective of being on a grave or in a vase by a window.

It should be said that the idea of conceptual stability has been questioned both theoretically and through empirical evidence and is now considered slightly outdated (see Chapter 4 for a discussion on this topic). For the purposes of this dissertation, it is sufficient to mention here the Wittgenstein's (1953) famous argument. Using the word “game” as a paradigmatic example, he showed that meanings and appliances of a word are manifold and cannot be reduced to a fixed set of features (think of what have in common chess, solitary-game, ball games, video games, broad-games). As any attempts to find a sufficient and necessary definition that encompasses all occurrences of a concept is vain (e.g., Do all kinds of games imply winning or losing? Are they all fun?), Wittgenstein introduced the famous notion of *family resemblances* to point out that the range of meanings of a word are related to each other like the members of a family in which some pairs have similarities, but others vary considerably. Taking again the example of “game”: It is the context in which the word appears that determines whether dribbling the ball with hands is a solitary activity or a competitive basketball match. Henceforth, the words meaning are better characterized by their *uses* in language, rather than by univocal links with their referent.

Major criticisms of cognitivism rely on the notion of amodal representation. One of the first arguments raised counter to the symbolic models of mind is likely the celebrated Searle’s “Chinese Room” thought experiment (Searle, 1980). Its criticism is directed against what the author dubs “strong version of AI”, that is the claim that an appropriately programmed symbolic system (i.e., computer) does or at least can think and act in a human-like fashion. In its original version, the counterexample consists of imagining a person who behaves like a computer: An English speaker, who is supposed to know no Chinese, is locked in a room and receives as input a large batch of Chinese string, then, by correlating them only through a set of rules over other formally defined symbols, s/he produces Chinese written answers as output. The demonstration that the strong analogy between machines and the human mind is inconsistent follows by the fact that manipulating uninterpreted formal symbols purely on the basis of their shape, as is the case of the example, does not necessarily mean that person in the room (hence the computer) understands the meaning of Chinese symbols she is using and processing. In other words, any computational processes implemented in an artificial machine, being solely syntactic, are not a sufficient condition for understanding something; thereby, the AI strong hypothesis is wrong. What is missing to have intentionally mental states is the access to the intrinsic meaning, namely setting up a referential semantic link between the words (or symbols) and the entities used to speak about. According to Searle, knowledge of meaning is posited to be a causal effect of being human agents, with a specific biological and neural structure that makes us capable of perceiving, learning, and understanding.

Ten years later, Harnad (1990) advanced a similar argument that became widely known as "the symbol grounding problem". This refers specifically to the failure of the amodal symbolic approaches in explaining how words and concepts connect to their referents, hence to the general problem of how symbols can get their meaning. A related issue is the converse argument noticed as the *transduction problem,* which concerns the lack of an account for the transformation mechanism that should map perceptual states into amodal symbols in our cognitive systems. As Harnad summarized it:

> How can the semantic interpretation of a formal symbol system be made intrinsic to the system, rather than just parasitic on the meanings in our heads? How can the meanings of the meaningless symbol tokens, manipulated solely on the basis of their (arbitrary) shapes, be grounded in anything but other meaningless symbols? (p. 335)

An easy way to think about this problem is to mention the example provided by Harnad himself, which consists of a modified version of Searle's argument. Consider a person trying to learn Chinese as a second language only from a Chinese/Chinese dictionary. In this condition, she will run into a vicious circle of a succession of meaningless symbols connected to other meaningless symbols (the definitions) without ever catching the meaning. The scenario is similar even when the same person is learning Chinese as her first language, providing only a Chinese manual as a source of information. In order to get off this symbol/symbol infinite regress, the meaning of words must be grounded in something other than their syntactic properties.

The great resonance of the *symbol grounding problem* lies in acknowledging that the meaning is not accessed only via formal syntax and combinatory rules, but rather it is necessary to map it into real-world experience and knowledge. Harnad's alternative solution sketches a hybrid symbolic/non-symbolic system, in which symbols are grounded by means of a "bottom-up" mechanism of non-symbolic representations, namely the iconic and categorical representation that picks out the sensory and invariant features of their referents. In this view, elementary names like "horse" and "stripes" are not arbitrary shapes of the symbol, but it is supposed to be grounded in the sensory projections of seeing a horse or a stripe, coupled with the ability acquired from the experience to discriminate the respective categorical members. Consequently, the high-order concept of "zebra" indirectly inherits its grounding in the description of the membership relations of its constituent categories, i.e.., "horse" & "stripes".

Although amodal symbolic and computational theories still gain some popularity, arguments such as symbol grounding and transduction problems have led some scholars to move away from the traditional paradigm, ascribing a different format to symbols, that is, a perceptual and motor format.

1.1.2 Mind, Body, and World. Grounded cognition approaches

Traditional cognitive science has approached the study of cognition through the lens of what Susan Hurley (2001) has ironically called "the sandwich model". The metaphor is particularly illustrative: cognitive and computational scientists treated the mind as a kind of sandwich with the meat in the middle, the cognitive processes, em-breaded by two separate and peripheral elements, perception and action. Since it was argued that any information coming from the sensory domains is transformed into amodal symbols upon which cognitive processes are realized, the common strategy was to throw away the bread and focus on the filling. As a result, cognition appeared to be divorced from the body for a long time.

The centrality of the body in shaping cognition was reclaimed by a vast asset of research programs known as Embodied and Grounded cognition (EGC), that in the early 1990s started to question the traditional theories of mind. To offer an initial portrait of the EGC theories, it might be helpful to illustrate in what respects they criticized earlier approaches and what alternative views have advanced.

Proponents of embodied cognition generally show strong concerns about at least two basic assumptions of cognitivist and computational models. The first is the "isolationist" assumption. It refers to the claim to understand cognition as separate from perception and action and to view processing in low-level systems as secondary to cognition. This fracture has left a large gap in understanding how these processes are connected. In response, embodied cognitive science has modeled cognition in its broader sense, and specifically as a product of the dynamic interplay between cognitive, perceptive, and action processes of an agent in a situated context. Historical anchors for the idea of the circularity of these processes can be found in ecological psychology (Gibson, 1979), in the American pragmatist tradition (e.g., Dewey, 1896), and in the phenomenological philosophy (e.g., Merleau-Ponty, 1945), which initially emphasized, albeit at very different degrees, the primacy of perception as a guide to our behavior and actions in a rich environment, and the importance of physical world for the construction of knowledge and subjective experience.[1] In line with this tradition, early proponents of embodiment developed a framework in which cognition was conceived not as autonomous and independent of the body, but as radically interwoven with it (e.g., Varela, Thompson, Rosh, 1991). In this sense, cognition is said to be *embodied* because it is highly dependent on having a particular kind of organism, and by the fact that its physiological structure constrains the way an organism interacts with and understands the surrounding world in which it is embedded. Ultimately, cognition exists to serve actions, as it is inextricably linked to the sensorimotor circuits through which the world is experienced. Therefore, the structural coupling of the brain-body-world constitutes the heart of embodied cognition research program.

The second assumption is the "computer metaphor of mind", which conveys the idea of the human mind as software that processes information through symbols. Following the sharp arguments on the *symbol grounding problem* of Searle (1980) and Harnad (1990), embodied cognitive science explicitly rejects the mind-computer metaphor and denies that cognitive processes involve computations on amodal representations that have lost any links to entities in the world. The refusal of representationalism and computationalism represents a significant departure from the traditional paradigm. However, approaches within the embodied literature often diverge on this topic. Some forms of embodied cognition have entirely discarded the notion of representation, while others still view it as a powerful scientific construct for making predictions about the mechanisms underlying cognition. The first position, usually referred to as the "radical" version of embodiment, is generally held by a

[1] For insights into the theoretical background of embodied cognition approaches, see Valera, Thompson, Rosh, (1991) and Shapiro, (2011). It is sufficient to mention here that the various embodied approaches have emphasized the role of perception and action in cognition differently, depending on the cultural heritage that inspired them.

minority of cognitive psychologists and neuroscientists who argue that body-environment interactions can be described mathematically using dynamic systems theory, without postulating the existence of mental/brain representations (see Chemero, 2009). [2] Instead, the second position generally recognizes the representational nature of cognitive processes but denies that representations take a propositional amodal format. As we will see below, many embodied theories distance themselves from standard computational approaches by assuming that conceptual representations are expressed in *modal* formats, including visual, motor, and affective states (among others, see Barsalou, 1999; 2003). Henceforth, I will refer specifically to the second version of embodiment. Whether the construct of representation should be abandoned or whether cognitive science benefits from employing it remains an ongoing debate, but one that is beyond the scope of this dissertation (for a detailed discussion on this topic, see Matheson & Barsalou, 2018).

From this preliminary introduction, it is clear that the EG cognition account is better defined as a multitude of proposals with different nuances rather than as a single general theory (see Wilson, 2002). Nevertheless, in this general framework a central tenet is that cognition is strongly influenced by the physical attributes of the human body in interaction with the environment. In principle, all research programs are motivated by the common goal of describing how the brain, body, and environment interact and influence each other to promote intelligent behaviors.

In the last 30 years, the number of studies inspired by the embodiment has exploded in various fields: In addition to psychology and cognitive neuroscience (for a review, see

[2] Support for the anti-representation thesis comes from robotics studies built on embodied architecture (Brook, 1991), and in theoretical discussions of research programs based on *enactive* approaches of cognition (Chemero, 2009, van Elk, Slors, and Bekkering, 2010), as well as, from contemporary phenomenology (Gallagher & Zahavi, 2008; Gallagher, 2017).

Meteyard et al., 2012), in philosophy (e.g., Gallagher, 2014; Prinz, 2002; Shapiro, 2011), robotics and artificial intelligence (Brooks, 1991), linguistics (Lakoff, 2012), and even religious philosophy (e.g., Varela et al., 1991). As a result, the label "embodied" has become too inclusive, generically referring to the alternative to the traditional paradigm in cognitive science that accentuates the role of the body in cognition. However, it should be noted that the embodied account encompasses several versions, which researchers have emphasized by defining cognitive processes as *enacted*, *extended*, *grounded*, and *situated*. Although there are numerous and undeniable convergences, each version proposes a specific approach to the study of cognition. I briefly address each of them in turn.

The term *enacted* is generally used to emphasize the role of perception, which is understood as an exploratory activity mediated by sensorimotor contingencies developed during the experience (e.g., Varela et al., 1991; O'Regan & Noë, 2001; Noë, 2004). According to enactivists, knowledge of these contingencies does not require the activation of mental representations but arises directly from how an agent enacts in its environment. [3] Thus, the current of enactivism coincides in some way with a radical version of embodiment.

The notion of *extended cognition* dates back to the thesis of Clark and Chalmers (1998). In an influential article entitled *The Extended Mind*, they posit a model of the mind as a coupled system in which the human organism incorporates aspects of the environment. Using the well-known example of the notebook extending Otto's biological memory, the authors argued that external devices play an active causal role in driving cognitive processes by augmenting our

[3] Precursor of enactivism is considered the ecological psychology of Gibson (1979). The main argument can be summarized as the follows: 1) since perception is always direct and not mediated by inferences or representations; and 2) perception exists for action, not just to record external inputs, 3) then the environment must "suggest" information to guide action. This leads to the formulation of the famous notion of *affordance*, which can be broadly defined as the action possibilities that a given object "offers" to the agent. For the sake of brevity, I will not address this line of research in this dissertation, although the embodied approaches are clearly in debt to this notion and the Gibsonian tradition.

computational abilities. Thus, cognition is not limited within the boundaries of our head/mind but is said to be distributed throughout our brain, body, and external sources.

While the preceding terms refer, directly or indirectly, to a narrower line of thought, the notion of *embodied*, *grounded*, and *situated* are often treated together and interchangeably by the majority of scholars to reflect the close intertwining of sensorimotor, bodily, and social aspects in determining cognitive processes. The terminological clarification proposed by some researchers helps to disentangle their specificity (e.g., Fischer, 2012; Pezzulo et al., 2011). According to these authors, each term captures some diagnostic features of cognition: *Embodiment* reflects the sensory and motor constraints of the human body that have evolved over life experience; G*roundedness* refers to general constraints on cognition derived from physical regularities in both the structure of the body and invariant law of the natural world; and finally, *Situatedness* of cognition refers to the influence of current constraints bound by a particular context and goal-directed activities. Furthermore, Barsalou (2008) pointed out that the term "embodied" could lead to a misleading description because it wrongly suggests that the body is the *only* element necessarily involved in cognition. For this reason, he proposed using the term "grounded" to underline a broader view of cognition that integrate recursive relations between other domains of grounding, among which the body, the external and internal perceptual modality, affect, agent's motivation, values, and habits, the physical environment, and social environment (see also the recent proposal of a Situated Action Cycle, Barsalou, 2020).

In the remainder of this dissertation, I will specifically endorse an overarching perspective of cognition, taking into account its embodied, grounded, and situated components, showing how all these aspects contribute to the semantic grounding of language, but to a different extent for concrete and abstract concepts

1.1.2.1 Mirror mechanisms, neural reuse, and simulations

How can language be embodied and grounded? Let us consider my concept of coffee. This brings together a set of information about how coffee looks, smells, tastes to me, or that in order to enjoy it, I have to pick up the cup into which it is usually poured and bring it to my mouth. I have also learned from my own experience that it is a stimulating drink, so the best time to have a good cup of coffee is right after waking up or after lunch, not before bed. While I chose a coffee in a bar, I sometimes recall how was different the taste of the Turkish coffee I had drunk in Istanbul compared to an Italian espresso. Also, if I run into a friend I have not seen in a while, and she says: "Do you want coffee?", I will probably expect to drink coffee but also have a long and pleasant chat with her. Without further ado, it can be concluded that my concept of coffee merges a collection of experiences accumulated from encounters with coffee instances, and that, at least some of these experiences are retrieved to construct a conceptual representation of coffee, even in its absence, to support memory, thought, and predictions.

In a highly simplified manner, this example illustrates the process of simulation, which is one of the key concepts of embodied and grounded theories of cognition. Simulation is mainly used to account for the recruitment of the same neural areas active during the interaction with objects and entities in the world, as well as in language comprehension. As noted elsewhere, the notion of simulation is perhaps one of the most researched and controversial topics related to grounded cognition and comprises a variety of connotations (Borghi, 2011). Some prefer the term "motor simulation" to outline the predictive aspect of simulation, suggesting that the automatic reactivation of sensorial experiences is at the basis of a direct form of comprehension in terms of action preparation (Gallese, 2009). Others tend to associate it with a deliberate process that occurs a posteriori, such as mental imagery (e.g., Jeannerod, 1994; Decety & Grèzes, 2006). Finally, in the attempt to reach a comprehensive account of cognition, simulation is more often intended as a form of re-enactment of our past experiences acquired during the interaction with the environment (Barsalou, 2008; Barsalou, 2020). To better understand which mechanisms underlie simulation, it might help to mention some important findings from neurophysiological research on the phenomenon of motor resonance that first inspired this notion.

In the late 1990s, the study of ventral premotor cortex of macaque monkeys (F5 area) led to the discovery of the so-called "mirror neurons systems" (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). This area includes two varieties of visuomotor neurons: canonical and mirror neurons. Although both contribute to action execution, it has been demonstrated that they support different cognitive processes. Canonical neurons discharge during motor act execution and in response to the presentation of graspable objects. Typically, they are sensitive to the congruence between the visual properties of observed objects, such as size, shape, orientation, and the motor strategies required for manipulation (e.g., grasp a small/big object with precision or a power grip) (Rizzolatti & Fadiga, 1998; Fadiga et al., 2000). Mirror neurons are a particular class of neurons in the F5 area that discharge both when primates perform an action (e.g., picking up an object) and when they are just observing other members of similar species (monkey or human) performing a similar action (for a review, see Rizzolatti & Craighero, 2004; Rizzolatti & Sinigaglia, 2010). Notably, mirror neurons do not respond to the action itself but fire selectively for goal-directed actions. For example, Umiltà et al. (2001) placed a piece of food behind a screen and showed the monkey either a fully visible action directed toward the object or the same action with the last critical part of the movement hidden from the monkey's gaze. The activation of mirror neurons not only occurs in the full vision condition but also in the hidden condition when the grasping and holding movements could only be inferred. Similar activation of mirror network was found in Kohler and colleagues' (2002) study by making the monkey hear only action-related sounds.

Because of their goal sensitivity, it has been claimed since the earliest studies that mirror neurons play a functional role in recognizing actions performed by others. Action understanding is achieved by matching the observed action with the neural activity encoding the action. This mirror matching mechanism generates an "internal representation" of the movement that allows the observer to recognize the other's intentions by relying on their own motor process as if she/he were actively performing the same movement. After their discovery, neurons with mirror-like properties were also found in visceromotor and other sensory areas, suggesting that these circuits provide a general mechanism that fulfills a range of complex cognitive functions, including intentional actions, emotions, social coordination, and imitation. Thus, mirror neurons are said to provide a "route to knowledge of others" (Rizzolatti & Sinigaglia, 2016).

It is worth noting that these findings challenged the standard model of the mind that posited separate and sequential processing from perceiving to thinking to acting (i.e., the sandwich model). Rather than being independent systems, perception and action systems reciprocally interacts to support cognition: execution of actions enriches the perceptual representation of stimuli, and perceptual inputs influence actions understanding. The discovery of mirror mechanisms has inspired researchers to investigate phenomena that pertain at the same time to perception and action, such as *affordances* that refer to possibilities for action offered by the visual objects in the environment (e.g., Tucker & Ellis, 1998; Ellis & Tucker, 2000; Tucker & Ellis, 2001).

Of particular relevance to our aims is the research on mirror neurons in humans. Much evidence has indirectly suggested that a mirror system homologous to the monkey F5 area exists in the human brain (Fadiga, Pavesi, & Rizzolatti, 1995; Gallese, Eagle, & Migone, 2007; for a review, see Fadiga, Craighero, & Olivier, 2005) and that this system might be somatotopically organized. Neuropsychological and neuroimaging studies showed that passive observation of hand, mouth and foot movements selectively increases the activity of different regions in the human premotor cortex that usually are triggered for the execution of movements involving these effectors (Buccino et al., 2001; Buccino et al., 2005; Pulvermüller et al., 2001).

Crucially, it has been demonstrated that Broca's area, traditionally known to be involved in speech production, possesses mirror motor properties. For example, fMRI studies and transcranial magnetic stimulations reported neural activity in this area during action observation or imitation (Buccino et al., 2005; Koski et al., 2002). Given the close connection between the premotor cortex and Broca's area, some authors began to consider mirror neuron circuits as the neurophysiological mechanism from which language evolved. In this perspective, language comprehension is conceived as directly related to the mirror mechanisms that support action understanding. Human communicative abilities would derive from a motor simulation starting from manual gestures and phono-articulatory movements necessary to produce verbal speech, to progressively transfer to the semantic level of word meaning. (Rizzolatti & Arbib, 1998; see also Gentilucci & Corballis, 2006). Furthermore, it has been suggested that mirror neuron systems activation represents the neural substrate of the embodied simulation intended as a predictive mechanism to guide action (Gallese & Goldman, 1998; Gallese, 2008).

A slightly different view ascribes a broader extension to the notion of simulation, which is not limited to its role in the action. Referring to Barsalou's (2008) classic definition: “Simulation is the re-enactment of perceptual, motor, and introspective states acquired during experience with the world, body, and mind” (p. 618). This means that simulations generate a rich conceptual representation that integrates several situational elements of the surrounding environment, as well as individual experiences of cognitive, internal, and emotional states.

One of the most influential and systematic interpretations of the simulation mechanism within an embodied and grounded perspective is certainly the *Perceptual Symbol Systems* theory (PSS, Barsalou, 1999; 2008; 2009). Originally proposed as an alternative to traditional amodal approaches, PSS developed a model of representing knowledge that, while still acknowledging the importance of symbolic operations, assumes that concepts are entirely based on the neural re-enactment of multimodal states. In this perspective, perceptual symbols capture the neural states that underlie the perception of things in the world, generating a schematic representation in memory that has an analogous structure to the perceptual states that produced them. In this sense, perceptual symbols are said to have a non-arbitrary relation to their referent and therefore do not seem to be affected by the symbol grounding problem (Harnad, 1990; see also § 1.1.1.1).

To expound on the extent to which concepts are grounded in multimodal representations, (Barsalou, 1999) introduced the distinction between *simulators* and *simulations*. A simulator is a distributed, modality-specific representation generated from encounters with different instances of a category (remember the opening example of my concept of coffee). Simulators develop for each component of experience processed, and they are realized in the brain by a population of conjunctive neurons in the association areas typically active to encode these components (e.g., visual, tactile, gustatory, and emotional systems process the features aroused by coffee). Once simulators are established in long-term memory for a category, a subset of these components can be extracted to produce a context-specific simulation of these prior experiences associated with the concept (e.g., my memory of Turkish coffee). In this way, simulators act as a *type* representing a specific multi-modal conceptual content of a category across instances, while simulations functions as a *token* representing one of the infinite possible conceptualizations of a category. By assuming this type-token relationship, perceptual symbols can be productively combined in complex simulations to achieve basic conceptual functions, such as constructing propositions and categorial inference (Barsalou, 1999; 2017). Notably, the simulation process is primarily unconscious and always generates a partial representation of the experience by selectively focusing attention on relevant components to flexibly adapt to the context at hand. [4]

The underlying assumption of PSS theory is that there is no transduction process from perceptual inputs into an amodal format (as instead the traditional approach claims); rather, conceptual knowledge is constituted by the online or offline re-enactment of perceptual, sensory, and internal features connected with the referent of the word. For example, while processing the concept “chair”, our visual, motor, tactile, and emotional systems (and so on) are engaged in the retrieval of the concept creating a simulation of previous interactions with the object (Barsalou, 1999). According to simulation-based theories, language comprehension is not derived from a unique “language module” (Fodor, 1983) but directly uses the same brain

[4] See Chapter 4 for more insights on conceptual flexibility.

resources employed in perception and action. In this sense, language is said to be embodied and grounded in the sensory and motor systems of the body.

The embodiment language hypothesis is in line with neuroplasticity theories proposing the notion of *neural reuse* as the central principle of the functional structure of the brain, where the same neural circuits seem to support various cognitive functions (e.g., Anderson, 2010). Neural circuits evolved for an original purpose during the evolutionary and developmental pathway can be recycled or exploited for later emerging functions without losing their initial established uses. As Barsalou (2016; p. 1130) noted: "Neural reuse offers a natural account of what is means by simulation" in that sensorimotor processes originally evolved for visual and motor functions have adapted to support language processing and comprehension (for a similar account, see also *convergence zone theory*, Damasio, 1989).

Empirical support in favor of the assumption that language is embodied and grounded comes from plenty of behavioral and neuroimaging studies that, in the last decades, have provided compelling evidence that sensorimotor systems are automatically activated during words and sentence comprehension. As this literature is discussed in Part 2 of this Chapter, I will now introduce some recent hybrid approaches to the conceptual representation that combine both symbolic and embodied aspects.

1.1.3 Not so symbolic and not so embodied. Hybrid approaches

So far, two competing theories of concepts have been presented. Amodal symbolic approaches argued that concepts derive their meaning solely on the basis of the manipulation of arbitrary symbols, defined independently of modalities. In contrast, Embodied approaches posited that concepts require simulations and are grounded in perceptual and motor states of the body rather than in linguistic information. As illustrated, the debate at stake is about whether concepts are either symbolic or embodied. However, this is not the whole story.

Recently, some scholars have attempted to bridge the gap between symbolism and embodiment by proposing a hybrid approach that combines perceptual and linguistic/symbolic information (e.g., Andrews et al., 2009; Andrews, Frank, & Vigliocco, 2014; Louwerse, 2008; 2011; Louwerse & Jeuniaux, 2008; for a review, see Davis & Yee, 2021). Before going into detail, it might be helpful to step back to another popular approach to the study of semantic knowledge in cognitive science, namely distributional theories.

Distributional theories, developed primarily in computational studies, treat meaning as a consequence of the statistical distribution of words across spoken and written language. As one of the early proponents of this view concisely put it: “You shall know a word by the company it keeps” (Firth, 1975; p.11). According to this approach, the meaning of a word is constituted by its relationship with semantically related words. For instance, the meaning of “house” is determined by its semantic proximity with words such as “wall”, “door”, “window” etc. Two notable examples of distributional semantic models are Hyperspace Analog of Language (HAL, e.g., Lund & Burgess, 1996) and Latent Semantic Analysis (LSA, e.g., Landauer & Dumais, 1997). In both models, meaning is represented as vectors in high-dimensional space and is computed statistically: Meaning is derived from the frequency of co-occurrence of each word and its interlinguistic relatedness to other words in large text corpora. It has been shown that the output of the models correlates with human performance and successfully predicts a wide range of semantic phenomena, such as semantic synonym recognition, categorization, word-association tasks, and text learning ability (for review, see Lenci, 2018).

Distributional theories and grounded approaches have often been portrayed as contrasting paradigms. On the one hand, advocates of embodied cognition considered distributional semantics as a flawed and incomplete theory of cognition where no space is reserved for bodily and sensory experiences, and no explanation is given of how words relate to the entities to which they refer (e.g., Glenberg & Robertson, 2000a). On the other hand, as we will see below, embodied cognition is challenged to account for concepts that do not have a tangible referent (i.e., abstract concepts), whereas distributional theories seem to infer their meaning easily through interlinguistic relations (e.g., Andrews et al., 2014).

More recently, several models have been proposed to reconcile these two approaches. For example, Andrews and colleagues (2009) built a unified Bayesian probabilistic model combining experiential statistical data derived from feature production tasks and distributional data derived from co-occurrence patterns in texts. The two types of data were qualitatively different but also correlated. The experiential data provided semantic information that was mainly related to perceptual, motor, and physical aspects, whereas the distributional data provided semantic information that was more abstract and encyclopedic. Notably, the information extracted by combined models was mutually reinforcing and resulted in a richer semantic representation than those obtained from other models relying either on a single source or both sources independently. Similarly, Johns and Jones (2012) implemented a global memory model capable of making sophisticated inferences about the perceptual representation of ungrounded words from an initially limited set of perceptual data. Based on the redundancy between perceptual and linguistic information, the model infers perceptual properties of words with which it has experienced only by association strength with perceptual states of already grounded words. In doing so, the model performance also fits the results of various datasets and classical embodied experiments.

In a different but similar spirit, the *Symbol Interdependency Hypothesis* of Louwerse (2007; 2011) and Louwerse & Jeuniaux (2008) proposed that language comprehension can be both symbolic and embodied. According to this hypothesis, symbols are hierarchically structured in different levels of representation. At one level, symbols interact with other amodal linguistic symbols, while at another level, symbols can refer to their referents. [5] In this way, language structure encodes many of the perceptual relations found in the world and provides a communicative shortcut for accessing embodied simulation. The underlying argument is that when limited grounding is possible, meaning is derived more efficiently through associative symbolic representations. In other words, language comprehension need not activate a full embodied simulation in all circumstances, as it may be more convenient for speakers to rely on symbol-to-symbol relations to bootstrap meaning (i.e., the shortcut argument, see also § 2.4.1).

In support, Louwerse and Jeuniaux (2010) tested whether embodied relations, such as spatial iconicity, are similarly encoded in language. Based on Zwaan and Yaxley's study (2003), the authors presented participants with pairs of words or pictures of objects and asked them to judge whether they were semantically related or had an iconic relationship. Both pairs could be in standard or reverse order reflecting either the spatial configuration of the objects

[5] The *symbol interdependency hypothesis* draws directly on Deacon’s (1997) theory of language evolution, which in turn is based on Peirce’s (1923) theory of signs. For brevity, it suffices to mention that language is conceived as a hierarchical network of interactions between signs, which can be an icon, an index, or a symbol. These have a different relationship to the object they refer: An icon has a direct physical similarity (e.g., a picture representing an object), an index is mediated by spatial and temporal congruence and there is no physical resemblance (e.g., smoke and fire), and finally, a symbol is mediated by conventional relationship (e.g., yellow bracelet stands for hope). Thus, Deacon claims that human species is the only one that has evolved language because it is able to make connexions between symbols.

as in the Zwaan and Yaxley' experiments (*embodied factor*; e.g., attic above basement vs. basement above attic) or the standard order in which the word appears in the language (*linguistic factor*; attic-basement; basement-attic). Performance in the iconicity judgment about pictorial stimuli was better predicted by the embodied factor, while the linguistic factor better predicted the semantic judgment for words, suggesting that linguistic and embodiment information affects conceptual processing differently depending on the precise nature of the stimuli and the task. (see also Louwerse, 2008). The authors interpreted these results in terms of different processing levels in which a meaningful response is extracted from the stimuli. Specifically, they distinguished between "shallow" and "deep" language processing. In most cases, language information is activated at the early stage of lexical comprehension to produce a quick representation, and later, only whether the task explicitly cued it, the embodied information is activated. Louwerse (2018) pushed the line further, claiming that if embodied relations are encoded in linguistic structure, then experimental evidence attributed to embodied cognition can equally be explained by distributional models (for a similar perspective, see Lupyan, 2008, §. 2.4.2). Using LSA approaches, Louwerse (2011) showed that findings on perceptual simulations, affordances as well as spatial relations could be attributed to interlinguistic regularities between words, that is, to language itself.

In summary, the *symbol independence hypothesis* argues that conceptual processing cannot be exclusively symbolic or embodied but results from the interdependence of these two sources of information. Crucially, since language reflects many embodied experiences, symbols can but not necessarily have to be grounded in perception because linguistic regularities help to bootstrap meaning gained through embodied simulations.

Despite their wide application in computational and artificial intelligence research, distributional theories and the hybrid views do not evade the "symbol grounding problem" (Harnad, 1990; Searle, 1980). As in traditional symbolic approaches, meaning is assumed to be accessed through word-to-word associations, hence through ungrounded symbols. However, it must be acknowledged that by emphasizing the role of language, theories of distributional semantics have opened the way to fruitful lines of research in the panorama of embodied and grounded cognition. I will discuss these aspects in the next chapter, after taking a closer look at the main evidence for the semantic grounding of concrete and abstract concepts.

1.2 The easier problem: the semantic grounding of concrete concepts

Traditional theories assumed that conceptual knowledge is located exclusively in a modular semantic system that operates independently from other systems for perception, action, and emotions. These approaches further posited that concepts are amodal representations, in which the original sensorimotor information about the physical referent is transduced into a propositional format suitable for implementing conceptual functions only via symbolic and computational rules (Levelt, 1989; Pylyshyn, 1984; Fodor, 1975).

An emerging alternative theory is afforded by Embodied and Grounded view of cognition (EGC). In line with the description provided in the previous paragraphs, the main claim of EGC applied to language is that concepts are embodied and grounded in our bodily assets. In this perspective, our conceptual systems and our perceptual and sensorimotor systems are strictly interwoven. Thus, the format of the conceptual representation is closely related to the elaboration mechanisms of its content. According to EGC accounts, the meaning of a word is constituted by the reenactment (or *simulation*) of perceptual, sensorimotor, and internal experiences acquired during the interaction with the referent of the word (Barsalou, 1999). For example, while hearing or reading a word like “cat” our visual, auditory, and tactile systems would be activated to re-enact states associated with seeing its shape and size, its movements, and the softness of its fur, and with hearing is meowing. The same word would also retrieve emotional and introspective information, such as what it means to have had a cat in childhood. More to the point, EGC accounts argue that the processing of concepts implies that the same neural patterns usually engaged in interacting with entities they refer to partially reactivate in the absence of perceptual inputs, creating a simulation of the same interactions.

Much of the research framed on the EGC has intensively investigated the processing of objects nouns or action verbs, namely the class of concepts referred to as “concrete”. Existing evidence has successfully demonstrated that concrete words systematically activate sensorimotor features, and that such activation is highly detailed and dependent on specific modalities. In order to expound on this, I will review some of the most influential behavioral and neuro-physiological evidence in support of the grounding of concrete concepts. In doing so, I will show that amodal symbolic theories can hardly account for the findings concerning the activation of action-perception circuits during language comprehension, which can be accommodated best by EGC theories assuming a multimodal simulations process.

1.2.1 Multimodal Simulation: Behavioral evidence

Early support of the idea that perception and action causally interact with high cognitive processes comes from experimental studies on the phenomenon of *object affordances* originally performed by Tucker and Ellis (Tucker & Ellis, 1998; Ellis & Tucker, 2000; Tucker & Ellis, 2001). Roughly speaking, the notion of affordance, firstly introduced by Gibson (1979) refers to “cues to use objects”, thereby suggesting that the visual objects comprise information about actions usually performed with that objects and that such information is automatically extracted to conceptualize them.

In a seminal study, Tucker and Ellis (1998) investigated whether the recognition of visual object properties is facilitated when they overlap the movements that these objects naturally afford. Participants were asked to judge the upright or inverted position of depicted graspable objects. They found a compatibility effect between the orientation of the object’s handles, which was task-irrelevant, and the position of the response key (left, right). Participants were faster and more accurate when the position of the handle and the responding hand were spatially aligned as compared to when they were not. Similar compatibility effects have been found between object size and the optimal grip for using it. Tucker and Ellis (2001), for example, asked participants to classify objects as natural kind or artifact by performing either precision or a power grip and found better performance with power grip in case of large objects (es., apple) and with precision grip in case of small objects (e.g., fork). Overall, these findings suggest that merely viewing an object elicits the simulation of actions-related proprieties of that object. Literature on affordance has gained great credit from the discovery of mirror mechanisms, viz., a special class of neurons that discharge both when interacting with objects and when passively observing them (canonical neurons) or someone else doing an action (mirror neurons) (Rizzolatti & Craighero, 2004; see § 1.1.2.1). After the initial Tucker and Ellis’ works, substantial evidence from fields ranging from psychology (e.g., Tipper, Paul, & Hayes, 2006) to neuroscience (e.g., Craighero, Fadiga, Umiltà, & Rizzolatti, 1996; Kourtis & Vingerhoets, 2015) has proved that motor systems respond to visual stimuli in a higher automatic manner influencing the representation of stimuli itself. Thus, it has been proposed that motor simulation is the underlying mechanism that supports the conceptual representation of manipulable objects (e.g., Martin, 2007).

More relevant for this dissertation is the claim that the same simulation mechanism underlines the relationship between the word and its referent during language comprehension. When applied to language, the simulation-based theories hold that individuals automatically construct a mental simulation of perceptual and motor components of entities/objects to represent concepts. This hypothesis has been assessed via several behavioral tasks relying on the assumption that if simulations are a necessary component of conceptual knowledge, then manipulating a variable of perceptual modalities should affect conceptualization.

In a set of feature listing studies, Wu and Barsalou (2009) manipulated the variable of occlusion. Half of the participants received noun concepts that referred to entities whose internal features are hidden by the object's surface, e.g., a green rind occluded *red* and *seeds* for *watermelon* (occluded condition). The other half were presented with the same nouns coupled with a modifier that revealed the internal part of the object, e.g., *red* and *seed* are evident proprieties for *half watermelon* (unconcluded condition). If participants simulate conceptual referent to generate its properties, then the presence or absence of modifiers should influence the task performance. In contrast, if individuals rely on amodal representation, the manipulated conditions should only affect the conceptual combinations and not the entity's features. Results provided support for simulation-based accounts. Specifically, participants reported more often internal features when revealing modifies were combined with target nouns than when it was presented in isolation. This finding suggests that people access features via perceptual simulation: the noun combinations *half watermelon* increased the salient and visibility of internal object’s parts, eliciting the simulation of *red* and *seed* features that instead are difficult to access when the simple noun was presented. In further experiments, the authors obtained similar results for unfamiliar noun combinations (e.g., *gashed watermelon*) and comparing externally and internally focused properties (e.g., *striped watermelon* vs. *seedless watermelon*). Furthermore, the authors proved that this effect was not the result of roles for proprieties combinations, given the numbers of internal proprieties only increased when the occluded proprieties were revealed in the simulation of related referents (e.g., *rolled-up lawn*) but not of unrelated ones (e.g., *rolled-up snake*).

Increasing evidence has also documented the involvement of perceptual simulation in property verification tasks (for a review, see Barsalou, Solomon, & Wu, 1999). For example, Solomon and Barsalou (2001) found that when participants verified whether a property is true or false for a noun, such as *mane* for *pony*, they were faster if the same property was verified previously for *horse* than for *lion*. This result indicated that a detailed simulation of shape becomes active during the task, leading to facilitation in response to subsequent trials with similar perceptual forms (the shape of mane for a horse and pony but not for a lion). A control experiment confirms that this effect was not due to conceptual similarity but precisely to the perceptual similarity of the properties, as no difference emerged when the property was held constant across concepts (e.g., verifying *belly* for *pony*, *horse*, and *lion*). These findings were further replicated and extended by Solomon and Barsalou (2004) using a similar property-verification task in which – besides perceptual features – linguistic associations and expectancy (i.e., the different forms that a property can take across objects) were included as variables. The authors found that perceptual variables best predicted the verification response times and errors. Specifically, the property of size explains the high percentage of variance and heavily impacted the participants' performance: the rate of RTs and errors increased at the increase of property size to verify. Results are consistent with the idea of processing large proprieties taking longer than processing small ones, likely because a large region must be stimulated, thereby increasing the duration of the verification process.

The influence of simulation on conceptualization processes is not limited to visual proprieties but encompasses any aspects of the experience, including all five sensorial modalities, as well as action and emotions. Over the last 20 years, scholars have developed several experiments to directly assess the multimodal nature of simulations. Specifically, it has been explored whether individuals activate modality-specific simulations in accordance with the semantic components of a given concept. If simulation-based theories are correct, processing words related to specific modalities should lead to corresponding simulations, then switching from one modality to another should involve a processing cost in conceptual tasks.

Evidence supports this hypothesis. For example, Spence, Nicholls, and Driver (2001) showed a perceptual effort in detecting a signal on a modality when the previous signal was on a different modality. In a simple perceptual detection task, participants observed an unpredictable sequence of visual, tactile, or auditory targets that could appear either on the left or on the right, and responded to the stimuli location. Performance was faster and more accurate on trials preceded by the same modality than on trials preceded by a different modality, suggesting that the processing is less efficient when attention shifts between different perceptual modalities. An analogous *modality-switch effect* has been found by Pecher, Zeelenberg, and Barsalou (2003) in a set of propriety verification studies with verbal stimuli. The experiments consisted of presenting short target sentences in which the concept nouns can be associated with one of six modalities proprieties, i.e., vision, audition, taste, smell, touch, and action. Participants judged whether the propriety was congruent with the object (e.g., "apple is round" vs. "apple is square"). Crucially, the sensorimotor proprieties were manipulated to vary or remain constant trial by trial. The authors found that switching modalities entailed a cognitive cost, resulting in an increase in response times. For example, when participants had verified auditory propriety (*blender-loud*), in the consecutive trial, they were faster to verify propriety from the same modality (*leaves-rustling*) than propriety from a different modality (*cranberries-tar*). Findings demonstrated that concepts activate multimodal simulations relying on the same systems that are recruited in perception across different sensory modalities. This explains why transferring processing from one modal system to another involves processing effort. Importantly, this kind of evidence rules out the view of conceptual knowledge as amodal representation as there should not be any difference in processing time in the same-modality and different-modalities conditions.

Other studies also reported perceptual simulation effects on sentence comprehension, in which individuals construct a mental simulation of fine perceptual details of objects and actions described in the utterances. For example, in a sentence-picture matching task Zwaan, Stanfield, and Yaxley (2002) showed participants with sentences that describe animals or objects in different locations implicitly suggesting a specific shape (e.g., eagle in the sky, eagle in the nest), and asked them to judge whether the following picture represented the word mentioned in the sentence. An advantage in response time emerged when picture and sentence match, such as when the sentence "The ranger saw the eagle in the sky" was followed by a picture of a bird with outstretched wings rather than with folded wings. Similar evidence exists for the implied orientation of objects. Stanfield and Zwaan (2001) showed that reading about a sentence that implicitly suggests a horizontal or vertical orientation of an object (e.g., "He hammered the nail into the wall" vs. "He hammered the nail into the floor") leads to respond faster to a subsequent object picture whose orientation matches with the orientation described in the text.

Further studies have focused on motor information, showing that simulation involved in language comprehension is sensitive to the direction implied by the sentence describing an arms movement. In a famous study by Glenberg and Kaschak (2002), participants judged the sensibility of sentences using a button box where keys were arranged at three different distances: near, halfway, and far away from the body. Authors manipulated the sentences to describe actions directed toward or away from the body (e.g., Open the drawer, Close the drawer; respectively). They found a significant interaction between direction sentence and response, referred to as the *Action-Sentence Compatibility effect* (ACE). For example, responses to the sentence “Open the drawer” were faster when participants were required to perform a movement toward their body than away from their body; the opposite was true for a sentence like “Close the drawer”. In a similar but different spirit, other studies demonstrated that the specific body states or moments could affect the processing of valenced stimuli. For example, the processing of negatively valenced words (e.g., garbage) is slower when performing an approach arm movement (pulling) than an avoidance movement (e.g., pushing) (i.e., AAE, *Approach-Avoidance effect*, Chen & Bargh, 1999). Taken together, these studies show that both verifying and producing features for a concept is implied a dynamic and multimodal simulation of its referent. Ultimately, it supports the thesis of language grounding, showing that perceptual and motor details are retrieved across several conceptual tasks and that modality-specific information plays a major role in accessing the word meaning. More importantly, this evidence calls into question the amodal representational view that, by assuming separate systems for sensory and semantic processing (Pylyshyn, 1984; Fodor, 1983), can hardly account for these sorts of findings.

Over the years, the notion of simulation has been adopted in much behavioral research as a crucial cognitive mechanism to explain language comprehension. However, it is not exempt from limitations. First of all, the finding that words and sentences comprehension activates sensorimotor simulations does not establish the extent to which this effect should facilitate or interfere with the ongoing task. Indeed, much research reports either facilitation or interference effects during language processing. (e.g., Gozli et al., 2013; Estes et al., 2015; Ostarek & Vigliocco, 2016). The lack of strong hypotheses about the direction and timing of activation is quite problematic, as any effects could support grounded theories, while not ruling out alternative explanations (i.e., both linguistic and perceptual/motor information are encoded at amodal level) (for a discussion, see Ostarek & Huettig, 2019). In this context, behavioral experiments raise reproducibility problems. An exemplary case is the Action Compatibility Effect (ACE), whereby a vast, preregistered, multi-lab research has recently failed to replicate the original findings (Kaschak et al., 2020; for a discussion, see Zwaan, 2021), likely due to the high variability involved in simulation processes. In general, behavioral paradigms that focus on congruency effects between linguistic and visual or motor aspects are useful for identifying whether sensorimotor simulation is activated, but they are not decisive in determining the nature of the underlying mechanisms. A fruitful way to address this issue is to use interference paradigms, both neural and behavioral, in which the suppression or impairment of perceptual and motor processes directly tests their functional role in language comprehension (see Ostarek & Bottini, 2021).

1.2.2 Multimodal and somatotopic brain activation: Neuroscientific evidence

Embodied and grounded theories postulate common brain mechanisms for action, perception, and semantic processing, in contrast to the standard view that assumes separate modules, one of which would be handling linguistic information. In the past decades, brain research has provided compelling evidence for a reciprocal connection between language mechanisms and action-perception circuits. This link was found to be involved both in speech production and perception (e.g., Pulvermüller, 1999). To put it simply, when a word or a sentence is pronounced, the articulatory motor system of the speaker is activated, and at the same time, the self-perceived sounds lead to specific activation of auditory systems. Conversely, listening to spoken words requires a strong motor resonance in articulatory systems to detect the speech sounds, even in passive speech perception. This indicates the presence of a motor-to-auditory activation flow during language processing (for a review, see Pulvermüller & Fadiga, 2010).

Important insights about how these connections are implemented in our brain have been offered by studies on the neuroanatomical structure and functional organization of neuronal populations, based on the neural key principle of the Hebbian learning rule: "neurons that fire together wire together and neurons out of sync delink" (Hebb, 1949). According to the model proposed by Pulvermüller (1999; 2012), nerve cells that are frequently co-activated are stored in a distributed circuit (i.e., cell assemblies), and the strength of their mutual connection increases the probability of future co-activations of the whole neuronal circuits.

This principle offers appealing explanations for the brain topographies of linguistic and semantic processing. In order to represent and produce words, nerve cells in the sensory and motor systems are reciprocally connected to map acoustic phonological information to the concordant motor program required for word articulation. The emerging circuits are thought to be localized in the left perisylvian cortex, thereby considered the cortical basis of linguistic spoken-word form (Pulvermüller, 1999). Importantly, this region shows rich neuroanatomical connectivity with other relevant sensory-motor areas, as it includes adjacent regions, [6] often called multimodal association areas, which function as convergence zones to bind information from different modalities-preferential areas into a coherent representation. This cortical connectivity allows the establishment of a referential semantic link between word form and the sensory and motor information of the object/entity it is related to; that is to say, it determines the semantic grounding of meaning in the world. As an example, the meaning of a word like *cake* is linked up with the object and its features through the recruitment of a distributed neuronal activations pattern spanning across visual, auditory, somatosensory, olfactory, and gustatory brain areas, as well as its word form encoded in the left perisylvian language cortex. Therefore, it has been suggested that conceptual processing, rather than relying on an isolated "amodal semantic system", draws on a hierarchy of interconnecting neural circuits involving multimodal association areas, in which the activity of sensory areas is primarily dedicated to a single sensory or motor modality converges (Damasio, 1989; Simmons & Barsalou, 2003).

Great support for language grounding derived from neuroimaging studies showing that semantic areas are activated to different degrees depending on word type category, leading to the emergence of category-specific semantic circuits. To date, research has scrutinized all the sensory domains in order to verify if perceptual and motor aspects conveyed by words are reflected in the activation of the corresponding sensorimotor brain areas.

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[6] The brain region surrounding the sylvian fissure, which is called the perisylvian language cortex, includes the posterior inferior frontal area named after Broca (Brodmann areas, BA, 44, 45) along with the superior temporal cortex (BA 42, 22) sometimes considered Wernicke's region, plus further adjacent sites in inferior frontal, parietal and temporal cortex, that are most relevant language network (Pulvermüller, 2018; p. 5)

Simmons and colleagues (2007) conducted an fMRI experiment to assess whether the regions responsive during color perception are also engaged in retrieved semantic knowledge about object nouns with color features such as *banana*, *elephant*, *carrots*. Participants were presented with a set of object nouns followed by either a color adjective or motor propriety, and they had to indicate whether the property was inherent to the object or not (e.g., *banana-yellow*; *football-throw*); finally, subjects' color perception areas were assessed by a functional perceptual task. Overall, the results showed that the visual cortex was more activated in retrieving color than motor properties. Notably, the authors found a direct overlap in the left fusiform gyrus, which was activated both in perceptual and conceptual color representations. Likewise, Pulvermüller and Hauk (2006) have reported distinct activation patterns in the inferior temporal cortex for color and form-related words (e.g., *brown*, *square*), where the former activates areas adjacent to the visual cortex, and the latter activates areas adjacent to the premotor cortex.

Activation of modality-specific brain regions has also been documented for the nonvisual aspects of word meaning, such as gustatory and olfactory features. Using the fMRI technique, some researchers showed that passively reading olfactive-related terms, such as *cinnamon* or *eucalyptus*, elicited more activation in the primary olfactory cortex than words with neutral olfactive associated meaning (González et al., 2006); while processing taste-related words, such as *salt* or *pizza* (Barrós-Loscertales et al., 2012) or simply viewing food pictures (Simmons, Martin, & Barsalou, 2005) produced a great activation in the primary and secondary gustatory cortices. A similar investigation has been made about the neural representation of sound-related words. In an fMRI study by Kiefer and colleagues (2008), participants made a lexical decision on a set of words and pseudowords visually presented.

Crucially, all selected words denoted everyday objects but differed with regard to the relevance of sound contents: for half of the words, acoustic associations were high relevant (e.g., *telephone*, *dog*), while for the other half, acoustic associations were less relevant (e.g., *tree*, *table*). Then, in order to localize cortical regions that subtend the processing of non-linguistic auditory stimuli, participants were asked to passively listen to a set of real sounds (e.g., ring). The authors found that words with acoustic association triggered early activations in the superior temporal auditory areas, which anatomic overlap with the activation pattern observed in hearing real sounds. These results were corroborated by a study by Trumpp et al. (2013), which described a patient with focal lesions in the auditory cortex who displayed selective impairment in conceptual processing of words for which auditory-semantic features are highly relevant, suggesting that this area plays a functional role both in perceiving sounds and comprehending sound-related linguistic stimuli.

In the same vein, several neuroimaging and neurophysiological studies have extensively examined the link between the processing of objects and actions-related words within the activation of the motor cortex. For example, Chao et al. (1999) showed in a set of experiments that the naming of tools, but not of animals, has a functional correlate in the activation of the left premotor cortex, which is also activated when participants image to perform grasp movements with their dominant hand or produce features about objects. This evidence indicates that tool words semantically related to manipulable actions are rooted in the motor and premotor brain regions (e.g., Chao & Martin, 2000; Martin & Chao, 2001; Martin, 2007). Further support for the contribution of sensory and motor proprieties in conceptual representation was provided by a study by Fernandino and colleagues (2015), showing that a regression model derived from a set of 820 words defined across five semantic attributes (i.e., sound, color, visual motion, shape, and manipulation) could consistently predict the fMRI word-specific brain regions activation during a semantic categorization task. Interestingly, the authors further reported that at least some of these attributes are co-activated in higher-order association areas, reflecting a multimodal representation of conceptual knowledge in line with the embodied and grounded theories' predictions (Fernandino et al., 2016).

More fine-grained level investigations about the role of the motor systems in language comprehension have suggested that motor features conveyed by words are represented in a somatotopically organized map in frontal cortical areas in a way that captures the layout of the body parts normally used to execute specific movements (i.e., Semantic Somatotopy hypothesis, Pulvermüller, 1999). One influential contribution in support of this claim is the study of Hauk, Johnsrude, and Pulvermüller (2004) in which actions verbs related to specific body parts, such as words referring to the face (e.g., *talk*, *lick*), arm (e.g., *grasp*, *pick*), and leg (e.g., *kick*, *walk*) were presented in a passively reading task. Results of event-related fMRI showed a category-specific activation of motor and premotor areas that control corresponding movements of the tongue, fingers, or feet, suggesting that the conceptual meaning of action-related words is grounded in motor areas in an effector specific fashion. The somatotopy of action semantics in motor brain regions was also reported during comprehension of action sentences (Tettamanti et al., 2005; Aziz-Zadeh et al., 2006) as well as using different classes of action verbs and nouns (Kemmerer et al., 2008; Pulvermüller et al., 2009; Buccino et al., 2005).

Of paramount importance to supporting the claim of language grounding is whether the activation in modality-specific regions is causally involved in the language comprehension or may reflect a mental imagery process that follows meaning comprehension. In order to disentangle this possible criticism, researchers within the embodied and grounded framework have adopted neurophysiological methods to explore the time course of brain activation by assuming that sensory and motor activity should emerge within the same interval in which semantic processing occurs. For example, Pulvermüller, Shtyrov, and Ilmoniemi (2005) conducted a study using high-density MEG (i.e., magnetoencephalography) to investigate the spatiotemporal dynamics triggered by listening to verbs encoding actions related to the face and leg. The somatotopic mapping of semantic content in different premotor areas was found in response to word stimuli: Face-related verbs engaged inferior frontocentral areas more strongly than leg-related verbs, while an opposite activation pattern was found at superior central sites. Importantly, these activations can emerge as early as 150-250ms after the onset of critical linguistic stimuli, thereby contributing actively to the access of meaning that is manifested in the brain signatures evoked by the words (for similar evidence, see also Hauk et al., 2006; van Elk et al., 2010). This early motor brain response has been widely interpreted as an index of motor simulations triggered by words, which reflect automatic access to semantic content instead of deliberative post-comprehension processing. Therefore, it is argued that sensorimotor activations are a necessary component of semantic processing (for a different interpretation, see Mahon & Caramazza, 2008).

If it is the case that conceptual representation is mapped in our body systems, they should not simply be engaged when words are processed, but modifying their functional operations should affect the semantic processing of specific subcategories of words. This prediction was directly tested in an influential study by Pulvermüller, Hauk, Nikulin, and Ilmoniemi (2005) using transcranial magnetic stimulation (TMS). Subjects make a lexical decision task on words related to arm/hand actions (e.g., *to grasp*) and leg/foot actions (e.g., *to* *hike*) while after 150ms words onset TMS pulses were applied both on their hand and leg loci over the left hemisphere. The pattern of results showed a somatotopically facilitation mapping that led to easily recognizing action words when the concordant motor region was activated. Stimulation of the leg motor areas accelerated the processing of leg-related verbs; on the contrary, TMS at the hand motor regions induced faster responses to hand-related than leg-related verbs. In short, this study provides evidence that a brief activation of body-part motor areas facilitates the automatic retrieval of motor features in accordance with the word meaning.

Finally, evidence from brain damage studies has also contributed to confirming the causal role of sensorimotor circuits for semantic processing. A wealth of studies have reported semantic deficits restricted to the category-specific domain of living vs. non-living entities, which tend to be linked with distinct lesion sites. For example, damage in the frontal cortex (motor) and the temporal-occipital cortex (perceptual) differently impair the processing of tools and animals names, as they entail a different degree of relation with actions (e.g., Warrington & Shallice, 1984; Warrington & McCarthy, 1987; Humphreys & Forde, 2001). In a very recent study, Miranda et al. (2022) used behavioral and neuroimaging methods to explore action-semantic processing in a patient with a rare form of double cortex in motor regions. Compared to control subjects, the patient responded faster to action than to object concepts during a picture-word association task, and this advantage was accompanied by a hyperconnectivity in bilateral motor cortices, suggesting that the structural organization of motor networks might influence the processing of relevant category. Further, patients with massive lesions and degenerative brain diseases that affect their motor systems, such as Parkinson's disease (PD) and other types of dementia, also show severe impairments in the recognition of action-related words (among others, Kemmerer et al., 2012; Arévalo et al., 2007). Overall, neuroimaging results and patients' evidence presented in this section are consistent with the claim that language processing and comprehension are intertwined with, and dependent on, sensorimotor processes.

However, it should be noted that conflicting evidence has emerged in this area of research. For example, Humphries et al. (2019) recently found that PD patients were not selectively impaired in the comprehension of action sentences compared to sound sentences. At the same time, they showed a moderate impairment with predicate action metaphors ("The stock soared") but not with nominal action metaphors ("Fear is a roadblock"), contrary to the prediction that modality effects occur independently of the type of actions and sentences constructs (see also Raposo et al., 2009). A different line of research investigating color representation demonstrated that blind individuals, despite their limited color perception, are successful in communicating and making causal inferences about the color similarities (Kim et al., 2021) or color-emotion associations (Jonauskaite et al., 2020), indicating that color representation is not necessarily connected to direct visual experience. Similarly, apraxic patients demonstrate motor deficits in executing voluntary action involving objects or tools but unimpaired language ability in object naming and action recognition (see Negri et al., 2007; Mahon and Caramazza, 2005). The inconsistency of results seems to undermine the relevance of sensorimotor processes in language comprehension. I address this criticism below.

1.2.3 Are concepts reducible to sensory-motor activations?

Embodied and grounded cognition is not without criticisms and typically struggles with the charge of being a reductionist theory. At its most general, the criticism refers to the alleged claim that concepts are entirely reducible to sensory and motor representations. Some scholars are skeptical about considering that the neural activation in modality-specific systems triggered by words plays a constitutive role in conceptual knowledge. For example, Mahon and Caramazza (2008) (see also Mahon, 2015; Leshinskaya & Caramazza, 2016), although they recognized that conceptual processing reaches into sensorial and motor information, pointed out that this cannot rule out that the format in which a concept is represented is still a-modal and symbolic. According to the authors, in order to fully endorse the embodied view of language processing, one must first reject the alternative interpretation that the activation of sensory-motor systems is merely a by-product of lexical processing.

To illustrate their arguments, Mahon and Caramazza (2008) introduced an analogy with the automatic phonological encoding of unproduced words. Studies investigating speech production showed that similar-sounding words are rapidly retrieved even though the lexical item is not actually selected for production. For example, in a naming-picture task, responses were found to be faster when distractor pictures represent an item that is phonologically related to the target picture (hammock-hammer) than when it is phonologically unrelated (hammock-bottom). However, note the authors, this finding does not lead to drawing the inference that the meaning of concepts is constitutive by those words that are phonologically connected to it (Morsella & Miozzo, 2002; Navarrete & Costa, 2005). Following this analogy, the automatic activation of sensorimotor information during semantic elaboration could be a sort of 'Pavlovian' reflex due to contingent associations, such as performing a throw action and using the word *throw* to describe it. Mahon and Caramazza (2008) stated that the co-activation of the motor cortex when reading/hearing action-based words would not be a sufficient condition to infer that such activation is a necessary part of conceptual content. Instead, it would be explained through a model of spreading activation from an abstract conceptual level to sensorimotor input in the same way as in speech production information cascade from a semantic representation down to a phonological level.

The alternative explanation proposed by the authors to account for sensorimotor systems activation consists of the *Grounding by Interaction Hypothesis*, according to which conceptual processing does not depend in any way on sensorial modalities but interacts with them. Concepts would be represented in an amodal and symbolic format upon which specific instantiations of concepts are realized. Even though the authors acknowledge that sensory and motor information contributes to enriching the representation of concepts in a given situation, this information would not be constitutive of the semantic content of concepts. Interaction hypotheses assume that separate brain areas are used for processing conceptual and sensory modalities, such that abstract computations are sufficient for accessing meaning and interacting with adjacent sensorimotor regions only after a concept has been instantiated. To further support their hypothesis, Mahon and Caramazza (2008) reported evidence from neuropsychological studies of apraxia (i.e., an impairment in the use of objects that cannot be explained by basic sensory or motor impairments). Patients typically lose the ability to plan and voluntary execute movements with objects, while semantic conceptual knowledge related to the object remains intact (e.g., they can still name it or recognize the partmimesis associated with its use). Because conceptual deficits do not necessarily follow after sensory and/or motor impairments, the authors conclude that motor activation is irrelevant to semantic processing. Thus, embodiment, or at least its strong form, can be rejected.

On closer inspection, however, the argument for sensorimotor activations as entirely “ancillary” to language comprehension appears inconsistent for several reasons. As noted by Meteyard et al. (2012), the “spreading activation” hypothesis advanced by Mahon and

Caramazza (2008) is based on a problematic analogy. While spreading activation of phonologically similar words (e.g., hammer-hammock) in a picture-naming task is to be expected because production is part of the task, activation of the sensorimotor cortex is not that obvious and cannot be explained by spreading activation to motor units as no action is required to perform the linguistic task (p. 799). Furthermore, the hypothesis of passive spreading activation from amodal concepts to input/output levels can hardly account for evidence of semantic-specific impairments caused by local TMS pulse stimulations, where the spread of activation has been reversed from motor systems to semantic knowledge (Pulvermüller et al., 2005; Willems et al., 2011). Moreover, studies reported an early and automatic emergence of such activations (ca. 100-200ms), reflecting a joint and simultaneous contribution of sensorimotor systems to access meaning rather than the late post-understanding process (e.g., Hauk et al., 2004, see § 1.2.2).

The skepticism against embodied and grounded theories seems to be based on some misconceptions about its core assumptions. [7] First, at a broader level, the embodiment and grounding thesis refers to studying cognition in a new way from the classical paradigms, establishing an account of how cognitive processes utilize modalities, body, and environment. This does not imply the reductionist claim that conceptual processing is entirely constructed by sensory-motor processing. Although some scholars hold this minimal form of embodiment (e.g., Engel et al., 2013; O'Regan & Noë, 2001), the major approaches within the embodied and grounded framework do not agree with the assumption that concepts are no more than information that is represented within sensory and motor systems. Conversely, as will be further

[7] A detailed discussion about common misconceptions of embodied cognition can be found in Pulvermüller, 2003; in a special issue of *Psychonomic Bulletin and Review* about the Representation of Concepts, and specifically in the contribution of Barsalou, (2016) and the responses of Mahon & Hickok, (2016) and Leshinskaya and Caramazza, (2016).

clarified in the following of this dissertation, it has been pointed out that sensorimotor mechanisms in and of themselves are insufficient to explain concepts and conceptual processing, and that other sources of knowledge might be involved, such as language, internal, and affective states (e.g., Barsalou & Wiemer-Hastings, 2005; Reilly et al., 2016).

Second, the studies on neuroanatomical connectivity discussed in the previous paragraph clearly showed that language depends on – but does not reduce to – modality-specific systems, as higher intermediary associative areas are also needed to implement a multimodal compression of conceptual features carried across sensory and motor pathways (Pulvermüller, 1999; Fernandino et al., 2016; Simmons & Barsalou, 2003). As the semantic circuits are widely distributed over a range of cortical areas, including modality-preferential areas and multimodal regions, the circuits - and not the single brain areas - contribute to conceptual processing. Therefore, neurophysiological evidence on double dissociations between conceptual deficits and neural motor disease (i.e., either intact motor systems with a deficit in understanding action concepts or deficit in acting but intact actions concepts) do not prejudice the accounts of grounded cognition. It assumes a distributed neuronal network which, in case of local damage, can rely on the resources distributed over the circuit (see also the notion of "neural reuse" in Anderson, 2010).

Lastly, there is an inherent contradiction in arguing that conceptual processing is implemented using symbolic codes that interact and exchange information with adjacent sensory-motor areas and assume that language comprehension occurs in a distinct amodal region. What often is missed by the class of theories assuming amodal representations is a clear definition of what amodal concepts are; thus, it should not surprise that they have been ironically referred to as "the black holes in conceptual space" (Barsalou, 2016, p. 1127). Still, it is worth mentioning that scholars who endorse theories of amodal semantics have proposed that, at a neuroanatomical level, the Anterior Temporal Lobe (ATL) can work as the "hub" integrating all kinds of conceptual information (i.e., hub-spoken-model; Patterson et al., 2007; Rogers et al., 2004). Crucial evidence for this hypothesis comes from neurophysiological studies on Semantic Dementia (SD), focal brain damage in ALT that results in a generalized impairment of conceptual knowledge across all category domains and perceptual features. The functional role of ALT for language processing has been replicated in healthy individuals in which TMS stimulations in this area lead to a deteriorated performance in semantic tasks similar to the deficit found in Semantic Dementia patients (Pobric et al., 2007). However, the pattern of the results is quite controversial as the low local resolutions of fMRI only allow an indirect validation of the existence of single neural areas that hold symbolic (amodal) codes (for a discussion, see Simmons & Martin, 2009). Furthermore, recent evidence showed that other potential integrative areas contribute to conceptual processing (for metanalysis, see Binder et al., 2009; Wang et al., 2010) and that these areas functional couple with sensory and motor regions through a hierarchy of processing circuits ranging from a lower level of modality-specific areas to multimodal/heteromodal associations cortex (e.g., Kuhnke, Kiefer, & Hartwigsen, 2021).

Together with the previous arguments, these findings provide reasons for reservation about approaches assuming a stand-alone "amodal region" dedicated to semantic representation; and favor embodied theories that intend associative regions as areas where *multi*-modal information converges, playing a functional role in language processing.

1.3 The ‘hard nut to crack’: the semantic grounding of abstract concepts

By focusing on the meaning of object nouns and action verbs, the evidence discussed in the previous paragraphs is confined within a conceptual realm that appears to be solidly grounded in the body and physical world. What about words used to speak about not physical, touchable entities, namely concepts usually termed as “abstract”, such as *freedom*, *idea*, or *justice*? Abstract concepts posit a serious challenge to grounded cognition theories, which assume that conceptual representation is essentially rooted in multimodal simulations tied to perceptual and motor states. Some of the questions animating the debate are: How could concepts without perceptible and manipulable referents rely on modality-specific systems? How are they coded in the brain? Or, more generally, how can abstract language be grounded in bodily experiences? The mere existence of concepts that have an intangible character seems to falsify EGC accounts and leave room for some forms of amodal symbolic representations (e.g., Dove, 2009; Dove, 2016; Mahon & Caramazza, 2008).

Over the last decades, several theoretical accounts have been offered to address the inquiry of abstract concepts representation within the embodied and grounded framework. This section aims to outline some of these seminal proposals critically evaluating the evidence supporting them and bringing out their strengths and weaknesses. The literature review does not pretend to be comprehensive, but it is limited to sketching out some very influential theories, focusing on embodied ones. In what follows, I will first clarify the notion of an abstract concept, showing that it could be itself problematic for all theories of cognition and conceptual processing, including the amodal ones. Then, I will briefly illustrate classical theories that focus on the cognitive and neural distinction between abstract and concrete concepts. Finally, I will review theories that strived to account for abstract concepts embracing either a fully or partially embodied perspective, identifying specific contents and mechanisms in which they can be grounded, such as metaphors, actions, situations and introspection, and emotions. Here, I intentionally omit the new frontiers of this flourishing debate, namely a set of recent proposals called “Multiple Representation Views” (MRWs), to which special attention will be paid in the next Chapter.

1.3.1 What does it mean for a concept to be abstract?

> Abstract art places a new world, which on the surface has nothing to do with “reality,” next to the “real” world. Deeper down, it is subject to the common laws of the “cosmic world.” And so a “new world of art” is juxtaposed to the “world of nature.” This “world of art” is just as real, just as concrete. For this reason, I prefer to call so-called “abstract art” “concrete art”.

The famous painter Kandinsky used these words to face criticisms from both the public and other artists on the new art movement known as “abstractionism”, of which he was one of the early proponents. What is worth noting about his declaration is the idea that abstraction transcends concrete reality; nevertheless, it is much more enclosed into it than what appears at first glance. Although the object under discussion is different, scholars embracing simulation-based theories struggle similarly to explain abstract concepts and how they can be grounded in the physical world as concrete concepts are. For the sake of this dissertation, it might be helpful to follow the example brought by the artist and start by defining what an abstract word is.

“Abstract” is itself a nebulous concept. It is often associated with something vague or cannot be easily grasped both physically and mentally. However, abstract words represent a vast and multifaced semantic universe, as indicated by the fact that a high percentage of the English lexicon is relatively abstract in content (Lupyan & Winter, 2018). Consider, for instance, that some of the words I have already used in this paragraph, like *art, pioneer, discussion, struggle, criticism*, fall all under the label “abstract”.

To bring the topic of this dissertation into focus, a caveat is needed. That is the distinction between *abstraction* and *abstractness* introduced by Borghi & Binkofski (2014). To some extent, all words are abstract in that they arbitrarily stand for their referent through a set of symbols. From a cognitive standpoint, the abstraction mechanism is at the base of all categorization processes. For example, in order to categorize an object as a dog, some salient properties need to be extracted from the single instantiations and then unified under the same general concept of “dog”, although some of the exemplars of the category might not be similar at all (think of a dachshund and a Great Dane). The degree of abstraction becomes even more prominent at the superordinate categorization level, as in the taxonomic classification of “dachshund”-“dog”-“mammal”-“animal”. Thus, “animal” has a higher level of abstraction than “dog” because it collects instances that share a few general properties (e.g., being alive); despite that, each instance of this category still denotes material and tangible entities. In this context, the word “abstract” literally means pulling something out from something other, and *abstraction* relates to a general process through which any concept is formed. On the contrary, *abstractness* does not refer to the extremes of a conceptual hierarchy; but indicates those concepts that lack a physical referent, which can be perceived or interacted with.

It should now be clear that embodied and grounded cognition approaches struggled in framing *abstractness*, specifically the property of referent of a given concept to being detached from the sensorial reality. A standard criticism raised against EGC is that it is an incomplete theory due to providing a satisfying account for concrete concepts but not for abstract concepts. However, as already noted elsewhere (Borghi et al., 2017; Bolognesi & Steen, 2018; Barsalou, 2020), abstract concepts impose challenges for any theories of cognition. Proposing that amodal symbols represent abstract concepts or that meaning is derived from the statistical co-occurrence of words in the language, as argued by distributional theories (Andrews et al., 2014; Louwerse & Jeuniaux, 2010), does not solve the problem of symbol grounding mentioned before (Harnad, 1990). Roughly speaking, in order to avoid circularity, symbols and words need to be linked with anything in the "world" but other arbitrary symbols. Moreover, the necessity of amodal symbols does not follow by the default from the assumption that abstract concepts cannot be grounded in sensorimotor systems, mainly because no direct evidence of amodal symbols in our cognitive system has been provided (Barsalou, 2016).

Notably, the theoretical definition of abstract concepts does not always offer many insights into the object defined, especially as expressed in a negative way. Within the framework stemmed from grounded approaches, the negative definition of abstract concepts as to be essentially "everything that is *not* concrete" appears both misleading and unproductive since it is not informative of their semantic content (Barsalou, Durieux, & Scheepers, 2018). On the one hand, it does not take into account that, in principle, each concept can integrate complex elements – both concrete and abstract – of the situations in which it is experienced. For example, the abstract concept of *art* includes, among their meanings, the experience of beauty, but it is generally implemented through material artifacts (e.g., painting, sculpture) or bodies (e.g., dance, drama). Conversely, even the most concrete concepts include considerable amounts of abstract content. For example, the concept of *book* certainly refers to a concrete object that contains written pages, but its meaning goes beyond its material attributes: It is mainly a medium of knowledge or can even convey a sacred value, as in the case of the Bible.

On the other hand, the sharp distinction between abstract and concrete concepts focusing only on superficial differences in the presence/absence of perceptual elements left aside other sources of information that might contribute to their representation (see Chapter 2).

For these reasons, in the course of this dissertation, the use of “abstract concepts” and “concrete concepts” must be conceived as a simplification and operational definition, bearing in mind that those who write do not assume such marked distinction; instead, it is in continuity with recent attempts to refine this standard classification (e.g., Borghi et al., 2017, 2018; Barsalou et al., 2018; Barsalou, 2020).

1.3.2 In the beginning, there were concrete and abstract concepts

One of the most common ways of formalizing the idea of a distinction between abstract and concrete concepts is found in the influential concreteness norms by Brysbaert and colleagues (2014), who gave participants the following prompt to rate the words: “Some words refer to thinks or actions in reality, which you can experience directly through one of the five senses. We call these words *concrete words*. Other words refer to meaning that cannot be experienced directly but which we know because the meanings can be defined by other words. These are *abstract words* […]” (p. 996, italics mine). This description suggests that the concrete and abstract concept representations rely on different sources of knowledge, one based on perceptual experiences and the other exclusively based on language.

This distinction can be traced back to two classical theories in psycholinguistic research: The Dual Coding Theory (DCT; Paivio, 1986; 1991) and the Context Availability Theory (CAT; Schwanenflugel, Akin, & Luh, 1992; Schwanenflugel, Harnischfeger, & Stowe, 1988) Both these seminal theories aimed at explaining the findings usually referred to as *concreteness* *effect*, viz., the processing advantage of concrete words over the abstract words, like being recognized faster and accurately in a variety of tasks, such as lexical decision, word naming, and recall (James, 1975; Whaley, 1978; Rubin, 1980).

The DCT maintains that word meanings are represented in two distinct cognitive systems, one linguistic-verbal and another iconic-no-verbal. These two independent but interconnected systems are characterized by different internal representation units, both with modality-specific activations. The first contains *logogens*, i.e., linguistics units representing the phonological and orthographic form of words, which are interwoven among them by associative links (e.g., the meaning of “telephone” is liked to words like “ring”, “call”, “number”). The second contains *imagens*, i.e., iconic representations for the modality-specific aspects of a concept (e.g., the word “telephone” also includes visual, acoustic, tactile, and motor features of telephones). According to Paivio, while concrete concepts equally activate verbal and nonverbal systems, abstract concepts depend more substantially on the verbal system. In other words, abstract and concrete concepts differ in the richness of their representation: Concrete concepts have a direct connection to images; abstract concepts, on the other hand, evoke first a verbal association and only then the respective images. Borrowing the Paivio example, the concept of “religion” might evoke an image only by the mediation of the related concrete word “church” (Paivio, 2007, p. 46). In this view, the dual codification and the consequent major amount of information trigged by concrete concepts should be at the basis of their advantage in RTs and accuracy over abstract words.

The CAT proposed an alternative explanation, according to which the difference between abstract and concrete concepts lies in the degrees of accessibility to their meaning as stored in semantic memory in a-modal format. This model admits a single processing mechanism based on the verbal system, according to which to capture the meaning of either abstract or concrete word requires accessing the set of related linguistic and semantic associations. Crucially, the context in which a word could appear provides some elements to understand its meaning. While concrete concepts tend to be strongly and univocally linked to a restricted number of contexts, abstract concepts are weakly associated with a broader range of contexts. Saffran and Sholl (1999) exemplified this difference by contrasting the word “rose”, which always refers to a kind of flower, with the abstract word “phase”, which meaning varies with the context in which it appears (e.g., *phase of the moon* and *phase of development*). Therefore, when presented in isolation, it is easier and faster to access concrete words than abstract ones because the latter requires more effort to activate appropriate interpretation, and this difficulty is reflected in slower processing. Crucially, when contextual constraints are provided, the disadvantage of abstract concepts disappears, and they are processed just as efficiently as concrete words (Schwanenflugel & Shoben, 1983; Schwanenflugel et al., 1988).

Even though these seminal proposals cannot be appropriately ascribed within embodied and grounded accounts, it is important to consider their implication for the current debate. Apart from their differences, both the DCT and CAT theories postulated a binary distinction between concrete and abstract words, where the former are considered perceptually richer and relatively more stable than the latter. A large body of studies framed on these two models has been conducted to examine processing differences between abstract and concrete concepts at both behavioral and neural levels. However, there are some inconsistencies that do not lead to unequivocal conclusions.

In some cases, psycholinguistic research failed to replicate the concreteness effect (Barca et al., 2002; Papagno et al., 2007), in others reported a reverse “abstractness effect” viz., the advantage of abstract concepts over concrete concepts in a lexical decision task, once controlled stimuli for imageability and contextual availability (which are the two psycholinguistic variables associated to DCT and CAT, respectively; Kousta et al., 2011). Furthermore, the central tenets of both models were not borne out by the results of Connell and Lynott's (2012) norming study in which a set of 592 words were rated not only on concreteness and imageability but also on the strength of perceptual experience evoked in each five modalities of vision, touch, taste, smell, and sound. Contrary to CAT prediction, the authors found that concepts with higher perceptual strength, generally assumed to be concrete, appear in a wider number of contexts than low perceptual concepts. In contrast to DCT, instead, results show that imageability is only weakly correlated with perceptual information. Further, compared to perceptual strength, imageability ratings did not offer an accurate prediction of processing performance: Rather than reflect the degree to which concepts are concrete or abstract, it seems visually biased by focusing only on the experience of arousing mental image. The authors concluded that perceptual strength in individual modalities is an important predictor of how people experience concepts across the abstract-concrete continuum, better than concreteness and imageability (see also Lynott & Connell, 2013). Recently, Pollock (2018) put forward some potential problems with the high variability of semantic psycholinguistic variables typically used to select stimuli, such as concreteness or imageability. Specifically, many studies tend to include in the range of concreteness scale only high concrete concepts with scarce variability across participants (low standard deviations) and intermediate abstract concepts with high variability across participants (high standard deviations). This led to no clear-cut differences between abstract and concrete words, thereby potentially explaining the inconsistency of these results.

Results on the neural correlates of abstract and concrete concepts are also very mixed. Findings from neuroimaging studies are more compatible with Dual Coding Theory, which posit two distinct conceptual systems for abstract and concrete concepts, than with Context Availability Theory, which admits only one system with a-modal structure. The outcomes of two recent meta-analyses of fMRI and PET studies (Binder et al., 2005; Wang et al., 2010; see also Wang et al., 2018) converges in highlighting a strong left-hemisphere activation in the language network areas for abstract concepts (ATL, left anterior temporal lobe; LIFG, left inferior frontal gyrus), and a bilateral activation for concrete concepts, specifically brain areas associated with visual-semantic features and spatial attention (i.e., left fusiform gyrus; bilateral posterior cingulate gyrus). Other studies, instead, have reported activity in sensory-motor systems for both concrete and abstract words (Pexman et al., 2007). The results of a study by Hoffman and colleagues (2010), which combined neurophysiological and rTMS methods, seem to fit well with the model proposed by the CAT theory. The authors investigated the processing of abstract and concrete concepts in brain-damaged and healthy subjects manipulating conditions in which contextual cues could be present or absent. Results of the semantic similarity task showed that the performance of patients with lesions in LIFG, which is a brain area generally associated with strategic semantic control, significantly improves with abstract concepts in relevant cue conditions compared to no cues conditions, while this effect was relatively small with concrete concepts. Healthy subjects who performed the same task while held an rTMS stimulation on the target site were slower to respond with abstract words only when those words were given without relevant contextual cues, while no variation in RTs was observed with concrete words. These findings support the hypothesis that the engagement of the linguistic brain area facilitates comprehension of abstract concepts, especially in the absence of a coherent context (see also Hoffman, Binnery, & Lambon Ralph, 2015).

Neurophysiological research has also fostered the hypothesis of distinct brain systems for abstract and concrete concepts. Evidence has mainly been based on double dissociations caused by two syndromes (for a review, see Shallice & Cooper, 2013). The first syndrome is deep dyslexia following left hemisphere damage, in which the most prominent symptom is a disorder of reading aloud, but the semantic errors are more frequent with abstract than concrete items (e.g., Plaut & Shallice, 1993). The second is the herpes simplex encephalitis (Warrington & Shallice, 1984) and Semantic Dementia (e.g., Warrington, 1975; Bonner et al., 2009) caused by neurodegenerative bilateral atrophy of the ATLs, which results in better processing of abstract rather than concrete concepts (i.e., reverse concreteness effect). These findings have been typically interpreted as evidence that abstract and concrete concept representations rely on separate systems organized through qualitatively different principles. Concrete terms tend to be structured into taxonomic, hierarchical categories defined by a set of features, such as the concept of *bicycle* is characterizable as "is a vehicle", "has wheels and handlebar"; whereas abstract concepts can only be accounted for by logical functions, owing to the semantic associative or thematic relation with other words, such as the concept of *democracy* is defined as "political system (*government*) in which power lie in a body of citizen (*electors*) who can elect people to represent them (*president*)" (e.g., Crutch & Warrington, 2005; 2010). Because of their reduced numbers of features, abstract words generate a weaker representation compared to concrete concepts, thereby requiring high-level computational operations, which likely occur in brain regions linked to language systems (ATL was often referred to as "a-modal semantic hub"; e.g., Rogers et al., 2004; Patterson et al., 2007).

This pattern of results should be treated with caution. Firstly, the reverse concreteness effect has been reported only in single case studies making it difficult to generalize to typical cognitive systems. Secondly, other studies showed that semantic dementia is caused by a gradual degradation which expanse in the temporal and frontal cortex and subcortical regions, and it is not limited to ATL (for a discussion, see Martin, Simmons, Beauchamp, & Gotts, 2014). Further evidence challenged the idea that the reverse concreteness effect is a typical index of semantic dementia across all abstract categories. For example, a null reversed concreteness effect was found in SD patients who preserved understanding of quantifier words and number representations (Halpern et al., 2004; Cappelletti, Butterworth, & Kopelman, et al., 2001). Crucially, Hoffman and Lambon Ralph (2011) conducted a detailed study investigating the performance of patients with a different range of semantic dementia diagnoses on several linguistic tasks, such as synonym judgment, verb similarity, word-picture and noun/verb description matching. Their results pattern conforms to the normal trend of worse performance with abstract than concrete words.

To sum up, a long-stand tradition posited an ontological distinction between concrete words that have immediately perceived referents and abstract words that lack well-bounded and material referents. However, evidence supporting separate cognitive systems for abstract and concrete concepts is extremely variable and conflicting. Some of the discrepancies in neuroimaging and behavioral results could be methodological issues as studies differ in the experimental designs and analyses adopted. In particular, the absence of universal criteria for selecting stimuli raises difficulty in comparing the results. In the last years, researchers endorsing an Embodied and Grounded cognition perspective have significantly contributed to reframing the traditional distinction between abstract and concrete concepts with the aim of demonstrating that overall concepts can be grounded in bodily experiences and sensorimotor systems.

1.3.3 Grounded theories of abstract concepts. A brief review of a long debate

In the following sections, I will present a theoretical review covering the main approaches that in the last decades expressly dealt with abstract concepts representation from an embodied and grounded perspective. As will be specified below, all of the approaches have provided new insights into the representation of concrete and abstract concepts; however, some have emphasized their similarities, arguing that they are based on the same grounding processes, others have turned their attention to the specific attributes that might be responsible for their differences (for an in-depth discussion of these theories, see Borghi et al., 2017).

1.3.3.1 Abstract thinking is metaphorical

People frequently talk about one thing in terms of another. One refers to *love* relationships as a *journey* that lovers embark on to go toward the same destination, even though they encounter some obstacles along the way. One could also describe the dynamic of an *argument* as a verbal *war* in which speakers aim to defend their opinions and demolish those of the others. These are only some examples of conceptual metaphors reported by Lakoff and Johnson (1980) in support of their Conceptual Metaphor Theory (CMT), which can be considered one of the first attempts to apply the grounding cognition theory to abstract concepts.

Starting from the analysis of the English common lexicon, the authors argued that metaphors are not mere figures of speech; rather, they structure our thought, helping us to grasp ideas that would not immediately be understood otherwise. Lakoff and Johnson noted that, as in the case of the examples introduced before, most of the linguistic metaphors are used to express abstract concepts: The metaphor of *love as a journey* is exemplified by sentences such as “We are at a crossroads” or “Look how far we have come”; while the linguistics manifestations of the metaphor *an argument is a war* might be expressions like “He attached every point of my thesis” or “Your claims are indefensible”.

The main idea underlying the CMT is that human thought is fundamentally metaphorical, and we systematically communicate complex ideas by analogical extensions from our own experiences. In this view, conceptual metaphors are conceived as conventionalized cognitive structures based on a mapping relation from a source domain to a target domain, where the source domain concepts are taken to be literal and concrete (*vehicles*), and the target domain concepts are figurative and abstract (*topics*). Because the structure of the two domains entails a fixed correspondence, this theory accounts for abstract concepts referring to the same processes engaged in representing concrete concepts. That is, in order to construct mental representations of abstract concepts, we need to rely on more concrete knowledge we have experienced in a direct way. Since concrete concepts are based on sensorimotor experiences, in a second step, the sensorimotor systems can be used to represent abstract concepts in linguistic structures which map specific meanings. Ultimately, in this frame, even though via an indirect process, abstract concepts seem to be grounded in sensorimotor systems as well as concrete ones are (for a discussion, see Pecher, Boot, Van Dantzig, 2011).

In order to illustrate this grounding process, Lakoff (1987) proposed that the conceptual mapping is built on a set of primary metaphors called *image schemata* that provide the fundamental structure of our conceptual system. A clear example of an image schema is the "more is up and less is down" one, which recurs in many metaphorical expressions in our everyday language, e.g., infections are *rising*, the medical resources *have fallen*. In this case, the metaphor of verticality is used to spatially map the more abstract domain of quantity. The correlation between the two domains is formed through empirical observations of structural co-occurrences of events. Consider the basic example of pouring a liquid into a container: the more water is added into a glass, the more the liquid in the glass grows up. During the conceptual mapping, the image-schema recording sensory-motor activities are preserved and transferred to the mental representation of even more abstract notions, such as the pandemic disease issues, that can be understood as they make use of the same image schemata directly related to our experiences of verticality.

That conceptual metaphor is employed as a vehicle for the grounding of abstract concepts has been supported by a variety of linguistics and behavioral evidence. For example, verticality was found to refer to the abstract notions of power or good/bad. In a set of experiments, Giessner and Schubert (2007) showed that the vertical spatial dimension influences the perception of authority. Participants were presented with a brief story on leadership in a fictive organization while observing a pictorial representation of a manager and his subordinates displayed as boxes connected by lines in a standard tree diagram. In keeping with the metaphoric relation of powerful is up/powerless is down, the authors found that increasing the vertical, but not horizontal, distance between boxes led participants to judge the leader as more powerful. Other studies have examined how verticality is used to refer to other abstract entities or events. Meier et al. (2007) demonstrated that participants memorized faster the location of God-related pictures when presented in a higher portion of the screen and devil-related pictures when presented in a lower location with respect to opposite conditions. Similar results were reported by a study focused on the moral domain, in which the high vertical position facilitated the processing of moral-related words more than that of the immoral-related words (e.g., charity vs. molest; Meier, Sellbom, Wygant, 2007). Overall, these findings support the view that abstract concepts are comprehended by mapping their meaning into more perceptible experiences, as shown by the metaphorical schemata of "God is up/ Devil is down" or "up is good and down is bad".

A considerable amount of research has investigated the abstract domain of time in the light of Conceptual Metaphor Theory. The main idea is that, since time transcends physical reality (it cannot be touched, seen, or smelled), we have developed a mental representation of temporal phenomena from a more experiences-based domain of space. Some key examples of how the abstract concept of time is understood by placing it in the concrete domain of space are cultural artifacts like hourglasses, graphs, clocks, or calendars. Our language is full of expressions in which spatial words are employed to convey the temporal duration of events, e.g., "The end of the holiday is getting closer" or "Don't look backward. Life is too short!". Of particular interest are findings that showed an asymmetrical relation between these two domains: we tend to speak about time in terms of space more frequently than we speak about space in terms of time. This is probably because the space movement of objects is immediately accessible through senses, while the time-passing can only be inferred by its consequences on the events. Based on these observations, scholars have investigated whether people automatically generate spatial representations when thinking about time. For example, Casasanto and Boroditsky (2008) conducted a series of experiments to demonstrate that the metaphorical relation between space and time is not limited to language expressions but exists at a more basic level of human conceptual systems. Using non-linguistic tasks, the authors analyzed the representations of distance and duration by asking participants to estimate the duration of movements of dots presented on a screen in different spatial displacements. Their findings showed that spatial information of distance covered by dots, even if irrelevant, influenced judgments on the time duration, while the converse was not true.

Other studies focused on the conceptual metaphor of "time as an object moving towards/away from us" commonly adopted in Western society, according to which the time spans across events that move backward (past) and forward (future). Boroditsky and Ramscar (2002) presented English participants with ambiguous sentences like "Next Wednesday's meeting has been moved *forward* two days", in which the word *forward* can be interpreted either as a movement of the subject or of the time. Before answering the question about when the meeting has been rescheduled, participants were shown pictures in ego-moving perspective (an observer moving in the direction of an object) and in time-moving perspective (an object moving in the direction of the observer). Results showed that the participants primed by a stationary observer tended to answer "Monday" adopting a time-moving perspective, while those primed by an observer moving along the timeline responded more frequently "Friday", hance adopting an ego-moving perspective. These findings suggest that spatial metaphors used at the moment can play a causal role in how people construct a representation of time.

A variety of cross-cultural studies have also shown that the way people mentally organize time depends on the spoken language, and specifically on the differences in spatial terms used to speak about time (for a review, see Boroditsky, 2011). Applying the same paradigm described above, Lai and Boroditsky (2013) found that English and Mandarin speakers tend to adopt a different perspective on time, with Mandarin speakers more likely to take the time-moving perspective. Consistently, linguistic analysis of metaphors used in the two languages showed that Western speakers conceptualize time across a front-back axis, where the past is something behind us, while the future is something ahead of us; in contrast, Chinese Mandarin speakers construct a vertical representation of time in which the past is up, and the future is down. A striking reversal of temporal flow has been documented in the Aymara population in a study by Núñez and Sweetser (2006), in which both linguistic expression and gestural data were analyzed. When talking about events in time, the Aymara population showed a spatial metaphor of time that is reverse to most Western cultures: They put the future behind them, while the past is in front of them, and this pattern is reflected in spontaneous co-speech gestures they produce.

Without a doubt, the Conceptual Metaphor Theory has contributed to the debate on the problem of abstractness and its standing as one of the well-established embodied approaches to abstract concepts. Besides the evidence discussed in this section, further studies yield support for the idea that metaphorical mapping provided “an anchor” to form and use abstract concepts through sensorial experiences. However, several questions remain unsolved.

One potential problem is that this proposal does not provide a plausible explanation of how abstract concepts are acquired. Indeed, evidence suggested that comprehension of metaphors occurs relatively late: Children start to use metaphors only around 8-10 years, even without fully grasping their sense (Winner et al., 1976), while being able to use abstract concepts correctly at an early age. Further, recognizing abstract concepts by mapping them into concrete concepts seems to be possible only if the target domain is already known, hence by a prior understanding of the concept. Still, it might be difficult to foresee how this approach handles all kinds of abstract concepts as no concrete domain seems suitable for mapping concepts with a high level of abstractness, like “respect” or “philosophy”. Finally, image schemata highlight the common and basic features of conceptual content without detecting their essential differences: for example, the metaphors of *journey* can serve as a source domain to conceptualize both *love* and *life*, even though they do not represent the same things; and the *up/down* schema is used to refer the notion of *power*, which likely not exhausted its meaning.

1.3.3.2 Language is (for) action

Scholars that relate language to action have proposed a straightforward approach to the grounding of abstract concepts. At a general level, action-based theories assumed that language calls upon the same neural mechanisms used in planning and performing actions, as words function basically as a guide for interacting with the environment (for a review, see Fischer & Zwaan, 2008). In the light of neuroscience evidence on mirror neuron mechanism, Gallese and Lakoff (2005), for example, claim that understanding of words or phrases (e.g., “to grasp”) implied the activity in primary sensory and motor cortices which is used to represent semantic content through simulation of direct experiences (e.g., grasp a cup, grasp a ball). Because the simulation process is implemented in the sensory and motor brain systems, conceptual representation is considered completely dependent on sensorimotor information, which is a necessary element in language comprehension.

In this vein, an influential proposal is the *Indexical Hypothesis* by Glenberg and Robertson (2000), which conceived words as *indexed* to objects in the sense that they are directly mapped to objects/events or analogical perceptual symbols (see also Barsalou, 1999). This view proposed that language comprehension is made possible to a reader to the extent that s/he cognitively simulates whatever the language describes, and that this simulation necessarily requires activation of bodily experiences. This hypothesis has been assessed in relation to action sentence comprehension, assuming no substantial differences between concrete and abstract concepts.

Evidence supporting this view mainly stems from the *action-sentence compatibility effects* described in the previous sections (ACE, Glenberg & Kaschak, 2002; Glenberg et al., 2008). The ACE shows that people react to a sentence faster when they perform a movement that matches the direction of action described by the sentence. In the study by Glenberg and Kaschak (2002), the authors reported a second experiment showing that ACE is extended to abstract concepts. Specifically, participants were equally facilitated by moving the arm toward themselves to respond to sentences that describe transfer action that implied concrete objects, like “Courtney handed you the notebook” or abstract entities, like “Liz told you the story”. This result was corroborated in a subsequent study by Glenberg and colleagues (2008) using TMS techniques to measure the index activity in the hand motor system during the reading of sentences including transfer verbs, such as “give”. Overall, they found a larger Motor Evoked Potentials for transfer sentences compared to no-transfer sentences, suggesting that activation of motor systems is modulated by linguistic content. Importantly, no difference in the size effect was found between sentences referring to the transfer of physical objects (e.g., give the card) and to the transfer of abstract information (e.g., give responsibility). The authors interpreted these results as evidence that the comprehension of both abstract and concrete transfer sentences is influenced by the concomitant activation of the motor system to simulated semantic content, leading to facilitation when the direction of responses is compatible with the direction of sentences presented and interference when the direction is incompatible. Similarly, in an fMRI study, Boulenger et al. (2009) found that idiomatic and literal sentences including action words (e.g., “grasp” in “He grasped the idea” or “He grasped the cup”) lead to the activation of similar brain motor regions within a time window of 150-200ms. This result further supports the idea that comprehension of transfer involves an automatic simulation process in which the motor system is used to simulate specific actions, even in figurative/abstract language.

The evidence discussed has been taken to argue that grounding in perception and action is not solely limited to concrete concepts but is also possible for abstract concepts, as they rely on similar processes. The explanation proposed by Glenberg and colleagues (2008) is based on what they call “action-schema”, a mechanism that provides a coherent organization and interpretation of events. In their perspective, action schema initially develops to recognize and control acts at a physical level (e.g., grasp, throw), and then is generalized to understand the language used to speak about similar events at a more abstract level (e.g., inform, announce) (see also Glenberg & Gallese, 2012).

Although this proposal is broadly consistent with an embodied approach to abstract concepts, it is likely not sufficient to apply to all their varieties. While the reported results fit well with words that refer to kinematic movements or transfer actions that can be easily mapped into action schemas, they can be hardly generalized to more abstract words, such as “truth” or “empathy”, that do not necessarily imply similar motor processes. Furthermore, the recent problems in replicating ACE have severely questioned this approach (Zwaan, 2021).

1.3.3.3 Situational contents of abstract and concrete concepts

Although to a different extent, both theories discussed in the previous paragraphs have addressed the problem of abstractness, focusing on mechanisms at the base of abstract and concrete concepts representation. Some argued that the entire language is action-based

(Glenberg & Kaschak, 2002; Glenberg & Gallese, 2012), others assumed that abstract concepts are understood by mapping them to concrete knowledge domains (Lakoff & Jonson, 1980). Does that mean that abstract and concrete concepts can be equated with one another, or can they be grounded in perception and action but still differ in some respects?

The perspective I will present in this section gives important insight into this question. This approach first challenged the standard distinction between abstract and concrete concepts by describing the specificity of their semantic contents adopting a situated simulation approach. In line with the context availability model (Schwanenflugel et al., 1992; § 1.3.2), Barsalou and Wiemer-Hastings, (2005) claimed that the meaning of concepts is never established in isolation, rather against background situations that provide relevant information to understand and interpret their appropriate use in specific contexts. Hence, a first hypothesis is that concrete and abstract concepts activate in equal measure situational contexts, which are necessary for understanding all kinds of concepts. The examples provided in their article clarify why the role of situations is not limited to the access to the meaning of complex abstract concepts – that typically benefit when presented in context – but also to concepts directly related to their referent. As Barsalou and Wiemer-Hastings notice (2005, p. 134), to gain a complete understanding of concepts like HAMMER, it is not sufficient to know that it is constituted by a head and a handle, as its physical parts do not allow to infer how and for what proposes we should use this object. What is needed to master the category of HAMMERS is information derived from the observation of their use in specific settings; for example, that they are suited to pound nails into a wall for hanging a picture or to tap two broads together and are generally employed to fixed things. Situations assume an even more central role when applied to abstract concepts. From the semantic analysis of the concept of TRUE, Barsalou

(1999) noticed that its meaning required the integration of multiple situational components, including different agents, their mental events, and current states of the world.

Based on these observations, Barsalou and Wiemer-Hastings advanced further promising hypotheses. First of all, they proposed that even if being equally related to situations, abstract and concrete concepts differ in the type of proprieties activated, which in turn influence their representation: Concrete concepts focus mainly on objects in situations, hence their representation tends to be circumscribed spatially in narrow settings (e.g., hammer uses); in contrast, abstract concepts encompass sparse configurations of events and introspective states, distributed across a broad range of situations (e.g., the truth of a statement, the truth of the matter). Given the variety of situations evoked by abstract concepts, their representation should be more complex than that of concrete ones. Finally, in keeping with the embodied and grounded claim, the authors posited that our modality-specific systems capture all of the content experienced in situations and then later simulate these contents to represent concepts. Among them, the introspective experiences, including emotions, inner states of the body, and cognitive operations, would be significant for abstract concepts.

To test these hypotheses, Barsalou and Wiemer-Hastings (2005) used a features generation task in which participants were asked to produce typical proprieties for three abstract (*truth*, *freedom*, *invention*), three concrete (*sofa*, *bird*, *car*), and three intermediate concepts (*farming, cooking*, *carpeting*). Results confirmed their predictions: Regardless of the type of concepts, people generated a large number of proprieties related to situations and contexts in which a given concept occurs. Interestingly, in considering the coding properties, they found that the two kinds of concepts rely on different situational information: Concrete concepts tend to evoke physical properties of entities, while abstract concepts elicited high proportions of settings/events and introspective situations (i.e., a reflective looking of cognitive operations, intentions, mental states as well as affective evaluation of an agent in a specific circumstance). Overall, results showed that concrete concepts depend on spatially restricted elements of situations, such as locations and typical actions, whereas abstract concepts representation increases in complexity, including more information, contingency relations, and introspective states (e.g., agents, communicative acts, affect, social institutions, and belief). By this finding, the authors conclude that abstract and concrete concepts equally appeal to the simulation of situational components, but differences exist in their contents and complexity. Wiemer-Hastings and Xu (2005) provided further evidence of this using a similar paradigm on a larger sample of 18 abstract and 18 concrete concepts spanned across six abstraction levels. Participants were asked to characterize the properties and the situations/contexts usually associated with each concept. Consistent with Barsalou and Wiemer-Hastings (2005), the authors found a qualitative and not quantitative difference between the concepts: indeed, both abstract and concrete words evoke situations but differ in their foci with abstract concepts elicited fewer intrinsic properties of items and more subjective and relational experiences than concrete concepts.

Even though there is a limited body of evidence supporting this approach, what is interesting to note from these studies is that the role of context and its components vary as a function of specific concepts. Moreover, this proposal has the credit of having enlarged the debate on abstract concepts by pointing out that other sources of information, besides perception and action, may be responsible for their representation and that introspective and inner experiences seem to play a central role.

1.3.3.4 The emotional substrate of abstract concepts

A recent line of research emphasized the role of affective and emotional experiences as a crucial source of information for learning and representation of abstract words. According to the framework outlined by Vigliocco and colleagues (2009), there are two general classes of knowledge that contribute to conceptual processing, namely *experiential-based* information and *linguistic-based* information. The first includes experiences derived not only from sensory and motor activities with the external world but also from affective and internal states; instead, the second refers to verbal associations arising through patterns of lexical and syntactic co-occurrence. In this view, what differentiates concrete and abstract concepts are the different proportions of information from which they are formed; specifically, whereas concrete words rely to a great extent on perceptual and motor information, abstract words rely primarily on linguistic and affective information, both in their acquisition and their subsequent representation and use.

Theorists favoring this proposal also argued that affective and emotional information, rather than language *per se*, can be thought of as a diagnostic feature of abstract concepts (e.g., Kousta et al., 2009; 2011; Vigliocco et al., 2013; 2014). The basic idea is that abstract concepts are more emotionally connotated than concrete concepts, and that emotional information is an integral part of the acquisition and processing of abstract terms. This claim was addressed both via behavioral and brain-imaging studies.

In a lexical decision experiment, Kousta et al. (2011) investigated the speed of word recognition for a large sample of abstract and concrete words, controlled for a variety of lexical variables typically associated with concreteness. Besides familiarity, age of acquisition, and frequency, the stimuli were controlled for constructs of imageability (see Dual Coding Theory, DCT; Paivio, 1986) and context availability (see Context Availability Theory, CAT; Schwanenflugel et al., 1992), which derived from two of the most influential accounts of differences in representation and processing between abstract and concrete words. As illustrated in the previous paragraph (see § 1.3.2), these theories put forward different explanations of the processing advantage of concrete over abstract concepts (i.e., *concreteness effect*). The DCT assumed that abstract concepts are coded solely in the verbal system, while concrete concepts benefit from both verbal and image systems coding. Whereas the CAT argued that since abstract words are supposedly applied in a large number of very distinct contexts, it is more difficult to retrieve their semantic content compared to concrete ones.

In contrast with the previous literature, Kousta and colleagues (2011) found that, once imageability and context availability were kept constant, the typical concreteness effect is substituted by a reverse pattern referred to as "abstractness effect"; that is, responses were faster for abstract than concrete words. Moreover, findings from regression analyses showed that, when critical psycholinguistic measures were statistically controlled, emotional valence significantly predicted lexical decision response times and negatively correlated with concreteness: the more a word was evaluated as abstract, the higher is its emotional valence; conversely, the more a word was evaluated as concrete, the less likely it is to be emotionally connotated. The authors interpreted these results as evidence of the influence of emotional content on abstract words. Given that words with positive and negative affective associations were processed faster than neutral words (Kousta et al., 2009), the authors conclude that, once all lexical factors influencing word recognition are controlled, abstract concepts have a processing advantage over concrete words because they tend to have a great affective load.

This proposal suggested that emotional information provides grounding for abstract concepts through a bootstrapping mechanism that facilitates their acquisition. As noted by Kousta et al. (2011, p. 25), the acquisition of words that denote emotions and feelings is a crucial step in the development of abstract thought as they are the first example of words acquired without a direct association with an observable referent in the physical environment, rather than by association to internal states of the body. In support of this hypothesis, the authors reported that abstract words with highly emotional valence are acquired earlier than abstract words with an emotionally neutral meaning. More recently, Ponari, Norbury, and Vigliocco (2018) analyzed ratings of adult speakers on concreteness, age-of-acquisition, and emotional valence for a large set of abstract and concrete concepts, including negative, positive, and neutral emotional words. Results showed that valence modulated the learning process of abstract words: emotionally valenced abstract words were acquired earlier than neutral ones, and both concrete and abstract positive words showed an advantage compared to the others. In a further experiment, the authors tested children between the age of 6-12 on a lexical decision task with positive, negative, and neural abstract and concrete words. They found that valence affects the developmental trajectory of abstract concepts, but not concrete ones: Children aged 8-9 are more accurate in recognizing positive abstract words than neutral ones; this advantage disappears as recognition and understanding of neutral abstract words increases at 10-11 years of age. The authors concluded that children particularly benefit from valence at an early stage, since later, with the increase of vocabulary and lexical competence, they tend to rely on linguistic information to recover abstract meaning.

To further support the idea that emotional information is engaged during the processing of abstract words, Vigliocco et al. (2014) asked participants to perform a lexical decision task on a set of abstract and concrete words while undergoing an fMRI scan. The authors found that the processing of abstract concepts was associated uniquely with activation in the rostral anterior cingulated cortex (rACC), an area considered to be part of the cortical network engaged in affective processing and regulation. However, other studies cast doubt that this region is preferentially sensitive to abstract concepts. For example, Skipper and Olson (2014) reported distinct neural representations for abstractness and valence. Contrasting brain activation to abstract and concrete words matched for valence, they found that rACC was responsive to emotional contents regardless of whether the words refer to abstract or concrete concepts and no overlap with the neural activity for abstract concepts.

Although the idea that inner experiences such as emotions characterized abstract concepts is quite plausible, it is not uncontroversial. While it may be true that emotional concepts are abstract to some degree, it does not necessarily follow that all abstract concepts have emotional components. Consider, for example, scientific or mathematical concepts like *equations*. One could have some negative or positive feelings associated with the personal experiences of learning this kind of operation at school, but we would not be willing to say that the meaning of *equation* is exhausted in its emotional contents.

Crucially, the inclusion of emotional concepts as a subset of abstract concepts could generate possible confounds in effect observed in these studies. Instead, other scholars have remarked that emotional concepts should be considered as a distinct kind of concepts, irreducible to both concrete and abstract ones (for an extended discussion, see Mazzuca et al., 2017). Among others, Altarriba and colleagues (1999; Altarriba & Bauer, 2004) have documented the peculiar status of emotional concepts obtaining ratings on standard psycholinguistic criteria for independent sets of abstract, concrete, and emotional words. The analysis of emotional words showed that they were rated as more imageable but less concrete, than their neutral abstract counterparts. Similarly, in a rating and proprieties production task Setti and Caramelli (2005) reported a net difference in conceptual knowledge related to emotional concepts compared to both concrete and abstract ones. These and other studies suggest that, rather than being common for the whole abstract concepts, the affective components are a distinctive trait of emotional words that hold an intermediate level of abstractness, sharing some properties with most concrete and with most abstract words. Further evidence for different mechanisms underlying the representation of emotional concepts with respect to other abstract concepts will be presented in the third Chapter.

1.4 First remark: Strong, weak embodiment, and beyond

As testified by the literature reviewed in this Chapter, the debate concerning the nature of conceptual knowledge is still an open issue in cognitive and brain sciences. At a broad level, contending theories in this debate are the Amodal Symbolic accounts and the Embodied and Grounded accounts. The first argues that concepts are fixed, symbolic, amodal representations held by a stand-alone cognitive system detached from the mechanisms regulating perception and action. The second, instead, posits a strict interdependence between higher cognitive abilities and sensorimotor processes and claims that concepts are dynamic, multimodal, and grounded representations, in that they utilize the neural resources that pertain to features in the body, sensorimotor modalities, and interactions with the environment. Recently, Hybrid accounts are gaining increasing success. This view attempts to combine aspects of both two theories, recognizing the role of sensorimotor grounding and the important role of symbolic, word associations to access meaning.

Over the past 30 years, the increasing empirical evidence for embodiment and grounding has questioned models for studying cognition that exclude the experiential domain. Any theory of cognition that does not take seriously into account the role that the body and environment play in the constitution of our cognitive processes is nowadays considered misleading, or at least incomplete. With respect to conceptual knowledge, for instance, the amodal symbolic approach misses an important component of semantics, namely the crucial connexions of words/symbols to entities they refer to (i.e., the problem of *symbol grounding*; Searle, 1980; Harnad, 1990). To overcome the lack of semantic referential link posited by the traditional paradigm, proponents of embodied and grounded cognition introduced the notion of *simulation* as a means to account for the contribution of our bodily mechanisms and neural architecture in language comprehension and processing. In this view, perceptual, motor, and affective states related to concept referents, rather than being converted into amodal and symbolic descriptions, are captured by multimodal brain regions, and then partially re-enacted to support conceptual knowledge (among others, see Barsalou, 1999; Barsalou et al., 2003; Pulvermüller, 1999).

The evidence discussed in §1.2 disclosed that the model proposed by Embodied and Grounded theories has arguably numerous strengths compared to other models in terms of applicability and explanatory power regarding the way our cognitive system implements conceptual knowledge. Simulation-based accounts are particularly suited to explaining concepts whose referents are manipulable and perceivable objects or denote action movements. Processing of this kind of concepts, i.e., ‘concrete concepts’, has been found to activate specific sensorimotor states related to experience with its referent. However, the strengths of EG theories of cognition seem to diminish as the level of *abstractness* of a concept increases. When considering abstract concepts such as *ethics*, which have no single and clearly perceivable instance as referent, it is much more difficult to demonstrate their grounding in activations of multimodal bodily states. It is no wonder that abstract concepts represent one of the main challenges that theories of embodied and grounded cognition need to face.

Nonetheless, a number of solutions have been offered over the years to comprise abstract conceptual representation into an embodied and grounded model of cognition. As the brief review of literature in § 1.3.3 shows, researchers have taken slightly different perspectives depending on the degree of connection that semantic content is supposed to have with sensory and motor systems. Following the classification proposed by Meteyard and colleagues (2012), theories can be distinguished according to their "stronger" or "weaker" level of embodiment.

Strong forms of embodiment claim that conceptual representation depends entirely on perceptual and motor information; hence when linguistic stimuli are processed, the activation of sensorimotor systems contributes to comprehension. Scholars embracing this view argue that the grounding of abstract concepts is not so different from that of concrete ones. Some stated that the abstract concepts meaning is expressed and understood through metaphorical relations derived from concrete domains (Lakoff & Johnson, 1980), others stressed the link between abstract concepts and action-oriented processes (Glenberg et al., 2008).

Weak forms of embodiment, on the other hand, acknowledge that other systems besides sensorimotor ones can be involved in representing the meaning of abstract concepts. For example, some authors proposed that abstract concepts are represented by referring to introspective states and social proprieties of situations (Barsalou & Wiemer-Hastings, 2005), while others argued that the representation and acquisition of abstract concepts are supported by emotional and affective information (Kousta et al., 2009; 2011; Vigliocco et al., 2014).

Among the range of solutions, those assuming a "weak" version of embodiments are particularly appealing since they submit a definition of abstract concepts that rely neither on difference nor analogy with concrete concepts but emphasize their peculiarity. In this sense, this version adopts a broader extension of the notion of *grounding*, in which not only the body and its biological structures but also other experiences influence human cognition, such as affective, introspection, and social situations, which might be much relevant for abstract concepts.

Although all the accounts illustrated so far have offered a great contribution to the scientific knowledge of abstract concepts, they suffer from a similar shortcoming: None of them seems to be able to extend their hypothesis to all varieties of abstract concepts. Stemming from the arguments discussed in the previous sections, the action-based theory provides an explanation that is limited to abstract concepts whose meaning is reflected in action movements (e.g., giving responsibility); theories that emphasize the introspective and affective properties of abstract concepts apply mainly to emotional and mental state concepts (e.g., anger, guilty); whereas conceptual metaphors theory seems suitable for explaining abstract concepts through linguistic expressions as long as they are conveyed through an appropriate mapping with physical information (e.g., power).

The literature reviewed so far leaves some outstanding questions: Does a unique representational structure need to be identified to unfold the grounding of all abstract concepts kinds? If so, should it be the same as that underlying the representation of concrete concepts? Moreover, does the shift from an amodal to a multimodal format of concepts mean that the information carried out by natural language plays no role in shaping our conceptual knowledge? The next chapters of this dissertation are devoted to presenting fresh approaches to the study of abstract concepts that advance novel theoretical and empirical strategies to address these issues.

CHAPTER 2

THE MULTIPLE GROUNDING OF ABSTRACT CONCEPTS

2.1 The promising avenue of Multiple Representation Views

One of the major achievements of Embodied and Grounded (EG) theories is to have brought back the body at the center of research on human cognition, renewing its status from a mere vehicle that sends signals from the environment to the mind to a primary source of information that influences our high-level cognitive processes, including language and conceptual knowledge.

Despite the impressive amount of evidence collected in the last years (for a review, see Fischer & Zwann, 2008; Barsalou, 2008), embodied theory of language still has challenges to face. As we have seen, one of the most debated issues concerns abstract concepts representation. By assuming that conceptualization is based on the reuse and re-enactment of mechanisms supporting perception and action, how could this approach possibly explain concepts that lack sensory-motor contents? Because of this concern, a long-standing tradition states that grounding cognition can provide a satisfying account of concrete concepts (e.g., table) but not of abstract concepts (e.g., truth), which, instead, would require a symbolic/verbal representation (e.g., Paivio, 1986; Mahon & Caramazza, 2008).

The review of literature presented in the first Chapter testified that, although the extensive effort to identify the grounding of abstract concepts, there is little consensus on their representational constructs. If we look critically at the range of proposals discussed so far, we can see that as long as it will assume a unique mechanism, these explanations risk being confined to domains that are quite specific. Abstract concepts have been proposed to be grounded in metaphorical mappings (Lakoff & Johnson, 1980), actions-schema (Glenberg & Kaschak, 2002; Glenberg et al., 2008), introspective and situational information (Barsalou & Wiemer-Hastings, 2005), and emotions (Vigliocco et al., 2013) (see § 1.3.3). Although evidence that supports them is compelling and insightful, none of these theories seems entirely satisfactory to explain the whole phenomenon of abstractness.

One possible cause of this "scientific impasse" is that most approaches have adopted, albeit tacitly, some misguided views about conceptual representation.

The first can be tacked back to traditional theories of concepts. As noted by Weiskopf (2009), scholars have generally endorsed a "monolithic position" in studying concepts based on two implicit assumptions: 1) any instance of a given concept needs to fit a specific requirement to pertain to *the* concept (there is such thing as a unique concept of "mother", i.e., *singularity assumption*); 2) all concepts are constituted by a single kind of psychological structure (the same mental representation kind can explain concepts of "mother", "fish", "bird" etc., i.e., *uniformity assumption*). Over the years, concepts have been identified with different forms of mental structure; for example, in the case of the classical theory is a formal definition; in other cases, it can be an exemplar, a theory-like structure, or a prototype. These theories, despite their specificity, maintain that there is a sort of invariable representation that underlies all conceptual knowledge (for an extended review, see Laurence and Margolis, 1999).

This view has been refuted by empirical evidence, particularly in the area of EG cognition, showing that concepts are not stable constructs in our minds. On the contrary, conceptual systems reliably use a variety of information derived from modality-specific experiences that are stored and retrieved in long-term memory in a highly context-dependent manner (Kiefer & Barsalou, 2013; Kiefer & Pulvermüller, 2012). Indeed, the processing of concepts and categories is affected by contextual constraints: Conceptual representations dynamically adapt to the situations in which concepts are employed, to the task being performed; and the relevant features encoded by a concept might also vary considerably across individuals, languages, and cultural factors (for the literature on *conceptual flexibility*, see Barsalou, 1982; 1983; 1987; Yee & Thompson Shill, 2016; and the discussion in Chapter 4). On this note, recent proposals converge on the idea that identifying a uniform representational principle that explains all of the phenomena for which concepts are responsible is a highly pretentious commitment. Nevertheless, there is still a general reluctance to endorse a position that posits *more than one* mechanism to explain conceptual representation. Even within the EG perspective, scholars have mostly focused on sensory and motor mechanisms, and then also on emotional and introspective states, to account for the entire conceptual domain. This has led to considerable difficulty in sharply framing abstract concepts in the same bodily mechanisms engaged by concrete concepts.

Another common misconception is to consider abstract concepts as a collection of uniform exemplars, referring to them just in opposition to concrete concepts. Generally, it is claimed that since abstract words, like “freedom” or “number”, do *not* refer to tangible things, they must be structured differently from concrete words, like “table or “bottle”, whose referents are perceptible. Again, the implicit assumption behind this idea is that all concepts that represent abstract entities belong to the same ontological domain, which can be identified with a similar representational principle, likely different from that of concepts denoting concrete entities. This is particularly striking when considering the extreme intra-class variability of abstract concepts: the concepts of *freedom* and *numbers* mentioned above, for example, refer to abstract entities that differ significantly from each other, and no one would be willing to argue that their representational constructs are equivalent. However, while a more fine-grained distinction between semantic categories of concrete concepts has been confirmed in numerous (neuro)cognitive works, abstract concepts have traditionally been considered as a whole. As will be clarified in the course of this dissertation (see Chapter 3), an in-depth investigation of abstract concept categories might mitigate, and perhaps solve, the difficulty of explaining abstract concepts within an EG perspective.

In recent literature, interesting new trends are emerging to lead over the stalemate facing theories of abstract concepts. Specifically, the shortcomings of previous proposals, along with the experimental findings and theoretical arguments against a single monolithic theory of concepts, suggested defending a pluralistic account of concepts (Rips, 1995; Weiskopf, 2009; Dove, 2009). This epistemic turn opens the possibility that the conceptual system, just like other cognitive systems, employs a variety of different representational structures to serve concepts, each of which is available to be activated depending on the kind of information they convey and the circumstances that promote their use.

Drawing from this pluralistic stance, cognitive psychologists in recent years have begun to consider the role of different kinds of experiences for human conceptual processing and acquisition. The major novelty in the field is the emergence of Multiple Representation Views (MRVs), a set of new proposals that combine embodied approaches with diverse lines of research that outline the importance of linguistic, emotional, social, and internal experiences in conceptual representation (for a review, see Borghi et al., 2017).

Given their extended reach, Multiple Representation Views seems the most promising candidate to account for abstract concepts in their variety and complexity. Indeed, bridging together a pluralistic approach and MRVs on abstract concepts means to recognize that (a) the panorama of abstract concepts is richer and more heterogeneous than previously supposed; (b) different classes of abstract concepts are acquired and grounded differently; (c) not only sensorimotor mechanisms but also other crucial mechanisms might concur in their representation; (c) the value of these mechanisms can vary depending on the kind of concepts, on the task for which it is required and the situation it is embedded in.

Stemming from these arguments, in this Chapter, I will discuss the recent developments of Multiple Representation Views on abstract conceptual knowledge. In particular, I address the literature that points to interoception, metacognition, language and social interactions as possible sources of grounding for abstract concepts. In the following discussion, I do not focus on these mechanisms *per se*, but rather on their relation with abstract concepts in order to show that adding these dimensions to the usual embodied approaches could lay the groundwork for developing a more compelling theory of abstract concepts.

2.2 Interoception as a grounding source

Embodied and grounded theories have intensively investigated how the body and its highly specialized perceptual systems influence our cognition. However, in addition to the experiences gathered through the senses of sight, hearing, touch, smell, and taste, human beings perceive and integrate many other sensations. Think of stomach growling, dry mouth, tense muscles, cold/heat, sexual arousal, heart racing, pain, or relaxation. Which sensory system is responsible for these *internal* feelings? Does this system play a role in high-level cognitive processes, hence in conceptual representation, just like other sensory modalities?

Interoception is the lesser-known sense that refers to the perception of the internal states of the body. At its most basic level, interoception allows us to feel the body from the inside and respond appropriately to physiological needs. More precisely, it plays a critical role in ensuring the energy balance of the organism (i.e., homeostasis) and preparing for future actions or needs (i.e., allostasis) (Sterling, 2012). For example, noticing a growling stomach serves as a cue that we are hungry and encourages us to eat, or noticing goosebumps on the skin serves as a cue that we are cold and prompts us to look for a sweater. In line with classical theoretical accounts of emotions, interoception should be considered as an integral part of emotional experiences (i.e., The Lange-James theory; see James, 1884; Lange, 1885; see also Damasio, 1999). Indeed, inner bodily states are often (even if not always) correlated with the emergence of emotions. For example, that increased heart rate and deep breathing while speaking in public indicate that we are anxious or that the feeling of butterflies in the stomach on a first date lets us know that we are falling in love with someone.

Interoception is now mostly used as an umbrella term to indicate the body-to-brain axis that contributes to the subjective experiences of the body states (Cameron, 2001). In order to gain a better comprehension of the concept of interoception, it might be helpful to take a step back and discuss its original meaning and how its definition has changed over time.

Interoception is a relatively recent notion originally introduced by Sherrington (1906), who was the first author to attempt a systematic analysis of the functions of all sensory information to which living organisms have access, including internal sensations. In his model, Sherrington distinguished three sensory systems based on the location of specific receptors in the body. He referred to interoceptive receptors to describe sensory nerves located on the deep surface of the body that provide information about the state of its internal organs, such as the stomach and intestines. Interoception is used here as a synonym for visceral, excluding all receptors whose functions can be described as exteroceptive or proprioceptive. With the term exteroception, Sharrington specifically refers to receptors of the traditional five senses that receive information from the external environment, while proprioception includes receptors that track the contractions of the skeletal muscles, reflecting the position and movement of the body in space. This view posits interoception as an antonym of exteroception, drawing an opposition between sensations originating from exogenous (from outside the organism) and endogenous (from within the organism) stimuli, assuming that only sensations coming from the viscera are interoceptive.

Over the years, this distinction has been widely reviewed in the literature (e.g., Ceunen et al., 2016). The main reason is that it does not account for the fact that numerous inner bodily sensations might have exogenous causes. For example, gastrointestinal sensations often follow the ingestion of exogenous substances. Likewise, the sensation of pleasure in affective touch is caused by another (exogenous) agent. Other experiences may require integration of external and internal information, as in the case of feeling cold/warmth, which is not necessarily an endogenous consequence of illness but may just be elicited by external temperature. It is now widely accepted that neither the origin of the stimulus nor the organ involved is significant in determining which sensations are interoceptive. Rather, what is relevant to defining a sensation as interoceptive is whether it is informative about bodily states.

Following these observations, current research has adopted a broader meaning of interoception to include the physiological conditions of the entire body, and not just the viscera (e.g., Cameron, 2001; Ceunen et al., 2016; Craig, 2003; 2009). This inclusive definition of interoception encompasses a range of signals originating from multi-sensory channels (e.g., temperature, pain, itch, tickle, sensual touch, muscular and visceral sensations, hunger, thirst) that are transmitted to the central nervous system, which ultimately integrates them to construct a representation of body state. More recent approaches conceptualize interoception within the influential models of predictive coding, which conceives the brain as a statistical organ that actively generates explanations for the stimuli it encounters in terms of probabilistic inference tested against sensory evidence (Friston, 2005). Adopting this framework, several authors (e.g., Seth, 2013; Ainley et al., 2016; Barrett & Simmons, 2015; Pezzulo, Rigoli, & Friston, 2015; Seth & Friston, 2016) have proposed that interoception is driven by a continuous process of comparing expected and incoming inner states of the body, together with the percept of stimuli from the external world (exteroception), in order to estimate physiological needs to restore homeostasis. Any mismatch between predicted and actual states leads to prediction errors in interoceptive inference. This model provides a powerful tool to account for dysfunctions in interoceptive perception typically observed in clinical disorders or, more generally, to assess individual differences in interoceptive performance in terms of the ability to generate accurate predictions and minimize errors by paying attention to changes that take place inside the body.

As shown by this short overview, interest in interoception has increased considerably in the last few years. Its meaning has changed from restrictive to inclusive definition, emphasizing its relevance for a broader model of body representation. The scientific debate is flourishing and involves researchers from different areas of psychology, medicine, neuroscience, psychiatry, and philosophy (for a detailed discussion, see the theme issue Tsakiris & Critchley, 2016). Despite this research field is still in its infancy, it is now recognized that interoception represents a complex sensory modality that can no longer be disregarded. Ultimately, the construct of interoception seems to enrich the theoretical framework through which to investigate the embodiment of cognitive and affective processes, going beyond the purely sensorimotor domains.

2.2.1 Looking inside the body

Empirical research on interoception presents undeniable difficulties. The ability to sense changes in internal states of the body seems an elusive phenomenon, inaccessible to others. Nevertheless, several techniques have been developed in recent years to quantify interoceptive processes.

One of the most classical methods involves the measurement of heart activity, which is a discrete regular event, that can be easily and noninvasively detached. Heartbeat perception tasks are typically used to examine individual differences in interoceptive accuracy during behavioral performances. Two standard paradigms in the literature are the heartbeat tracking task (e.g., Schandry, 1981) and the heartbeat discrimination task (e.g., Whitehead, Drescher, Heiman, & Blackwell, 1977). In the first task, participants are asked to silently count their heartbeats during a specified interval time by focusing on their own bodily sensations without checking their pulse. Typically, the estimated number of heartbeats by participants is compared with the actual occurrence of cardiac signals extracted from ECG. In the second paradigm, participants are required to report their own heartbeats by tapping or in sync with external signals. The two methods are highly correlated, but address different underlying mechanisms of interoception, as the former focuses on internal monitoring and the latter on the integration of internal and external information. Moreover, the results of these procedures are differently influenced by individuals’ expectations, stress, or attentional processes (Schulz et al., 2013).

An alternative method is to measure the subjective account of experiencing internal sensations using self-report questionnaires that capture both the ability to perceive bodily signals and the degree of confidence in interpreting them. Recently, it has been outlined that these subjective measures quantify different aspects of interoceptive experience and should not be conflated (Garfinkel & Critchley, 2013; Garfinkel et al., 2015). On the one hand, the construct of *interoceptive sensitivity* (IS), assessed by surveys such as the Autonomic Perception Questionnaire (Mandler et al., 1958) and Body Perception Questionnaire (Porges, 1993) measures one’s ability to focus on and perceive internal bodily states (e.g., To what extent do you “believe” you focus on and detect internal bodily sensations?), but not directly whether this subjective sensitivity is accurate. On the other hand, the notion of *interoceptive awareness* (IA) provides a measure the level of awareness related to perceived interoceptive accuracy during a given task. For example, the Multidimensional Assessment of Interoceptive Awareness scale (Mehling et al., 2012) is often used to map confidence in performance to accuracy (e.g., Do you “know” whether you are accurately or inaccurately assessing your heart-timing?). Thus, a common strategy in the study of interoception is to combine objective interoceptive measures (e.g., heartbeat perceptual tasks) with the subjectively perceived interoceptive ability (self-reports), based on the assumption that interoceptive behavioral accuracy is predicted by subjective confidence in task judgments.

Researchers have adopted these methods to test the impact of interoceptive signals on higher-order cognitive processes, including affective experiences, decision making, the sense of self in both healthy and clinical populations (see special issue: Tsakiris & Crichley, 2013).

A vast line of research has extensively investigated the role of interoceptive experience in shaping bodily self-awareness by combining interoceptive tasks with bodily illusions (e.g., Rubber Hand Illusion, Tsakiris et al., 2011; enfacement illusion, Paladino et al., 2010; Tajadura-Jiménez & Tsakiris, 2014; full-body illusion, Lenggenhager et al., 2007; Aspell et al., 2013; Monti et al., 2021; effort illusion, Iodice et al., 2019). Overall, these studies showed that individuals who are more accurate and aware in detecting inner bodily signals (i.e., high interoceptive sensitivity) are less affected by external influences triggered by these illusions, suggesting that the experiences of self and body ownership require integration of exteroceptive and interoceptive percepts. Consistently, interoceptive deficits have been found to be associated with several psychiatric and neurological disorders, including anxiety, schizophrenia, and anorexia. Generally, that patients show poor control at feeling their cardiac signals and tend to have a weaker sense of body agency compared to the healthy population (among others, see Hur et al., 2014; Ardizzi et al., 2016; Jenkinson et al., 2018).

In literature, it is now recognized that the relevance of interoception goes beyond homeostatic and physiological regulation, including many other cognitive functions, ranging from affective feelings to motivation, and from self-awareness to physical and psychological disorders. Given the pervasive impact of interoception on human cognition, one might wonder whether and how this sensory system is involved in conceptual processing and representation. The next section is devoted to presenting some recent works that provide interesting insights into this line of research, especially with regard to abstract conceptual knowledge.

2.2.2 Interoception and Abstract concepts: the forgotten modality

Despite the growing interest in interoception, studies on concepts have somehow neglected the role and influence of this “inner sense” for conceptual representation. This is particularly striking when considering abstract concepts. First, the abstract domain includes concepts, such as mental states and emotional concepts, that are likely grounded in inner processes because of their content. Second, seminal theories (e.g., Barsalou & Wiemer-Hastings, 2005; Vigliocco et al., 2013) have suggested that internal properties, such as introspection and affective valence, might be more relevant for abstract concepts than concrete ones. Still, the process of grounding concepts on systems tracking states and processes inside the body (i.e., *inner grounding*) has long been underestimated. As a matter of fact, research in psychology, linguistics, and cognitive neuroscience on conceptual grounding has generally been limited to consideration of exteroceptive sensory systems; thus, they focused on the classical five perceptual modalities of vision, touch, hearing, taste, and smell, leaving aside interoception, which is not by change defined as “the forgotten modality”.

Only recently, some authors have recognized interoception as a valuable component that contributes to the perceptual grounding of concepts, in particular abstract concepts and emotional ones. A remarkable example is a recent work by Connell, Lynott, and Banks (2018). The authors reported a mega-study based on the collection of perceptual strength ratings for over 32.000 concepts in six modalities, using separate scales, e.g., “Rate to what extent do you experience this WORD through each of six sensory modalities: by hearing, by tasting, by touch, by seeing, by sensation inside the body”. From inspection of the dataset, they showed that interoceptive ratings capture distinctive information of perceptual experiences not represented in the classical sensory modalities and that the ability to predict concreteness effect in naming and word recognition tasks is enhanced when interoceptive strength is also included. In addition, results showed that interoception covers a wide range of conceptual domains, including not only sensations associated with classical interoceptive states, such as physiological and thermoregulatory functions (e.g., heartbeat, breathing, hunger, pain, cooling, warmth), but also other domains linked to fatigue, illness (e.g., tired, sleepy, flu), drugs (e.g., adrenaline, caffeine), and a variety of emotional states (e.g., sadness, happiness, love, anger). Interestingly, interoception dominates a greater proportion of abstract than concrete concepts. In the selected sample of 500 abstract concepts, the role of interoception information is markedly more relevant in the experiences of emotional concepts than other abstract concepts with similar levels of abstractness, and even more relevant for negative categories of emotions. Overall, the modality-specific measure of interoception seems an important means of capturing the sensory basis of concepts that would otherwise be misinterpreted as lacking perceptual experience.

Further evidence has demonstrated that interoceptive experiences re-enact modality-specific neural activity during the conceptual representation. In a recent neuroimaging study, Wilson-Mendenhall and colleagues (2019) presented participants with immersive, language-based scenarios that were designed to provide either an interoceptive experience (e.g., *Launching out of your chair, your heart is palpitating wildly in your chest*) or an affective experience focused on external details and actions (e.g., *You become lost in the dark. The trees close in around you, and you cannot see the sky*). As predicted, the authors found greater activity in the primary interoceptive cortex (i.e., dorsal posterior insula) after participants heard and imaged experiences with vivid interoceptive details than after immersion in scenarios with other sensory experiences. These results support the simulation-based theory of language, extending the evidence to interoceptive systems: Words that refer to internal bodily states activate the corresponding brain regions as in the case of other modality-specific systems.

These findings open new research avenues on conceptual representation. Beyond the five perceptual modalities and motor experiences, internal states of the body are integrated and influence conceptual representation, and their role seems to be even more crucial for some types of abstract concepts. However, further studies should manipulate interoceptive signal processing under experimentally controlled conditions to investigate whether this grounding source is causally involved in the representation of specific abstract concepts, an idea I explore in Part II of this dissertation.

2.3 Metacognition as a grounding source

Embodied approaches hold that concepts are grounded in the re-enactment of a variety of cognitive and physical states we perceive. Most studies have focused on external experiences derived from perception and action, showing that sensorimotor grounding primarily supports the representation of concrete concepts (Kiefer & Pulvermüller, 2012). In recent years, other areas of research have emerged on the role of inner grounding (i.e., re-enacting internal states or processes), providing empirical support to the hypothesis that affective states (Vigliocco et al., 2013) and physiological conditions of the body (i.e., interoception, Connell et al., 2018) contribute to abstract concepts representation. However, among inner experiences, those associated with cognitive states and processes have received much less attention in the literature.

One notable exception is the seminal proposal of Barsalou (1999), which first highlighted the relevance of *introspection* to abstract conceptual knowledge. In this view, the term introspection refers to a set of different internal experiences that correspond broadly to affective states, representational states, and cognitive operations (p. 585). The last includes mental processes such as beliefs, evaluations, motivations, search, retrieval, reasoning, or representation of other objects/agents' states. As defined, representational and cognitive states have often been interpreted widely as any process that occurs in our minds. This might explain why their role in grounding abstract concepts has not been systematically explored.

Novel insights are emerging from psychological research on a particular form of cognitive activity, namely metacognition. Metacognition was classically described as “thinking about thinking” (Flavell, 1979) or “the monitoring and control of thought” (Martinez, 2006). Although the definition of metacognition seems relatively vague, its practice is pervasive in a variety of everyday situations: Checking the results of a math problem, following a recipe, memorizing poetry, or writing an article are activities that require metacognitive operations. In such cases, we typically create a meta-representation of our cognitive processes, and the self-interrogation concerning the state of our own knowledge against certain criteria of quality and effectiveness is essential to improve the activity itself. Ultimately, metacognition refers to the human ability to represent, monitor and control ongoing thought and behavior.

Metacognition has been classically studied in relation to memory and learning and now is increasingly extending to other cognitive processes. Literature on developmental education has focused extensively on meta-memory and meta-comprehension, showing that these forms of metacognition have predictive power for subsequent learning. Typically, children that are more efficient in the assessment of their own competence in reading and writing are more able to find successful strategies to overcome their difficulties and master such activities (for a review, see Tobias & Everson, 2009; Hacker et al., 2009). Other studies have highlighted a strong link between metacognition and problem-solving and critical thinking. Indeed, both cognitive activities are supported by constant monitoring and evaluation of our ideas, from defining problems and goals to exploring possible alternatives and critically judging the results to decide whether plans need to be revised. This self-regulatory process is typically guided by asking questions such as: What am I trying to pursue? Is my strategy working? Is the idea coherent? (e.g., Davidson et al., 1994; Martinez, 2006).

Another line of research has demonstrated that metacognition involves not only rational thought but also emotional and motivational considerations. For instance, in self-regulated learning or other demanding situations, metacognition is often accompanied by the negative feeling of difficulty, uncertainty, or the possibility of failure (e.g., *I don't understood what it means*; *I am not able to solve the equation*). In the face of difficulty, metacognition also entails positive thoughts that can support persistence and focus in order to overcome obstacles (e.g., *Don't give up*; *Stay on track*) (e.g., Efklides, 2011; Efklides et al., 2018).

The role of metacognition has also been investigated in low-level processes. Most studies have focused on two related aspects of metacognition: the awareness of our cognitive processes and control processes, usually measured in terms of decision confidence and error monitoring. Finding from studies on perceptual decisions-makings (e.g., Yeung & Summerfield, 2012; Fleming & Lau, 2014; Bahrami et al., 2010) reported a positive correlation between the confidence judgment (i.e., the certainty or uncertainty associated with a decision, a belief, percept, etc.) and error detection (i.e., the ability to detect and signal our errors), suggesting the importance of metacognitive sensitivity for the self-regulatory strategies to coordinate our and other's behavior in ongoing tasks after discovering knowledge errors.

Recent research has extended the metacognition functions to general social abilities, such as mindreading (i.e., the capacity to infer the mental states of others and predict behavior) (e.g., Carruthers, 2009; Frith, 2012) and meta-perception (i.e., our judgment about how others perceive us) (e.g., Lees & Cikara, 2019).

To include the wide range of processes and functions that underlie metacognition, theorists have proposed a broader definition that pertains to the ability to direct cognitive processes either at one's own mind or at the mind of another agent. In this framework, metacognition is defined as "the set of capacities through which an operating subsystem is evaluated or represented by another subsystem in a context-sensitive way" (Proust, 2013, p. 4).

A detailed characterization of the metacognition functioning has been provided by Shea and colleagues (Shea et al., 2014, see also Frith, 2012). In their model, the authors identified two different cognitive control systems in which metacognition plays a role: *System 1* for intra-personal cognitive control and *System 2* for supra-personal cognitive control.

In *System 1*, metacognition operates within a single agent, building a meta-representation of sensory signals to estimate the more reliable inputs and outputs to modulate ongoing thought and behavior. For example, system 1 metacognition allows us to represent our body movements to coordinate actions according to objects' position in the space. This process is usually automatic and implicit, and does not require working memory.

In *System 2*, metacognition operates across two or more interacting agents. Its main function is to make implicit metacognitive information available for verbal reporting and communication. A common manifestation of system 2 metacognition is joint tasks in which we often report our own's metacognitive confidence to others in order to optimize the possibility of coordination to archive a solution. This system is affected by a general working memory load because it is a conscious process that leads to explicit outcomes expressed in words. According to the authors, this explicit form of metacognition has evolved uniquely in humans to support complex social practices and create conditions for cumulative knowledge. This sophisticated ability can be present in synchronic interactions, when agents cooperate on the same task (e.g., making a group decision), and in diachronic interactions, when people discuss their own metacognitive representation to improve future performance (e.g., when experts teach novices how to correctly perform a cognitive or physical activity) (for cultural origins of metacognition, see also Heyes et al., 2020).

This brief review of the literature shows that metacognition processes extend beyond thought or memory, involving perception and action, feelings, and other social abilities. Although many of these functions are related to some extent to language, only a few studies so far have directly examined the intersection between concepts and metacognition.

For the arguments of this dissertation, some recent proposals (Shea, 2018; 2020; Borghi, Fini, & Tummolini, 2021) are particularly noteworthy. According to them, the monitoring process of metacognition can provide a new resource for understanding how abstract concepts are grounded. The main idea is that, since abstract concepts have more indeterminate meanings usually linked to complex and different experiences, they might require an extensive monitoring process to be used and represented. In this framework, it has been suggested that metacognition supports some fundamental mechanisms: On the one hand, an implicit form of metacognition might be used for monitoring and refining our knowledge about abstract concepts, likely through inner speech; on the other hand, an explicit form of metacognition might be involved when we defer to or cooperate with others to find an exhaustive explanation of abstract word meanings. (Borghi et al., 2021; Borghi, 2020). These two hypotheses will be examined below.

2.3.1 Search for meaning in self: the role of inner speech

Have you ever heard a little voice inside your head? Whether we call it inner speech, self-talk, inner dialogue, or verbal thinking, it seems that silently talking to ourselves is a fundamental aspect of our daily life. For example, while reading a text or writing down our ideas, we often have the subjective experience of hearing our inner voice narrating the words. When we are facing difficult situations, we sometimes speak to ourselves to strengthen our motivation or evaluate our performance. From early childhood, inner speech plays a vital role in learning, reasoning, and regulating emotions and behavior. Inner speech can also offer a memory aid when we covertly repeat the list of things to buy at the supermarket. It also contributes to self-awareness and self-regulation. Before an important job interview, we may prepare ourselves by silently simulating in our head how we think the conversation might go, possibly hearing our own voice and the voice of the interviewer. In many cases, we formulate inner speech in short and fragmentary form without following the syntactic rules used in outer speech. A minority of us produce only small snippets of inner speech. Others might experience its pathological consequences, as in the case of rumination, a form of excessive negative self-talk associated with depression and anxiety, or auditory verbal hallucinations, common in people suffering from schizophrenia.

Inner speech is a multifarious and complex phenomenon that occurs in different forms and situations. Scientific literature converges in recognizing its critical role for a wide range of psychological functions, including reading, learning, memory, motivation, planning, problem-solving, self-knowledge, and mental health (for reviews, see Alderson-Day and Fernyhough, 2015; Fernyhough, 2016; Langland-Hassan & Vicente, 2018; Morin, 2018; Perrone-Bertolotti et al., 2014).

More relevant to our aims is the general function of inner speech, which is to allow us to "think about our own thoughts". In this sense, inner speech is closely related to the metacognition mechanism described in the previous paragraph: It operates on second-order cognition, helping us to make thoughts conscious and to monitor our own cognitive processes. As several influential philosophers have pointed out, the linguistic medium is essential in this process (see Clark, 1998; Jackendoff, 1996; Bermúdez, 2018). Inner speech can be considered a peculiar linguistic tool that – just like overt speech – helps us to shape our knowledge and create new thoughts. This monitoring and productive function of inner speech can be seen, for example, in the simple fact that when we talk to ourselves, new ideas come into our minds while others are refined or abandoned. These ideas, or thoughts, are typically expressed in words. Inner speech, therefore, contributes to the inner monitoring of our conceptual knowledge, and its role might be even more relevant for operating with concepts that have blurred meanings, such in the case of abstract concepts. Before delving into this idea, it may be helpful to briefly outline some crucial aspects of inner speech, and in particular, its relation with overt speech.

Over time, inner speech has been investigated in line with two influential traditions. The first one, proposed by Vygotsky (1934/1987), intends inner speech as an initial form of social speech, internalized during the conceptual development, and useful to regulate and enhance other cognitive functions. The second, related to Baddeley's research on working memory (Baddeley & Hitch, 1974), defined inner speech as an active rehearsal mechanism within the phonological-articulatory loop, using offline speech to search, active, and then produce linguistic materials.[8] Recently, it has been proposed that inner speech and overt speech activate a simulation of articulatory movements, with the difference that in the inner speech, the motor execution is blocked and no sound is produced. In the words of Alderson-Day and Fernyhough (2015), inner speech is “the subjective experience of language in the absence of overt and audible articulation” (p. 931).

According to this “embodied or motor simulation view”, inner speech would partially retain the same motor structures and neural correlates of overt speech. Consistently, neuroimaging studies have shown that both overt and silent articulation of words recruit Broca’s area and left inferior frontal gyrus (LIFG), regions typically associated with speech production. Other activations involve the supplementary motor and premotor cortex, and Wernicke's areas in the superior temporal gyrus, associated with auditory experiences (Price, 2012; Geva et al., 2011). However, while the activation of motor and premotor regions is more pronounced in overt speech, inner speech engages neural regions associated with inhibitory mechanisms (i.e., cingulate gyrus, left middle frontal gyrus), that are not recruited during overt speech (Basho et al., 2007). This finding supports the idea of a continuum between overt and

[8] Illustrating the classical theories of inner speech is beyond the scope of this dissertation. For the sake of discussion, it suffices to say that their focus differs. Vygotsky investigated the developmental trajectory of inner speech. He assumed that inner speech would emerge around three years old as a product of progressive transformation from *social speech* (interpersonal dialogue between child and caregivers); to *private speech* (children talk aloud to themselves when are engaged in difficult cognitive tasks), to *inner speech* (an inner “conversation” with the self). During this transition, private speech, whose primary function is to regulate children’s thought and behavior, persists in adulthood with syntactic and semantic transformations assuming a more condensed character (i.e., a decrease of vocalization, some words are dropped, agglutination, private sense prevail over meaning). Baddley’s view is more confined to working memory. His famous model comprises three elements: a visuospatial scratchpad system responsible for representing verbal, auditory, and phonological information; a central executive system responsible for allocating attention; a phonological-articulatory loop composed by a passive, phonological store, in which information decays rapidly after 1-2 seconds and an active, rehearsal mechanism that uses offline speech for the planning process. The latter largely corresponds to a form of inner speech (for an integration of the two approaches, see Al-Namlah et al., 2006).

inner speech, with the latter involving motor planning and articulation but not an actual movement (for a review, see Loevenbruck et al., 2018).

Further evidence has confirmed that inner and overt speech share common articulatory components, including activity in orofacial musculature. Findings from studies with electromyographic (EMG) showed that lips and tongue are selectively activated depending on the inner pronounced phonemes (e.g., T vs. P) (McGuigan & Dollins, 1989). In other studies, EMG records an increase of labial activity during the silent recitation of verbal stimuli (Livesay et al., 1996) or mental rumination (Nalborczyk et al., 2017) compared to rest conditions.

The engagement of articulatory movements during inner speech is confirmed by interference effects in dual-task studies. The rationale here is that blocking subvocal articulation in a secondary task can investigate whether inner speech impacts a primary task involving other cognitive processes. A typical method to assess the involvement of inner speech is articulatory suppression, e.g., repeating syllables or numbers while engaged in another verbal task. Generally, it is used with an additional, nonverbal condition to control the effects specific to the inner speech process. Numerous studies have found that while finger tapping affects mainly visuospatial tasks, articulatory suppression selectively interferes with verbal tasks, suggesting that inner speech is involved in retrieving and encoding verbal information (Baddeley, Lewies, & Vallar, 1984; Baldo et al., 2005). Similar effects are present on memory tasks. Baddeley and Larsen (2007) demonstrated that articulatory suppression removes *words length effects* (the worse recall of longer words) and *phonological similarity effects* (the worse recall of phonologically similar words, like “hat”, “cat” compared to dissimilar words, like “bar”, “kid”), in line with the hypothesis that when verbal materials are activated in phonological working memory interfere with one another. However, there is no conclusive evidence on the adoption of inner speech across other kinds of tasks: for example, in logical reasoning, the effect of articulatory suppression is more pronounced in children than in adults (e.g., Lidstone et al., 2010; Rao & Baddeley, 2013).

Whether inner speech is necessarily articulated remains a debated topic. According to an alternative view, known as the "abstraction view", inner speech occurs only before speech articulation; hence it would be abstract and not necessarily related to articulation and acoustic components (see Jones, 2009; Newell & Simon, 1972). Evidence that favors this view is mainly based on the observation that some phonological, syntactic, and articulatory processes involved in overt speech are absent in inner speech. For example, inner verbalization is not subjected to physiological constraints of breath; thus, it is produced faster than overt speech (Korba, 1990) and tends to have a condensed form, in which some words are dropped, and meaning is less explicit (e.g., Vygotski, 1934). However, it is now widely recognized that inner speech might occur in a variety of forms, [9] and their use can be adapted to the context. For example, a more condensed form of inner speech might be sufficient in an open-ended form of verbal thinking, while a more expanded form of inner speech might be required in specific planning tasks (e.g., Fernyhough & Fradley, 2005).

Novel approaches are more inclined to adopt a hybrid vision, assuming that inner speech does not necessarily require a full articulation, but is flexibly modulated depending on the difficulty of the tasks and the situations. For example, Oppenheim and Dell (2010) tested the speech errors of participants who were asked to imagine repeating tongue-twister phrases

[9] Evidence for different forms of inner speech comes from self-report studies based on questionnaires and introspective approaches (e.g., VISQ, the Varieties of Inner Speech Questionnaire McCarthy-Jones, 2011; and its revised version, Alderson-Day et al., 2018; STS, Self-Talk scale, Brinthaupt et al., 2009; DES, Descriptive Experience Sampling, DES; Hulburt et al., 2013; Hulburt, 2017). One average, the most common forms of inner speech are positive/evaluative self-talk (82%), dialogic inner speech (77%, i.e., a back-and-frontal conversation vs. monologue), condensed inner speech (36%, short and fragmentary pieces of discourse vs. extended sentences), while a minority reports the presence of other people in inner speech (25.8%).

in articulated and unarticulated inner speech (i.e., moving or not their mouth/lips), and to report their errors immediately. In the articulated inner speech, both phonemic similarity effect and lexical bias were present, while in the unarticulated inner speech, the first effect, localized to an articulatory processing level, was absent. Notice that the relative involvement of articulatory does not imply that inner speech is amodal. Rather, inner speech always integrates sensory and motor dimensions, reflecting auditory percepts to monitor and execute specific verbal goals (Loevenbruck et al., 2018).

In line with this view, Borghi, Fini, and Tummolini (2021) have recently proposed that inner speech, and its articulatory components, are strictly related to semantics. Specifically, they claim that inner speech might help us to access the range of word meanings in working memory, retrieve information about category members, assess the status of our knowledge, and plan what we need to fill in gaps. While this internal monitoring process can occur with any type of verbal stimuli, it is possible that it is more frequent with abstract concepts than with concrete concepts.

The arguments advanced in support of this hypothesis rely on the great difficulty of acquiring and using abstract concepts. Most evidence demonstrates that abstract vocabulary emerges later in language development (Gleitman et al., 2005; Ponari et al., 2018), likely in conjunction with other social and metacognitive skills (e.g., Proust, 2013; Kuhn & Dean, 2004). Different from concrete concepts, abstract concepts have fewer perceptual features; hence their acquisition benefits largely from the input of others mediated by language (Della Rosa et al., 2010) (see § 2.4.5.1). During this acquisition phase, inner speech might support the rehearsal and internal articulation of the word sound and linguistic explanations associated with an abstract concept in order to consolidate it in memory.

Even after learning, it may be difficult to process the meaning of abstract concepts. Reliable evidence for this is the longer response times to recall and encode abstract words compared to concrete words (i.e., concreteness effect). Borghi and colleagues suggested that this could be an index of uncertainty that is reflected in a longer search for abstract word meaning, likely through inner speech. When we are unsure of the meaning of a particular word, we may need to retrieve associated words to compare its possible meaning, or even to re-explain it to ourselves. This form of inner speech, related to verbal working memory, also helps us to explicitly evaluate the adequacy of our conceptual knowledge; therefore, it has a function of self-reflection and self-regulation linked to metacognition. According to the authors, this inner monitoring process is more likely to be used when we are dealing with abstract concepts because of their variety of meanings and uses (consider, for example, the numerous applications of concepts such as *morality* or *freedom*).

The proposal that abstract concepts require a further search for meaning is consistent with neural evidence showing a great activity in the left inferior frontal gyrus (LIFG) during their processing. As we have seen, this region is generally associated with lexical retrieval and phono-articulatory processes underlying inner speech, and its activation in relation to abstract concepts has been ascribed to the longer time they are kept in phonological memory to be processed (Binder et al. 2005, Wang et al., 2010) and to the stronger demands on executive semantic control processes compared to concrete concepts (Della Rosa et al., 2018). Consistent with this, the authors proposed that the abstract monitoring process is accomplished by articulatory components, the mouth motor system activation. This led to two predictions: If the inner speech, along with subvocalization and inner articulation process, is at play with abstract concepts, then activating the articulatory components of mouth/lips might facilitate their processing. Conversely, interference with the inner articulation of abstract words by articulatory suppression tasks would impair or modulate their processing. Supporting evidence for these hypotheses will be reported in the last section of this Chapter and Part II of this dissertation.

To summarize: Starting from an overview of contemporary research on inner speech, I have presented a recent proposal that considers inner speech as a powerful cognitive tool to tacking information about our own concepts, and in particular abstract ones. This inner monitoring process consists of the metacognitive awareness that our concepts are inaccurate, which leads us to keep searching for their meaning: We might need to talk to ourselves to rehearse and re-explain it, also through inner articulation mediated by the mouth. However, in the case where this monitoring process leads us to detect only a few aspects of word meaning, we might search for a solution outside ourselves. I will discuss this issue below.

2.3.2 Search for meaning in others: semantic deference, social metacognition

Sometimes it is hard to grasp the meaning of concepts. For example, I know that *credit* and *debt* are very different but somehow related words. I might confuse about their distinctive characteristics, and an effective strategy to dispel my doubts is to ask someone for information, preferably an economist. This is a very simple case of *deference*, i.e., relying on others, in particular on experts, for the exact meaning and correct use of a word (Putnam, 1975). Deference can be driven by a deliberative process but also occurs by default. The speaker might realize that her concepts have vague connotations and explicitly formulates a request for clarification (Do you know the difference between *debit* and *credit*?); or she is simply inclined to trust others about how to apply a concept and integrates the conceptions of those who have more proficiency in the linguistic practice on which the meaning of the word depends (My *credit* concept relies on the banker's knowledge when s/he offers me strategies to increase it).

By deferring to experts, we implicitly recognize that linguistic meaning extends outside our head. Putnam formulated it in the famous notion of "*division of linguistic labor*", according to which in every linguistic community, only a subset of individuals have a good recognition of the instances of concepts, whose use by others depends on structured cooperation between groups of speakers (Putnam, 1975, p. 228). In other words, each member of a community does not need to internalize all information about concepts, as the large body of knowledge distributed among others members can help to identify reference-fixing criteria. Borrowing the classic Putnam's example, our understanding of the concept "water" requires a certain amount of deference to experts to access a complete characterization of its proprieties (i.e., having the chemical structure H_20). Notably, deference is practiced not only with natural kind terms but with many sorts of words whose meaning is identified, in part, in a collective way (i.e., social semantic externalism, Burge, 1979).

From a cognitive standpoint, it has been proposed that deference is a metacognitive outcome involving an explicit or implicit assessment of our concepts and their use at an interpersonal level (Shea, 2018; 2020). More specifically, we recognize other people as having a better mastery of concepts we unknown or are unclear; thus, we defer to them. In this sense, deference consists of a judgment on the thinker's own concepts, and it is compatible with the notion of "system 2 metacognition" introduced by Shea and colleagues (2014): agents monitor their own cognitive activity, sharing information about confidence and reliability of their knowledge in service of effective collaboration for performing some tasks.

The intra-agents monitoring process might be crucial in a variety of linguistic practices. For example, the social process of concept construction is primarily based on the assumption that meaning is not fixed but can be susceptible to collective revision between language users. This frequently happens in academic communities; for instance, within cognitive sciences, the terms “representation” or “consciousness” is a matter of controversy among scholars: some define them differently, and others debate whether they should be used, replaced, or abandoned. Even in everyday life, there are explicit judgments about the utility and correctness of some concepts. Public debates about racial terms are a clear example of negotiation of meaning, which is functional for changing the language currently in use. Interestingly, Shea suggested that this form of metacognition deference might provide distinctive grounding features for abstract concepts (Shea, 2018). While concrete concepts, like “chair”, exhibit less deference mainly because the criteria to fix referent are shared by almost all speakers on a common perceptual basis; abstract concepts, such as “migration”, lack a clear identifiable referent, and information covey by competent others can help us enrich and define their meaning.

Following Shea’s arguments, Borghi et al. (2021) have recently described a similar mechanism they called “social metacognition” to emphasize the role of other social agents in metacognition processes directed to abstract concepts. Their claim is that abstract words generate a high feeling of uncertainty due to their complex and vague meanings, which leads us to need the others more to be mastered. In some cases, these others might be figured in an inner dialogue with ourselves (see the paragraph above). In particular, a form of dialogic inner speech, which selectively activates brain areas involved in understanding other’s mental states, might be used to simulate conversations with imaginary others to analyze conceptual contents that cannot be directly accessed without self-reflection and verbal argumentations, like those of difficult or abstract words (see Alderson-Day et al., 2016; Borghi & Fernyhough, 2021). In other cases, the others are real agents to which we revert to clarify the (abstract) word meaning and/or to negotiate together a more compelling definition of a term and the criteria for its application.

Recently, Fini and colleagues (2021) have exploited a new interactive paradigm directly aimed at investigating the role of social metacognition for abstract and concrete concepts representation and its influence on interpersonal motor control. Participants performed a joint action with an avatar on the screen by grasping a bottle-shaped object as synchronously as possible with its movements. Depending on the experimental conditions, participants were instructed to perform the same (imitative) or the opposite (complementary) avatar's movements without knowing in advance whether the virtual character would grasp the lower part of the object with a power grip or the upper part of the object with a precision grip. Thus, they had to predict and monitor the avatar's movements and adjust accordingly. Before and after the joint action task, participants were submitted to a concept guessing task: they were presented with a set of images referring to situations linked to concrete and abstract concepts (e.g., "freedom", to run on the grass; "muscles" a bodybuilder during the training) and were asked to guess which concepts the image referred to. If they were unable to infer the concept immediately or after 60 seconds, they took suggestions from two different confederates, i.e., one for the abstract concepts and one for the concrete concepts. Importantly, participants associated the avatar identity with which they were interacting in the joint action task with the confederates, who helped them to guess abstract or concrete concepts. The authors measured the objective and subjective helping index. The first corresponded to the guessing accuracy and the average of the number of suggestions requested by each participant for abstract and concrete concepts. The second referred to the rating scores on the need for others' help in order to guess the correct concepts associated with the image. Results showed that both objective and subjective helping indices were higher for abstract concepts than for concrete concepts. This proves that participants asked for more hints with abstract than concrete ones, and that they were aware that others' help was more crucial in that condition. Moreover, the results on reaction and movement times showed that participants acted more synchronously and promptly with the avatar associated with the confederate that guessing abstract concepts than with the avatar associated with the concrete concepts, suggesting that searching for complex abstract meanings during social exchanges leads individuals to cooperate more with other, as in the case of joint actions.

The arguments and evidence discussed suggest that monitoring the limits and reliability of our and others' knowledge is particularly crucial for understanding abstract concepts. The difficulty and indeterminacy of abstract word meaning, lead us to rely more on others to construct and reshape their meaning (i.e., semantic deference, social metacognition). In this process, social interactions, especially during linguistic exchanges, might act as an additional resource to ground abstract concepts.

2.4 What is the role of language?

For years, studies inspired by embodied cognition aimed to show that concepts are grounded in perception and action systems, emotional, internal states rather than in linguistic information. Since its early days, theories of embodied and grounded cognition (EGC) invited to drop the "language of thought" view (Fodor, 1975), according to which concepts and words are arbitrary, abstract symbols represented in a linguistic mental format, deprived of any sensorimotor quality. The main reason to reject this traditional approach to conceptual representation was the so-called "grounding problem": to capture the conceptual meaning, symbolic representations could not be defined by other symbols; they need, instead, to be linked to their referents through non-symbolic representations (Harnad, 1990, see Chapter 1). As a result, within embodied and grounded cognition, the role of language in shaping cognition has been somehow neglected, and the focus of attention was on how to attach words to their physical referents.

The main objective of EGC was to demonstrate that concepts, and words that express them, re-activate the same sensorimotor circuits involved during real interactions with objects/entities they referred. Due to this stance, the embodied theories of language have often been considered an alternative to other influential theories of meaning, and in particular to distributional semantics models, which assumed that access to word meaning is derived from the linguistic contexts to which words are associated (e.g., HAL, Lund & Burgess, 1996; LSA, Landauer & Dumais, 1997).

In the last decades, this panorama is quite changed when embodied cognition scholars have started to adopt a different lens through which to interpret the language experience. The most interesting theoretical advance is offered by new proposals referred to as Hybrid Accounts (Bolognesi & Steen, 2018) or Multiple Representation Views (Borghi et al., 2017), for their consideration that embodied processes, such as perception and action, but also other systems might concur in conceptual representation and processing. Within this broad field of research, there is a growing interest in re-considering language systems as another important grounding source for word meanings. These approaches largely benefit from the insights of novel distributional semantics views proposing that language has both embodied and symbolic aspects and that sensorimotor features can be encoded in the linguistic information carried out by words (e.g., Andrews et al., 2014, see §1.1.3 of this dissertation).

The final sections of this Chapter aim to illustrate recent influential theories that assign a central role to language. All of them converge in showing that words are not mere symbols that stand for their referents in the world, as argued by classical views; however, each approach ascribes slightly diverse functions to words. In order to expound on this, I review and critically discuss these proposals in turn in the following, along with empirical evidence supporting their main claims. First, I will discuss the linguistic shortcut view, according to which words are either a superficial way to activate multimodal simulations (LASS theory, Barsalou et al., 2008) or an economical medium to access meaning, in some cases even only via verbal associations without forming simulations (Connell & Lynott, 2013). Then, I will introduce the hypothesis advanced by some authors concerning the role of verbal labels in enhancing our perception and cognition, likely supporting abstract thought (Lupyan, 2012, Dove, 2019). Finally, close attention will be paid to Words as Social Tools (WAT) theory, whose peculiarity is to consider the whole language as an embodied experience, including the social dimension and its impacts on conceptual representation and the body (Borghi & Cimatti, 2009; Borghi & Binkofski, 2014; Borghi et al., 2019). I will argue that the WAT theory, although it shares some common assumptions with other proposals, has greater explanatory potential for conceptual knowledge, as it provides a more precise account of how abstract concepts are represented, acquired, and used.

2.4.1 Words as a shortcut to meaning

The Language and Situated Simulation (LASS) proposed by Barsalou and colleagues (2008) was the first fully embodied theory that recognized the critical role of language. This proposal argues that linguistic and situated simulation systems regularly interact with each other to support our conceptual knowledge.

The main idea of LASS is that when a word is perceived, the linguistic and situated simulation becomes active, but the representation of the linguistic systems peaks earlier than the simulations. Consider "dog", we first recognize the linguistic forms (not the meaning) and generate other associated words (e.g., "cat"; "poodle"), then we ground the concept in situated modal systems; for example, by re-enacting the sound of bark and our previous interaction with it. At an earlier stage, conceptual processing is realized simply by patterns of co-occurrence words tied to the rapid activation of similar information stored in memory, following the principle of content-addressable memory and the encoding specificity (see Tulving & Thomson, 1973). Since linguistic information is more similar to the cue word than the experiences it refers to, the linguistic form reaches its peak first. However, once the word is recognized, it begins to support the associated simulations. Thus, the words would serve as "pointers" or a "shortcut" to situated conceptual representations.

Notice that, in the LASS perspective, representation and processing of concepts rely on both language and situated simulation systems, but only simulations guarantee access to meaning. In this sense, LASS proposes an opposite view with respect to traditional symbolic conceptual theories (see Chapter 1): Language *per se* cannot implement other operations such as prediction or combination because, in the absence of simulations, using only linguistic-propositional structure would be like manipulating symbols without a real compression (see

Searle, 1980). Linguistic strategies are, therefore, superficial “heuristic” forms that may be sufficient for some tasks in which no deeper conceptual information needs to be retrieved.

Behavioral evidence showed that when the conceptual tasks require only superficial processing, a quick word association strategy is applied (e.g., assessing whether a property is true or not of an object/entity); in contrast, when the task implies deeper conceptual processing, a slow simulation strategy is involved (e.g., found part relation linking the object and property) (Solomon and Barsalou, 2004). In an fMRI study, Simmons et al. (2008) further explored whether different time course activations of the linguistic and simulation systems occur during conceptual processing and whether this activation pattern varies depending on the task. Participants first performed a silent property generation task, producing associated words for a set of concepts; then, in a second scanning session, they imagined a situation related to a given concept. Results showed that early activation in property generation overlapped with the brain area activated during the words association task, i.e., brain regions typically involved in linguistic processing, such as the left inferior frontal gyrus (Broca’s area) and the right cerebellum. Instead, the late activation in property generation overlapped with the same brain areas involved in the situated simulation task, i.e., the precuneus and the right middle temporal gyrus, that are commonly ctivated in mental imaging and episodic memory. The authors interpret these findings as consistent with the LASS view that conceptual processing reflects both language and simulation, with the former being activated very fast, while the latter being engaged later. However, this result seems to contradict previous evidence showing that simulations are activated quickly and automatically within 200ms of word onset (Pulvermüller et al., 2005). According to Barsalou and colleagues, this inconsistency could be explained by the role of the executive control that selectively activates the system encoding relevant information, while others can be activated in parallel. In the case of the reported study, the executive processing immediately oriented attention to the linguistic system, given the cues of the tasks were words.

In the same vein, other scholars have recently suggested that linguistic information provides an economical shortcut to grasping meanings, especially when engaging in simulations would be too costly or unnecessary (Connell & Lynott, 2013; Connell, 2019). For example, relying on linguistic associations to produce synonyms/antonyms (house-home; right-wrong) or sound similarity (hear-here), and taxonomic features (cat-animals) might be a sufficient strategy. In contrast, simulations are required to verify a property for a concept (cat-has fur) or to describe its meaning (sea-expanse of saltwater that covers most of the earth). According to this proposal, it is the adopted task and not the kind of concept that determines the engagement of linguistic *vs.* sensorimotor systems.

At this point, the reader might wonder whether and how this kind of approach contributes to the discussion on abstract concepts representation. In the first place, the LASS theory was not directly aimed at explaining abstract words. However, since this approach was presented in connection with Paivio's Dual Coding Theory, the other seminal theory that distinguishes between "verbal" and "non-verbal" systems, one could assume that motor simulation supports concrete concepts representation and language supports abstract concepts representation. In contrast, Barsalou and colleagues admit that DCT is only partially consistent with their proposal: DCT assumes that deep processing takes place in both systems and postulates that linguistic processing is recruited to represent abstract concepts, whereas according to the LASS theory, deep conceptual processing occurs only in simulation systems. Therefore, the authors argued that the representation of both abstract and concrete concepts is supported by a mixture of language and simulation systems whose distributions differ under task conditions.

To conclude, it is worth noting that the LASS theory represents a significant step forward in the debate on conceptual knowledge. Starting from a fully embodied and grounded framework, this proposal acknowledges the importance of language forms as a vehicle for conceptual processing, excluding the existence of a-modal symbols. Differently from previous approaches, it focused on the underlying mechanisms of conceptual processing and their different time course, and not only on semantic contents. Nonetheless, one possible limitation is that the activation of such mechanisms depends largely on the task to be performed and not on the type of concept. Finally, since words serve as a shortcut mechanism to access meaning, here language seems to have only a marginal role.

2.4.2 Words as a cue to meaning

Whereas the LASS theory ascribes a shallow, superficial role to language in shaping concepts, the proposal advanced by Gary Lupyan focuses directly on how language, and in particular the practice of labeling, can exert an effect on human cognition.

In his initial work, Lupyan (2007; 2012) introduced what he calls the “Label-Feedback Hypothesis” to replace the classical distinction between verbal and non-verbal processes with a distributed and interactive system, in which language itself modulates ongoing low-level processing in a task-dependent and flexible way. Specifically, this view predicts that verbal labels selectively activate the diagnostic features of the named category, namely the features that most reliably co-occur with the label. This activity feeds back into both conceptual and perceptual acts, altering the representation of the current object. For example, when we hear the word “chair”, the most typical features related to such objects would be activated, leading us to better detect chairs in the enviroment. The main idea is that all cognitive and perceptual processes work with top-down feedback loops, in which our perception of the world influences the higher-level conceptualization of objects/entities, which in turn determines the way we label them. In this interactive processing perspective, naming an object makes the visual representation of objects/entities more categorial and less idiosyncratic (bottom-up), resulting in a discrete and coherent representation that matches the category (top-down).

To test the role of verbal labels in conceptual representation, Lupyan and Thompson-Schill (2012) examined the influence of verbal (e.g., “cow”) and non-verbal cues (e.g., a mooing sound) on categorization through a series of cued-recognition experiments. In a picture verification task (Experiment 1A-1C), the authors found a label advantage: Hearing a verbal cue (e.g., “cow”) led to a faster and more accurate recognition of subsequently presented pictures that matched the cue (e.g., a picture of a cow) or did not match (e.g., a picture of a car). Interestingly, the same advantage was observed in a cue-to-picture association learning task for novel categories of “alien musical instruments” (Experiment 4), although the names and sounds were learned equally by participants.

Similarly, Edmiston and Lupyan (2015) showed that auditory cues, such as dogs barking or guitars strumming, activate highly specific instances of a category, while verbal labels, such as “dog” or “guitar”, elicit more categorial representation, promoting effective performance when the task consists of recognizing the entire category of objects. The authors concluded that perceptual inputs work as *motivated cues* driven by a predictable correlation between a set of properties at specific times, just as the auditory input of a dog’s bark might be an index of its size. In contrast, category labels act as an *unmotivated cue,* as the word “dog” does not instantiate any specific properties of a dog (see also Lupyan & Bergen, 2016). This evidence suggests that language impacts visual and auditory recognition, and its hold not only for familiar stimuli but also for new categories. In particular, labels expand our perceptual representation and allow us to recognize more general and decontextualized properties of both existing and novel categories (e.g., Lupyan & Spivey, 2010; Zettersten & Lupyan, 2020).

In this view, labels are more than a simple vehicle of our thought or a mere placeholder for a category; rather, they are conceived as *a cue* that helps people construct meaning (Lupyan & Lewis, 2019; see also Elman, 2004; 2009). It's worth noting that Lupyan stands his words-as cue perspective as an alternative to the words-as-mapping perspective that posits preexistent conceptual repertories onto which words map independently by language (see, among others, Li & Gleitman, 2002; Levinson, 1997). Lupyan highlighted that the context-dependence and the cross-linguistic variability of word-meaning raise two insuperable problems with the idea that words gain their meaning onto universal concepts (for an in-depth discussion of these argumentations, see Lupyan & Lewis, 2019). On account of this, language, like perception, should be conceived as a source of experience that dynamically alters our semantic knowledge. For the sake of brevity, it suffices to mention a striking example that Lupyan uses to support the causal role of language in influencing our conceptualization. Consider the case of semantic knowledge of colors in congenitally blind people. Although they have no direct experience with colors, such individuals are fully capable of learning and using color vocabulary, and their knowledge of color semantic space appears to be similar to that of sighted people, e.g., a blind person may report that the sky is typically blue and that orange is more similar to red than to green. This ability owes solely to the linguistic experience of the statistical regularity of the use of color words by speakers (Lewis, Zettersten, & Lypyan, 2019).

Even more relevant to the topic of this dissertation is Lupyan's argument that the power of labels becomes more effective for those words that do not presumably exist apart from language, namely abstract concepts. In a recent paper, Lupyan and Winter (2018) precisely claim that "To understand the origin of (some) abstract concepts, we argue that we need to turn to language itself" (p. 1). Language helps guide actions, describe events in the world, and, most importantly, the distributional statistics of language provide a rich network of information to capture some abstract knowledge that we could not otherwise construct. After proving how ubiquitous abstract words are in our language, the authors suggested that abstractness is so pervasive because a great part of words resists iconicity (i.e., the resemblance between the form of a word and its meaning). The evidence discussed suggests an inverse relationship between abstractness and iconicity: The more a word is iconic and has a sensory vividness that gives a hit of its meaning; the more it is judged to be concrete (less abstract and arbitrary) (Sidhu & Pexman, 2018; Winter et al., 2017). Since iconic language only captures certain aspects of meaning in a narrow range of contexts, it is argued that iconicity limits generalization and abstraction. On the contrary, form-meaning arbitrariness can better convey abstract meaning, leaving room for all potential users of words.

In a nutshell, Lupyan's theory, while it cannot be properly classified either as an embodied or hybrid theory, pointed out that words are not simply arbitrary symbols to map into meanings but function like real physical tools that dynamically modify visual processing and facilitate conceptualization, in particular of not tangible entities, as those denoting by abstract concepts.

2.4.3 Words: from dis-embodied symbols to an embodied neuroenhancement

A key principle of embodied theories of language is that concepts are couched in sensorimotor representations, and the meaning must be grounded in something other than mental symbols. However, the challenge that abstract concepts pose to such a claim led some authors to revive the notion of a-modal representation and consider language as central to solving the problem of abstractness. In this respect, an inspiring proposal is the "representational pluralism" by Guy Dove.

In a seminal work, Dove (2009) pointed out that the evidence supporting simulation theory-based is fundamentally circumscribed and partial: Perceptual symbols theories (i.e., Barsalou 1999, Prinz, 2002) can account for highly imaginary and concrete concepts but fail to show how multimodal simulations support the representation of abstract concepts that refer to entities and events not causally related to their referent. According to Dove, to provide a successful theory of abstract concepts, it must be admitted that they are at least handled in some form of a-modal knowledge. Even though Dove does not explicitly call for a return to the modularity conception of cognition, he suggested that our conceptual system employs both modal and a-amodal representations, where the latter can be seen as distributed representation in neural networks that allows us to acquire semantic content that goes beyond perceptual experiences (p. 413).

In further works, Dove (2011) has partially reframed and extended its original idea. In his essay, he refers to language as a representational system that allows us to generate an appropriate simulation of verbal experience (e.g., acquisition, processing, comprehension). In this sense, both abstract and concrete concepts rely on perceptual symbols, but to a different extent. While concrete concepts mainly rely on perceptual symbols that integrate sensorimotor simulation of multimodal, schematic, and partially unconscious information of the physical world, abstract concepts depend more on sensorimotor simulation of natural language. Importantly, the linguistic and embodied simulation-based information interact but are conceived as independent systems. Dove provided indirect support to his theory by discussing brain imaging evidence on the higher engagement of linguistic regions (i.e., left temporal lobe and inferior regions of the left prefrontal cortex) in processing abstract concepts compared to concrete concepts (see meta-analysis Binder et al., 2009; Wang et al., 2010).

According to Dove, the relevance of language for abstract concepts derives from the necessity of an "ungrounded" knowledge that goes beyond perceptual information. Natural language, in this perspective, is a form of "dis-embodied" cognition. In Dove's formulations, a mental symbol is "disembodied" if (1) it is embodied but (2) it is embodiment is arbitrarily related to its semantic content. In other words, the semantic content does not derive from the simulation of linguistic experience itself but is captured through the inferential and associative relationships between other words, as suggested by the distributional approaches (e.g., Andrews et al., 2014). Therefore, language is defined as "an internalized amodal symbol system that is built on an embodied substrate" (p. 8).

With this caveat, however, Dove's proposal is far from being considered a fully embodied theory. In contrast to LASS theory, in which linguistic representation is purely modal, Dove holds that linguistic symbols solve two main objectives: first, dynamically activating sensorimotor simulations (in the same way as in the LASS theory), and second, triggering symbolically mediated operations, such as words or phrases. In his view, it is only by admitting the arbitrariness of language that it is possible to account for the flexible use of concepts, and especially to grasp abstract meanings.

Although Dove appeals to a-modal symbols, it is noteworthy that his proposal has contributed to rethinking language in a novel and fascinating way. Language should be considered neither as a mere vehicle for information nor as an a-modal system, thus contradicting the EC approaches, but rather as a medium of thought that extends our conceptual reach (Dove, 2011; 2014). More recently, Dove (2018) has outlined that language, with its combinatorial properties of productivity and systematicity, is an external symbols system through which we build new capabilities. Specifically, Dove defines Language as an Embodied Neuroenhancement Scaffold (LENS Theory, Dove, 2020) that provides a new set of objects – the words – that support our thinking (see also Clark, 2006). Our ability to label entities, manipulate and combine symbols, and hold conversations transforms our conceptual systems in a flexible, multimodal, and context-dependent manner. In this sense, language becomes an essential component to shape and refine categories, especially those not directly related to immediate experiences, such as abstract concepts.

Dove's proposals have contributed significantly to the debate on conceptual representation from a multidimensional perspective. Starting from strong criticism of earlier embodied approaches, he advocated for a hybrid and pluralistic view of concepts that involve both perceptual and non-perceptual experiences, among which natural language. Here, language is defined as a symbolic system grounded in sensorimotor experience that, by the mean of its structural proprieties, enhances our cognition, especially supporting the processing and representation of abstract concepts. Many of his insights resonate with other Multiple Representation Views and specifically with the one I am going to present in the next paragraph (the WAT theory), which emphasizes the relevance of language itself as a whole embodied phenomenon, as does Dove's theory, but makes a step forward, including a distinctive trait of language, namely its intrinsic social component.

2.4.4 Words as Social Tools: Language is an Embodied experience

> "Think of the tools in a tool-box: there is a hammer, pliers, a saw, a screw-driver, a rule, a glue-pot, glue, nails and screws.—The functions of words are as diverse as the functions of these objects. (And in both cases there are similarities). Of course, what confuses us is the uniform appearance of words when we hear them spoken or meet them in script and print. For their *application* is not presented to us so clearly. Especially when we are doing philosophy!" (Wittgenstein, PI § 11).

> […] here the term "language-*game*" is meant to bring into prominence the fact that the *speaking* language is part of an *activity*, or of a form of life. (Wittgenstein, PI § 23).

These famous quotes from Wittgenstein (1959) deeply inspired the theory known by the acronym of WAT (Words as Social Tools; Borghi & Cimatti, 2009; Borghi & Binkonski, 2014; Borghi et al., 2019).

In the initial formulation of this proposal, Borghi and Cimatti (2009), following Wittgenstein's metaphor, claim that words are not mere signals that point to something; on the contrary, they should be intended as real *objects/tools* of direct experience; each of them has a multiplicity of uses that allow us to act and operate in a social context. In line with the philosopher, the objection they moved to theories of language strictly based on a referential approach relies on the acknowledgment that the symbolic nature of language is insufficient to describe the essence of language, which incorporates another crucial feature: the social and normative function of words.

The rationale behind this argument follows Harnad's *Symbol Grounding problem* (1990) and extends it. In a certain way, language is a symbolic system organized around a set of syntactic rules and formal criteria to combine and produce meaningful expressions. Words are symbols, in the most trivial sense, because they stand for their referents in the world engaging with them a conventional relationship. However, the meaning of words cannot be fully explained by simply assuming a correspondence between words and the entities to which they refer. Consider, for example, that the connection that links the string of letters "h-a-m-m-e-r" to the object reference does say nothing about how the meaning of that word should be interpreted. Besides the perceptual and experiential grounding, what is crucial to understanding the meaning of the word "hammer" is to master a form of procedural knowledge that regulates its *uses* in linguistic practice. Put it differently, one needs to know the linguistic contexts in which the use of the word "hammer" is correct (e.g., I am going to hang a picture. Please give me a *hammer*) or incorrect (e.g., I am going to cut a paper. Please give me a *hammer*) in relation to a set of shared norms among a community of speakers. Hence, the way we grasp the sense of the concept "hammer" converges with the socially appropriate way to use that word, just as we follow the same rule for using a specific kind of tool, rather than a different one when we want to drive a nail into a wall.

This normativity aspect is a constitutive part of natural language: Without linguistic actors interpreting and sharing the meaning of symbols and syntactic rules, linguistic messages would make no sense at all. Therefore, in order to correctly describe the human linguistic experience, it is important to consider that words are *social*, public things that rest upon some normative rules that need to be respected to be useful and to ensure communication among people. In a nutshell, language is a social activity and words meaning depends on practice.

Starting from this view, Borghi and Cimatti (2009) claimed that an exhaustive theory of language should take into account not only *individual* grounded experiences but also the *human collective* embodied experiences of being immersed in a social context. To this end, some aspects of current embodied approaches to language need to be reframed.

In particular, the authors pointed out some limitations of the classical embodied theory based on simulation view and mirror-neurons systems. In this theoretical framework, linguistic social experience seems to be expressed only as a form of neurological resonance between healthy brain systems in specific situations (e.g., an observer "understands" an agent performing some gestures). Further, this process is thought to be an automatic consequence of mirror systems activity, which no admit exceptions. This kind of logical relation, note the authors, does not sufficiently describe the actual dynamics that occur between individuals in our ordinary life experience. Language exchanges are a form of conscious activity in a normative context, where the possibility of following or violating some linguistic roles is always present and occur very frequently. Therefore, the solution advanced by Borghi and Cimatti (2009) is to somehow extend the embodied view to account for (a) the human individual embodied experience; (b) the socially embodied experiences intertwined with mirror neuron system; (c) a theory of language as a social fact, and (d) a theory explaining how linguistic and social practices affect individual cognition.

These points are particularly relevant to addressing one of the critical and well-known problems of embodied view: the grounding of abstract concepts. The novelty of WAT theory is to offer a precise portrait of abstract concepts which are defined in a positive way and not just in opposition to concrete ones. The claim is that the classical distinction between abstract and concrete concepts should be reformulated as a difference between individual and collective grounding sources for word meanings. While the grounding of concrete words is primarily based on individual sensorimotor experiences with their referent, the grounding of abstract word meaning takes place in the social context, and it is made possible by a particular form of bodily experience mediated by linguistic, social tools that are *words*.

According to the authors, thinking of words as *social tools* allows us to anchor the meaning of abstract concepts in two different but related ways. On the one hand, all words, even abstract ones, are embodied because they are material things we experience with our senses: we hear the sound of words, we see the visual form of words on printed pages, and we utter them through our phono-articulatory system. As a form of bodily experience, words can namely influence and guide our cognition. On the other hand, words have a social function not only when we use language to communicate with others, but also because the presence of others is often required in the context of the acquisition and use of language; for example, to provide definitions of a term and clarify its meaning. The authors argued that in the process of building abstract concepts, which do not have a clear physical referent, the influence of linguistic and social exchanges might be stronger than for concrete concepts. In this respect, once recognized that social linguistic experience is a typical human embodied experience, the abstract meanings are embodied as just concrete concepts are.

Before illustrating the main tenets of WAT theory on abstract concepts in detail, it is worth taking a small step forward and presenting some general considerations. Differently from other proposals emphasizing the role of linguistic form information and verbal associations in explaining conceptual knowledge, the WAT theory ascribes a more extended reach to language. As recently argued by Borghi (2020), language can work as a pointer or shortcut to access meaning, but have other fundamental functions exemplified by the metaphor of *tools*. Words are physical tools that can extend and modify our perception, facilitating the recognition and categorization of entities in the external environment; words are inner tools for shaping and monitoring our inner/cognitive processes; finally, words are social tools to perform actions that modify social settings and our relationship with other people. Notably, all these functions actively contribute to the conceptual representation, but with a different weight for abstract and concrete concepts.

2.4.5 The WAT theory and Abstract concepts: Empirical Evidence

As sketched out in the initial presentation, the WAT theory put a strong emphasis on the role of language and its social practices in determining the meaning of abstract concepts. One of the main contributions of the WAT theory, indeed, consists of a systematic approach to the study of abstract concepts aimed at characterizing the mechanisms that subtend their representation, acquisition, and use.

A central tenet of this theoretical proposal is that both abstract and concrete concepts are embodied, but differ in the modality of acquisition because of the nature of their exemplars. Since abstract concepts have heterogeneous referents that typically do not correspond to distinct objects, we usually learn abstract concepts through linguistic and social inputs rather than perceptual experiences, as in the case of concrete concepts. In the example of Borghi and Cimatti (2009), the meaning of concrete words like “bottle” can be acquired by pointing the reference in the external environment, whereas the meaning of abstract words like “God” is conveyed solely by means of language. Consistently, Borghi and Binkofski (2014) pointed out that the role of language and sociality might be more crucial for abstract concepts than for concrete ones, for at least two reasons. First, language may help to keep the sparse experiences associated with abstract concepts under the same verbal label, ensuring conceptual coherence even in the absence of a single, clear referent. Second, because abstract concepts are less constrained by the physical environment, linguistic explanations provided by other speakers or by technological supports (e.g., books, Internet) are often necessary to learn and master abstract concepts meaning; thus, the linguistic and social experience can make up for shortcomings of perceptual inputs, serving itself as a scaffold for abstract concepts acquisition and representation. [10]

The linguistically and socially mediated modality of acquisition of abstract concepts is supposed to affect their subsequent representation at both neural and sensorimotor levels. On the one hand, the authors claim that the brain representation of abstract concepts involves sensorimotor networks, exactly like concrete ones (embodiment), but since they differ partly in the modality of acquisition, abstract concepts should activate the linguistic and social cognition networks to a greater extent than that of concrete ones. On the other hand, they hypothesize that the processing of abstract concepts might entail the engagement of the mouth motor system, as a result of this linguistic system activity.

Another consequence of the fact that abstract concepts are acquired mainly via linguistic and social experience is that their meanings are more likely to be affected by cultural and linguistic variability than concrete concepts. That is to say that abstract concepts tend to differ across individuals, cultures, and spoken languages.

This brief discussion exemplified the four central tenets of the WAT theory on abstract concepts (Borghi & Binkofski, 2014; Borghi et al., 2017), whose formulation has been enriched and developed over time (e.g., Borghi, Barca, Binkofski, & Tummolini, 2018; Borghi, Barca, Binkofski, Castelfranchi, Pezzullo, & Tummolini, 2019) and concern their 1) acquisition, 2) brain representation, 3) sensorimotor pattern activation, and 4) cultural and

[10] Borghi and colleagues have recently outlined that the role of sociality is not limited to a way of acquiring abstract concepts. Rather, it might be also relevant in other social phenomena involving metacogniton process and social metacognition, such as deferring to experts when unsure about the definition of some words (i.e., semantic deference), or when redefining the word meaning together with other people (i.e., negotiation of meanings). I have discussed this stance in § 2.3.2, and additional evidence will report later in this dissertation.

linguistic variability. Henceforth, I will endorse the WAT theory as, to the best of my knowledge, it seems to offer the most reliable approach to the issue of abstract concepts. To this aim, I will address the *first* and *third* tenets and discuss in turn its empirical basis in light of recent evidence as they are central points of the arguments of this dissertation. [11]

2.4.5.1 How to learn 'hard words': the role of language and sociality

Learning a language is, after all, a social phenomenon. Imagine we want to teach the words "ball" and "enigma" to a child we call Hannah. In the first case, we could simply take a round object and show her how it rolls and rumbles on the floor, repeating several times the name that stands for it: "This is a ball!". After a while, when Hannah encounters objects with the same perceptual characteristics, she will easily recognize them as "ball". The second case opens a more complex scenario. Let's assume that Hannah has already heard the word "enigma" when doing homework, her older sister says: "Math is still an enigma for me!" or when watching a Sherlock Holmes movie, her parents comment: "This case is very enigmatic!". Hannah probably asked curiously: "Mom, what is an enigma?". In response, the mother explained to her that it is something hidden, mysterious, and inexplicable. A few days later, her father reads her the *Mickey Mouse in the Lost Treasure of Maroon*; after he finishes, Hannah promptly exclaims: "There was an *enigma* in this story!". It is only at this point that we can infer that Hannah has learned the word enigma and is using it correctly. Even though word acquisition in both cases took place in a social-linguistic context, it was certainly more

[11] I will not address the (2) and (4) tenets of the WAT theory in detail, concerning respectively the brain representation and cross-linguistic and cross-cultural variability of abstract concepts. On the second tenet, I have already mentioned in course of this dissertation that converging neuroimaging evidence confirms a stronger activity in language brain areas during the processing of abstract concepts compared to concrete ones (see Chaper 1). On the fourth tenet, it suffices to say for our scopes that behavioral cross-linguistic evidence seems to support the high variability of abstract word meaning. An extended discussion on this topic can be found in Borghi (2019) (see also §.4.2.1 of this dissertation).

challenging for Hannah to learn the meaning of the abstract concept "enigma" than that of the concrete concept "ball". This is mainly because the acquisition of a concrete word is often supported by the physical presence of its referent, which is not the case with an abstract word.

It should be now clear from this simple example that different mechanisms are at play in the learning of abstract and concrete concepts. To form concrete categories, whose members are single, perceptually similar objects, the physical environment is the primary source of information. This does not mean that language is irrelevant in the acquisition of concrete concepts, but its role is partially limited to its referential function, namely ascribing a direct name-object link. On the contrary, language and its social dimension play a constitutive role in building abstract concepts meaning. Since their members are heterogeneous and occur in very different contexts, verbal labels work as a sort of "glue" to connect such sparse experiences that could not be captured otherwise. Moreover, as the example shows, in order to acquire abstract concepts, the linguistic inputs and clarifications provided by others could be necessary to understand the range of correct uses.

In conceptual developmental studies, not by chance, abstract concepts are referred to as "hard words". For example, Gleitman and colleagues (2005) argued that children start to learn "easy words" by associating them with the objects/entities in the world. However, only a limited class of terms, such as concrete concepts, can be learned solely based on this word-to-world mechanism. Knowledge of abstract concepts, instead, emerge later. Once children have mastered a certain number of words, a more sophisticated representation of the linguistic structure emerges, enabling the acquisition of the "harder" words. This learning process, known as *syntactic bootstrapping*, is based on a close connection between syntactic and semantic, with the former providing multiple probabilistic cues that help to infer the meaning of words. An early demonstration of this hypothesis comes from Gillette et al. (1999)’s study, which involved adult participants guessing the “mystery word” uttered in silent videoclips of mothers interacting with their toddlers. Participants' performance showed significant similarity to the typical course of vocabulary acquisition in children. Crucially, early and late word learning was better predicted by imageability (or concreteness) than the lexical categories: hence, a concrete verb, such as “kiss” was acquired before an abstract noun like “idea”. When a combination of the visual and linguistic-syntactic contextual cues was available, performance was efficient not only for concrete concepts but also for abstract ones, corroborating the idea that exposure to language information supports its identification.

Evidence for late learning of abstract words stems from an eye-tracking study by Bergelson and Swingley (2013) in which parents and infants were shown a set of pair videos and asked to name one of the events in the video. Younger children of 6-7 months of age already recognize the meaning of concrete words (e.g., “banana”) but not that of more abstract words (e.g., “kiss”). From the 10-13 months, infants looked significantly at the named target video. Their performance improved greatly around 14-16-months-olds, with a positive increase in target search for both concrete and abstract entities. Further comparison of these results with a video-corpus of parent-infant interactions showed that concrete words occurred more frequently in the presence of their referents (e.g., saying “a banana” when a real banana or a picture of one was in the scene); in contrast, abstract words were produced less frequently in association with their referents (e.g., saying “hi” when no-one was in the scene). The authors claimed that the developmental difference in the learning of abstract and concrete concepts is due to the referential uncertainty, which makes it difficult to recognize abstract concepts meaning only through environmental inputs. Moreover, the acquisition of abstract vocabulary demands specific social-cognitive skills, such as gaze-following and intention-reading abilities (e.g., Carpenter et al., 1998).

Consistently with the literature on conceptual development, the WAT proposal (Borghi et al., 2017) contends that concrete and abstract concepts differ in the modality of acquisition: While the meaning of concrete concepts is acquired predominantly through sensory and motor modalities, abstract concepts benefit most from linguistic and social inputs. Borghi and colleagues (2019) recently proposed that the formation of abstract concepts emerges in correspondence with some important, previously developed competencies. On the one hand, increased linguistic skills, such as the ability to use labels even in the absence of their referent, and to form categories based on common goal/intentions rather than the perceptual similarity of their items (e.g., ad hoc categories, Barsalou, 1983, see § 4.1). On the other hand, mastery of sophisticated social skills typically requires joint attention and joint action, such as sensitivity to linguistic cues in context, the ability to monitor the gaze of others, and to recognize a reliable source of information in adults.

The benefits of linguistic information in learning abstract concepts persist into adulthood. In studies mimicking the acquisition of novel words (Borghi et al., 2011; Granito, Scorolli, & Borghi, 2015), adult participants were presented with a set of 3D objects that denoted novel concrete (i.e., a single, perceptually salient object) and abstract categories (i.e., multiple interacting elements). After becoming familiar with these new items and forming the corresponded category, participants were taught the noun associated with each of them. Results showed that abstract categories were more difficult to learn than concrete categories, as in the case of real-world acquisitions. Furthermore, participants who were given a verbal explanation of the word's meaning exhibited a more accurate performance in the categorial recognition task than participants who had only learned the name. Crucially, language training enhances learning, especially for participants who initially had worse performance with abstract concepts, confirming the role of labels and word explanations for their acquisition.

Additional support for the peculiar mode of abstract concepts acquisition is provided by psycholinguistic studies that investigate parameters such as Age of Acquisition (AoA) (Barca et al., 2002) and Modality of Acquisition (Wauters et al., 2003; Della Rosa et al., 2010).

In AoA norming studies, participants estimate the age at which they learned a word (Gilhooly & Logie, 1980). Typically, AoA correlates negatively with the level of concreteness. Barca and colleagues (2002) collected ratings on more than 600 Italian nouns and found that earlier acquired words tend to be rated as more concrete than those acquired later.

MoA refers to the type of information that supports concept acquisition by distinguishing between a perceptual modality of acquisition (e.g., interacting with the object referent; “bottle”), a linguistic modality of acquisition. (e.g., listening to explanations; “grammar”), and a mixture of both modalities (e.g., showing a picture and explaining the meaning; “tundra”). Wauters et al. (2003), who first validated the MoA constructs, analyzed a set of words from textbooks used in elementary schools. The authors found that the MoA mean ratings increased with progressive increases in complexity over the text grades. Accordingly, the early graded words were acquired mainly through sensory modalities; in contrast, the advanced texts included a higher proportion of words acquired mainly via linguistic explanations.

Furthermore, Della Rosa and colleagues (2010) showed that the rating on abstract and concrete concepts has a different distribution with respect to MoA. The acquisition of concrete concepts is mainly perceptive, while abstract concepts are closely linked to linguistic inputs.

Results revealed a positive correlation between abstractness and MoA (.203), testifying that the more abstract terms are acquired primarily via linguistic information. The authors pointed out that even though MoA and AoA are strongly related, the two variables do not overlap, so they can be treated as independent predictors of abstractness or concreteness (for a review, see Borghi et al. 2017). Overall, AoA and MoA literature is consistent with the WAT predictions: The linguistic modality of acquisition becomes more critical with age; moreover, it might be particularly decisive for complex words, which are often abstract.

2.4.5.2 Abstract concepts and the mouth motor system activation

As emerged in the previous paragraph, linguistic inputs are crucial for the acquisition of abstract concepts whose referents are less constrained by sensory modalities and physical interactions. However, this does not rule out a potential integration between sensorimotor components and abstract conceptual knowledge. One of the main tenets of the WAT theory is that the role of language for acquisition, representation, and use of abstract concepts has an embodied counterpart in the activation of the mouth motor system. Below, I offer an overview of numerous pieces of evidence that support this hypothesis, and then, in the next section, I discuss some possible mechanisms that might underlie the relation between abstract concepts and mouth motor areas.

The recruitment of linguistic regions, specifically the mouth motor system, during the processing of abstract concepts and sentences is confirmed by neural evidence coming from fMRI and TMS studies. For instance, Sakreida and colleagues (2013) investigated the neural correlates associated with concrete and abstract content in an fMRI experiment in which nouns (denoting a graspable/non-graspable entity) and verbs (motor/non-motor verbs) were combined to encompass a spectrum from pure concreteness to pure abstractness of meaning (e.g., “to cares the dog/the idea”; “to think of the dog/the idea). In addition to a general activation of sensorimotor networks (i.e., left lateral precentral gyrus and medial premotor cortex), the results showed dissociative neural correlates: While the purely concrete expressions activated the left inferior frontal gyrus and the two foci in the left inferior parietal cortex, the purely abstract language contents triggered distinct activations in the anterior part of the left middle temporal gyrus, which is a brain region known to underpin lexical and phonological processing. In a TMS study, Scorolli et al. (2012) used phases containing a mixed combination of nouns and verbs, both abstract and concrete, and asked participants to perform a sentence sensibility task while single TMS pulses were delivered on the left primary motor cortex (hand-related motor systems). Analysis of motor evoked potentials (MEPs) showed an early activation of hand motor areas with concrete sentences and delayed activation of the same areas with abstract sentences. This result was likely due to a cascade effect from an initial mouth- to the hand-related area activation given to their topographical contiguity in brain regions. More recently, Dreyer and Pulvermüller (2018) extended previous findings of mouth activation with mental abstract words (e.g., logic) that elicited a stronger activation of face motor areas compared to emotional abstract words, which in turn equally activated different foci of the motor system (e.g., hand, leg, mouth) during a passive reading task.

Behavioral studies further demonstrated that the mouth motor system is actively involved during the acquisition and processing of abstract concepts to a larger extent than what happens with concrete concepts. The first evidence comes from studies that mimic the acquisition of new conceptual categories in adults that were asked to use the hand or the mouth to respond to learned concepts. In the already mentioned study by Borghi and colleagues

(2011), participants first learned novel categories of concrete and abstract entities (i.e., geometric shapes or names) and then were submitted to a property verification task in which they were asked to identify features associated with a specific concept. Results showed that responses to abstract concepts were faster when using a microphone to respond (thus engaging the mouth) and responses to concrete concepts when pressing a key with the hand. Granito et al. (2015) replicated this pattern of results in a study in which participants performed a categorical recognition task after learning verbal categories of new objects and names. Participants who had undergone the linguistic training were faster to respond to abstract words when the answer was provided with the microphone, while no advantage was found for hand responses. These findings confirm the link between mouth activation and verbally mediated acquisition and suggest that this association prevails for abstract concepts.

Evidence for facilitation of mouth responses during abstract concepts processing was also obtained in studies with real words and sentences. In an implicit word-definition matching task, Borghi & Zarcone (2016) presented participants with either concrete or abstract word-definition pairs and asked them to decide whether the definition matched the following abstract and concrete target words. Importantly, in the first block, they were invited to respond with a key on the keyboard, while in the second block with a device within the teeth. Overall, the responses given by hand were faster than those given by the mouth; however, the difference between hand and mouth responses was smaller for abstract concepts than for concrete ones. Thus, the advantage of hand responses over mouth responses disappeared during the processing of abstract concepts. These results were further replicated and extended in a study by Mazzuca et al. (2018) using a go-nogo paradigm. Participants first performed a lexical decision and then a recognition task on a set of concrete, abstract, and emotional words. The authors found that facilitation for abstract concepts occurred not only when the mouth was directly engaged in responding (Experiment 1), but also when it was indirectly occupied with a device held with the teeth; and responses to critical trials were provided by another modality, namely by pressing a pedal with the foot (Experiment 2). Interestingly, the effect was flexibly modulated by the task: the interaction between effectors (mouth vs. hand) and type of concepts (abstract, concrete, and emotion) was present in the recognition task but not in the lexical decision task, probably because of the too shallow level of processing. These findings of a connection between abstract concepts and mouth activation converge with those found in explicit rating studies in which participants were asked to what extent different effectors were involved with action with target words/sentences. People tend to associate abstract concepts, and especially mental states ones, with the mouth effector and concrete concepts with the hand effector, owing to their link to actions (Ghio et al., 2013).

Together, such evidence on mouth engagement during abstract concepts processing suggests that the role of linguistic motoric component is not a by-product but is constitutive of the representation of abstract conceptual knowledge. If so, one might wonder whether inhibiting mouth use could lead to a selective impairment with abstract concepts. To this extent, recent studies have found online and offline interference effects during abstract concepts processing, when the mouth is actively occupied while performing a task.

Previous works showed that blocking oral muscles that covert phono-articulatory simulation of a word, for example chewing gum, reduces the pleasantness of fluency of pronunciation in case of repeated exposure of a word stimuli (i.e., Mere Exposure Effects, MEEs; see Topolinski & Strack, 2009; Topolinski, Linder, & Freudenberg, 2014). Along this line, Fini et al. (2021) conducted a behavioral interference task aimed at investigating the functional role and mechanisms underlying mouth involvement during abstract concepts processing, and especially the role of inner language. To this end, the authors performed a study in which inner speech and the phonological loop were inhibited through the common method of articulatory suppression, i.e., syllable, words repetition (see § 2.3.1.). In this study, participants judged whether words were abstract or concrete by pressing two different pedals with their feet. Crucially, the authors designed different task conditions to activate the mouth and hand effectors: While performing the categorization task, participants were asked either to continually pronounce a syllable (articulatory suppression) or rhythmically squeeze a softball with their hand (manipulation) or do anything (baseline). Analysis of RTs showed that the processing of abstract concepts was slower than concrete concepts in the articulatory suppression condition, while no difference was observed in the manipulation condition. These findings indicate that disrupting the mouth use impacts the speed of accessing the abstract word meaning, generating interference. It also suggests that the processing of abstract concepts might rely on linguistic experience mediated by inner speech.

Further interference effects have been found in conceptual developmental studies investigating the role of mouth motor systems in abstract concepts acquisition. Two longitudinal experiments on children examined whether, in the early stage of linguistic development, the prolonged inhibition of mouth movements with an oral device, i.e., the pacifier, has a selective and long-term impact on abstract word processing and representation. In a first study, Barca, Mazzuca, and Borghi (2017) asked 6-7-year-old typically developed children to provide definitions of abstract, concrete, and emotional concepts. The sample of children was differentiated based on the number of years of pacifier use. Analysis of produced features showed that the over-exposure of pacifier did not affect word definition accuracy but modulated the conceptual relations elicited by different kinds of words. Specifically, compared to the other children, those who used pacifiers up to age 3 and beyond describe concrete components of concepts, such as exemplifications and functional relations, produce fewer free associations and refer less to emotions and experiential contents (i.e., the distinctive features typically associated with abstract concepts). Interestingly, the distinction between concrete and emotional words definitions, and between concrete and abstract words definitions were clear in children who have never used a pacifier or have used it to a minor extent and became progressively less sharp in later pacifier users, suggesting that extensive use of pacifier conflict with the recruitment of mouth motor systems involved in simulating abstract word meanings.

In a second study, Barca, Mazzuca, and Borghi (2020) confirmed this pattern of results using a semantic categorization task, in which 7-8-year old children with a different history of pacifier use had to discriminate between abstract, emotional, and animal concepts by pressing a button on a keyboard. In line with previous evidence, the spread of responses for the three types of concepts was influenced by the period of pacifier use in childhood: Compared to other children, who used the pacifier longer were slower in response to abstract words than concrete and emotional words. Overall, these studies suggest that the forced inhibition of facial muscles during linguistic acquisition might reduce the benefit of linguistic and social input on the acquisition of abstract words, resulting in an interference with subsequent abstract conceptual and linguistic competence.

The review of the extant literature on the link between the mouth motor system and abstract concepts confirms that linguistic experience plays a crucial role in their representation and processing. This is evidenced by the facilitating or interfering effect of mouth motor areas activation with abstract concepts and sentences in a variety of behavioral tasks in children and adults (i.e., emergence of new words, recognition task, interference paradigms, definition matching task), and by the strong activation of mouth motor systems in ratings and fMRI studies with mental states abstract concepts. Overall, these findings indicate, in line with the WAT theory, that the language is ultimately an embodied and grounded system, whose specific components actively contribute to abstract concepts representation.

2.4.5.3 Mouth activation: inner speech and social metacognition mechanisms

The evidence discussed so far demonstrated that the mouth involvement with abstract concepts plays a functional role, influencing speed in accessing word meanings. During learning and processing of abstract concepts, such activation leads to facilitation effects when the mouth is a response effector or to interference effects when the mouth is engaged in other motor tasks, or a device blocks its active use. Recently, Borghi and colleagues (Borghi et al., 2019; Borghi, 2020) suggested that different but not conflicting mechanisms can subtend this activation of the mouth.

One possible explanation might be the re-enactment of the linguistic/social acquisition process that characterizes abstract concepts. In accordance with the embodied view, conceptual knowledge consists in part of the simulation of previous experiences with the word referent during conceptual acquisition (Barsalou, 2008). Because no external referent is present, abstract concepts acquisition is typically mediated by language in a social context (i.e., use of labels and linguistic explanations, see § 2.4.5.1); thus, it is reasonable to think that the mouth activation could be due to the activation of this linguistically conveyed information that helps us to form compact and cohesive abstract categories (Borghi et al., 2019).

To expound on what kind of mechanisms are at stake when the mouth motor system is activated, Borghi, Fini, and Tummolini (2021) have recently examined the role of metacognition and monitoring processes as possible grounding sources for abstract concepts (see also Shea, 2018; Borghi, 2020; for extended discussion § 2.3). The authors hypothesized that, because abstract words refer not to single objects but to a collection of complex experiences that vary across contexts and situations, we might need a high level of metacognitive control over our cognitive activity in order to determine and represent their appropriate meaning. This monitoring process is flanked by high uncertainty and scarce confidence in abstract words' meaning, which leads us to a continuous search for it either in ourselves or in others. A possible outcome of this search might consist of the activation of the mouth motor system.

An inner monitoring process mediated by inner speech, i.e., a form of covert language through which we silently talk with ourselves, might help us to keep abstract concepts active in working memory in order to re-explain the alternative word meanings to ourselves, clarifying it. As already mentioned, inner speech is linked at a sensory and neural level to phono-articulatory mechanisms in working memory, namely a cycle involving both phonological encoding and articulatory planning to retrieve and pronounce word-related sounds (§ 2.3.1). Thus, inhibiting inner speech functioning might impair abstract concepts processing. Recent evidence speaks in favor of this prediction. In the articulatory suppression task (i.e., subvocal repetition of syllables) used to disrupt the phonological loop formed by articulatory systems and inner speech, abstract words are found to be significantly more difficult to process than concrete words (Fini et al., 2021). Hence, inner speech could be a functional component for abstract concepts representation, explaining the emergence of interference effects when the mouth motor system is occupied during their processing.

An external outcome of this monitoring process is the “social metacognition” mechanism, which refers to a form of semantic deference based on the metacognitive awareness that others’ contribution is crucial to build and refine our conceptual repertoire, in particular abstract knowledge (§ 2.3.2). Our feeling of uncertainty about abstract concepts might prepare us to ask someone for information to dispel ambiguities on word meaning, generally using language to formulate a request. In this sense, the activation of the mouth motor system might be due to a motor preparation to revert to others. This process is especially evident when considering the acquisition of abstract concepts: Children typically asked adults – possibly authoritative and reliable – for definitions of complex words like “democracy”, “infinity”. However, it also occurs in linguistic exchanges at a more symmetrical level - as in the case of peers negotiating and co-constructing meaning; for example, it might be relevant to identify the ambit that pertains to social and politicized concepts, which are subjected to collective redefinition in light of cultural and social changes (Mazzuca & Santarelli, 2020). Recent evidence has confirmed that the contribution of other social actors is pivotal to mastering abstract concepts. Using a conceptual guessing task and joint action task, Fini et al. (2020) found that participants had more difficulty guessing the meaning of abstract concepts than concrete ones, and they were more coordinated in movements with others that provided them suggestions on abstract words.

In the framework of WAT theory, the mechanisms of inner speech and social metacognition confirm the relevance of language and sociality in abstract concepts knowledge, in an embodied and grounded perspective. Inner speech is considered a powerful tool that provides a gateway to access and refine abstract concepts by means of articulatory systems. The social metacognition process further outlines that words *are* social tools that support dynamic interactions with others in linguistic practices and help us to give coherence, extend and refine our competence on the meaning and use of abstract concepts. In both mechanisms, the mouth motor system is activated as an embodied component: in the first case, it might support the inner articulation of word meaning, whereas in the second case, it might consist of a motor act towards other interlocutors. Notably, inner speech and social metacognition are not mutually exclusive but can co-occur. New research is needed to disentangle which mechanism is primarily responsible for mouth activation and whether they are more involved at the increase of word abstractness level.

2.5 Second remark: The internal and external determinants of abstract concepts

The topics discussed in this chapter show how the debate on abstract concepts has flourished over the years. Most theoretical and empirical advances have been favored by the affirmation of Multiple Representation Views (MRVs), which emphasize the need for a pluralistic perspective on conceptual representation. Within embodied and grounded theories, it is increasingly recognized that to fully account for the representation of abstract concepts, additional sources of grounding beyond sensorimotor and bodily dimensions should be considered. As illustrated, various streams of research have contributed to explicit that other fundamental dimensions of experiences influence our conceptual system.

What is emerged is a more detailed portrait of abstract concepts representation, which involves both internal and external sources of information. Though abstract concepts are less constrained by perceptual and motor systems, they are not entirely detached from the sensorial and bodily domain. The literature reviewed in the first paragraphs of this chapter suggests a strong connection between abstract concepts and internal perceptual systems that track information about states and processes inside our body and mind. On the one side, the interoceptive modality, i.e., the sensitivity to inner bodily signals, seems to provide important information for the perceptual grounding of abstract concepts, especially of emotional-related words (Connell et al., 2018). On the other side, metacognition mechanisms responsible for the monitoring of inner brain operations might help us to evaluate the bounded of our conceptual knowledge and identify effective strategies to improve it. The use of metacognition assessment becomes particularly relevant to master sophisticated knowledge that cannot be experienced directly in sensorimotor terms, as in the case of abstract concepts. It has been proposed that the high complexity of abstract words meaning leads us to inner monitoring their semantic content by re-explaining it in ourselves, likely through inner speech, and to prepare us to rely on others to fix their referent or negotiate together their meaning, i.e., social metacognition (Borghi et al., 2019; 2021; Borghi, 2020; see also Shea, 2018).

Both the inner monitoring process of inner speech and social metacognition, as we have seen, are tightly linked to another pivotal dimension in the process of grounding abstract concepts, namely language. Linguistic experience has gained new centrality in the current debate, as testified by theories presented in the second part of this chapter. Different from classical theories that consider language as a symbolic, amodal system (see Chapter 1), new hybrid approaches bridge insight from distributional semantic models with embodied and grounded views, recognizing the value of both word associations and simulations for capturing meaning. As discussed, the potential of language is multifarious. Information carried out by words can provide a useful shortcut to access meaning, especially in the case where a deep (sensorimotor simulation) processing would be too costly to be engaged (Barsalou et al., 2008; Simmons et al., 2008; Connell, 2019; Dove, 2011; 2014; 2016). Words also have a powerful influence on our perception and cognition: they facilitate the learning and recognition of cohesive categories, collapsing exemplars that might not be immediately noticeable under the same label; and offer an additional and flexible means to expand our cognitive capabilities (Lupyan, 2012; Dove, 2020). Moreover, language and its social practices shape and enhance our conceptual reach; in that, using words allow us to interpret object/entities in the external world, improve our thinking abilities, and mediate communication and interactions with others (Borghi & Binkofski, 2014; Borghi et al., 2018; 2019; Borghi, 2020).

Even if these functions of language are certainly relevant for all concepts, abstract concepts depend more heavily on linguistic and social inputs for their acquisition, representation, and use. Research revealed that abstract concepts are expressed by words that are typically acquired later and through linguistic explanations provided by others rather than pointing to their referent (Wauters et al., 2003; Della Rosa et al., 2010; Ponari et al., 2019). During the processing and use of abstract concepts, an inner articulation of word sound is likely involved to better track their conceptual referent, and others' contribution is often required to discern and clarify their meaning, generally establishing with them linguistic exchanges. At the sensorimotor level, those experiences are supported by activation of the mouth effector, and its higher involvement with abstract concepts reported in many behavioral and neuroimaging studies indicates a possible link with embodied components.

Although the extent of recent trends in research on abstract concepts is not reducible to one simple statement, the take-home message, for the purposes of this dissertation, is that abstract concepts are multidimensional constructs grounded in different aspects of cognition, ranging from sensorimotor engagement and inner processes to linguistic and social interactions. In the next chapter, I will show that the way in which these grounding dimensions are involved depends on the type of concept and its degree of abstractness. Specifically, I will address the importance of a more fine-grained definition of concepts beyond the simple dichotomy of purely concrete or abstract words.

CHAPTER 3

A MIXED BAG OF CONCEPTS

3.1 Overcome the dichotomy

In the previous Chapters, I have outlined the intense debate on abstract concepts as developed in theories of conceptual knowledge. I focused on some relevant problems that this class of concepts raises for Embodied and Grounded (EG) cognition approaches, which submit to the idea that our conceptual system is couched in our bodily states and sensorimotor systems and its influences by the environment in which we are embedded. Indeed, abstract concepts, like *freedom*, have been traditionally taken as the proof that the EG theories are a good fit to explain concepts whose referents are perceptible, tangible objects, but they are doomed to fail in framing concepts not endowed with a clear perceptual referent.

However, the first obstacle in puzzling out the thorny issue of abstract concepts lies in the definition itself. As already mentioned in the first Chapter, abstract concepts were primarily defined in a negative way, emphasizing what properties they do *not* possess compared to concrete concepts, rather than what properties they contain. Thus, a word is said to be "abstract" if it is *not* directly connected to a physical, concrete referent in the external world.

Traditional literature has implicitly or explicitly assumed a dichotomous opposition between concrete and abstract concepts, investigating the similarities and differences between words supposedly belonging to these two domains (e.g., freedom *vs.* table). The bias against abstract concepts has also contributed to reinforcing the view of abstract concepts as a unitary and monolithic domain to be differentiated from concrete ones. As a result, little attention has been paid to the distinctive features of abstract concepts and their internal differences.

In the last years, this scenario is gradually changing. Now it is widely accepted that binary opposition between abstract and concrete concepts is an oversimplified construct, not scientifically useful to unfold the flexibility and complexity of the entire semantic system. A significant contribution to the field comes from scholars who have pointed out that, on closer inspection, all concepts incorporate and re-enact both abstract and concrete attributes depending on current situations (e.g., Borghi et al., 2018; Barsalou et al., 2018).

An early example illustrating this overlap can be found in Hampton's (1981) analysis of concepts of "*art*" in his seminal work on the nature of abstract concepts. By asking participants to produce features for a range of abstract concepts, the author showed that the concept of "*art*" elicits aspects traditionally considered as concrete features of artifacts, such as visual, shape, and material components of artworks, as well as aspects traditionally conceived as abstract, concerning internal states, intentions, and aesthetic evaluations.

On the other hand, a more recent example discussed by Barsalou (2020, p. 9) clarifies that even the most concrete concepts, such as the concept of "*pizza*", can include some abstract components when considered in the context of situated actions. Experience of consuming pizza, indeed, aggregates not only information related to sensory experiences (e.g., how pizza looks, tastes, and smells), but also patterns of action (e.g., the sequence of movements required to eat it), emotions (e.g., reward to satisfy hunger), and even social interactions (e.g., sharing a slice of pizza with a friend).

Currently, the dichotomy concrete-abstract is often replaced by the notion of a "continuum" in which concepts are represented according to their level of abstractness, spanning from the “most abstract” to the “most concrete” concepts (Wiemer-Hastings et al., 2001; Wiemer-Hastings & Xu, 2005). However, this perspective does not completely escape the traditional dichotomy, since abstract and concrete concepts are conceived as the two extreme poles of this line. Moreover, the idea of a continuum seems to leave no room for possible subtle differences between concepts kinds and their corresponding experiences.

Recent developments within the EG research provided novel theoretical and methodological insights to better tackle some contentious issues of abstract concepts. As shown in the second Chapter, proponents of the so-called “Multiple Representation Views” (MRVs) have highlighted the relevance of different dimensions in semantic knowledge, including sensorimotor aspects, interoception, metacognition, language, and sociality. According to this view, the organization of conceptual knowledge is neither centered around the classical dichotomy between concrete and abstract concepts nor distributed along with a linear continuous of abstractness. Rather, concepts would be better represented as points in a multidimensional semantic space, in which many dimensions together contribute to their representation (among others, see Binder et al., 2016; Crutch et al., 2013; Troche; Crutch & Reilly, 2017; Harpaintner, Trumpp, & Kiefer, 2018).

Theoretical advances portrayed by Multiple Representation Views undermine some of the basic constructs that have characterized previous research on conceptual knowledge. First, the well-established distinction between abstract and concrete concepts clearly has limited explanatory power in the study of concepts. Even if words can be distinguished on the basis of their higher or lower level of abstractness, there are at least other dimensions to take into account which elicit experiences constitutive of conceptual knowledge (i.e., linguistic/perceptual modality of acquisition, interoception, metacognition, contextual availability). Second, to move beyond the sharp concrete-abstract dichotomy, abstract concepts cannot be accounted for by considering them as a whole without semantically important subdivisions. From an empirical point of view, these considerations suggest that in order to reach a reliable sketch of our conceptual knowledge, it is pivotal to examine concepts at a more fine-grained level considering the role of different representational systems. That is, to provide a description of each class of concepts according to their source of grounding.

This proposed strategy is not entirely new. A standard approach to the study of conceptual knowledge has consisted of comparing different conceptual domains of knowledge. Until a few years ago, however, research focused almost exclusively on categories of the concrete domain (e.g., tools, animals, natural kinds). A wealth of neuropsychological and cognitive neuroscience studies have demonstrated that the representation of concrete concepts has a higher degree of specificity depending on the type of concepts examined (review in Humphreys & Forde, 2001; Capitani, Laiacona, Mahon, & Caramazza, 2003). More recently, several scholars have attempted to apply the same strategy to the abstract domains, delineating characteristics for different subsets of abstract concepts.

The aim of this chapter is to offer a review of some relevant findings reflecting semantic categories specificity both within the abstract and concrete domain. Although the literature on the concrete concepts domains is much more extensive than that on abstract concepts domains, I chose to deepen aspects of the latter. The rationale for this is to illustrate the empirical advances in this area of research and their positive implications for the EG theories of abstract concepts.

3.2 Domains of concrete concepts

The kinds of entities encoded by concrete concepts are typically well-differentiated and can be easily classified into taxonomic, hierarchical categories. For example, given a set of concrete nouns, such as *tiger, lemon, monkey*, *apple*, it is straightforward to group them into the distinct semantic domains of animals and fruits. A common explanation is that concrete entities belonging to the same category share some salient features that distinguish them from other categories (e.g., animals but not fruits "breathe", "move", "have eyes" etc.). This similarity allows us to identify taxonomic relations that characterize concrete words. Taking the example of "tiger", one could easily infer that *tiger* belongs to the category of *felines*, felines belong to the category of *animals*, and animals belong to the category of *living beings*.

Over the years, the literature on semantic knowledge has extensively investigated the class of concrete concepts, distinguishing different sub-domains. One of the most critical contributions to the field comes from a series of neuropsychological studies conducted in the mid-1980s by Warrington, Shallice, and McCarthy (Warrington and McCarthy 1983; 1987; Warrington and Shallice, 1984). They describe brain-damaged patients with semantic deficits restricted to a single domain of knowledge, in which the ability to produce and understand certain categories of objects may be selectively impaired, while knowledge of other categories remains relatively intact. Since the seminal work of Warrington and colleagues, a large number of studies in the branch of cognitive neuroscience have documented the so-called "category-specific deficits". The most common dissociation involves impairment of conceptual domains related to natural kinds and artifacts (Keil, 1989), living and nonliving things (Warrington & Shallice, 1984), or in other cases, to specific categories (e.g., animals, plants, fruits/vegetables, musical instruments, body parts) (for a review, see Humphreys and Forde 2001; Capitani et al., 2003; Gainotti 2006).

Traditionally, two main theoretical explanations of category-specific deficits have been proposed in the literature. The Differential Weighting Hypothesis (e.g., Warrington & Shallice, 1984; Crutch & Warrington, 2003) holds that different conceptual domains are implemented as combinations of sensory and motor features that have different weights depending on the specific experience associated with a given concept. Accordingly, it has been hypnotized that living things depend heavily on perceptual information, while non-living things depend mainly on functional properties and information about their prototypical use. Thus, the dissociative pattern underlined by category-specific semantic deficits would arise as a consequence of damage in one of these two modality-specific semantic subsystems. Another approach to explaining this phenomenon is the Distributed Domain-Specific Hypothesis (e.g., Caramazza & Shelton, 1998; Mahon & Caramazza, 2009; Mahon & Caramazza, 2011). According to this proposal, the organization of conceptual knowledge is driven by our evolutionarily relevant history, which has determined separate neural domains mediated by innate patterns of connectivity that spread not only at the level of modality-specific systems for perception and action but also at a more abstract level of a conceptual system (i.e., a semantic hub). This view predicts that selective damages might be restricted only to evolutionarily salient domains (i.e., living and non-living entities, and foods), but affect equally all types of knowledge about that category.

Even though the debate on the nature of category-specific deficits is still open, for the purposes of this dissertation, it is worthy to note that the idea of a different representation and organization of concrete concepts kinds is consistent with the proposal of Embodied and

Grounded Cognition. Within this theoretical framework, the fine-grained distinction between concrete concepts follows naturally from the overarching idea that conceptual knowledge is grounded in brain regions engaged during the experiences with the concept's referent. As a consequence, the disruption of a region that primarily affects the modality information characteristic of a particular concept may selectively or disproportionately affect the retrieval of the corresponding semantic knowledge. For example, if the motor system is deemed especially important for the conceptualizations of tools, damage to this region might probably result in a deficit in this category rather than in the others.

As seen, the distinction of concrete concepts into different sub-categories is supported by well-established research. Because a comprehensive overview of all theoretical and empirical issues in this area of inquiry would require a whole separate discussion (for an extended review, see, among others, Forde and Humphreys 2000; Capitani et al. 2003; Mahon et al. 2009), in the following sections I will only focus on a few key findings to describe the major domains of concrete concepts – specifically animals, tools, and food concepts – that are commonly used as stimuli in experimental studies.

3.2.1 Animals

The most common category-specific deficits reported in literature concern the double dissociation in recognizing concepts of living and nonliving beings. However, several studies have also documented selective impairments affecting specific conceptual categories of living beings. Within this large class, one can distinguish primarily between living things that are *animate* - those usually called animals - and living things that are *inanimate* such as plants, fruits, and vegetables. One of the interesting findings is that some patients manifest semantic disorders that primarily affect one of these two domains. This section focuses on the specificity of animal concepts, and the next on the inanimate category of food items.

Evidence of semantic deficits for animal concepts has been frequently reported in patients with lesions in regions involved in the high-level visual processing of complex stimuli (i.e., medial and ventral anterior temporal lobes). For example, in a single case study, Blundo, Ricci, and Miller (2006) described a patient with selective semantic impairment of animal concepts as a result of herpes simplex viral encephalitis (HSE), an infection that destroys bilateral portions of the temporal lobes. On a variety of verbal and visual tasks involving animal items, this patient showed severe impairment in retrieving conceptual knowledge about sensory attributes of animals, such as shape, color, sound, and functional/associative properties (e.g., Does cow produce milk or eggs?); in contrast, conceptual knowledge about fruits/vegetables and musical instruments was spared. The selective disruption of the specific class of animal concepts observed in this patient, as in many others, could be explained by the major role that visual features play in object representation, but especially by the fact that detailed analysis of shape features could be fundamental to identify animal concepts that have similar forms (e.g., horses, donkeys). Studies conducted on normal subjects who rated the contribution of sensory-motor modalities to different categories of concrete concepts confirmed that the proportion of visual and auditory proprieties is higher in the representation of living entities like animals than for artifacts, which instead showed a great proportion of tactile and motor features (McRae and Cree 2002; Vigliocco et al. 2004; Gainotti et al. 2009).

Thus, animal concepts seem to differ in some respect not only from living things but also from other biological categories. However, it should be bear in mind that an inspection of the literature does not provide conclusive evidence, since some patients show a prevalent impairment in the representation of knowledge about animals, and others show an equal impairment for animals and other living entities. Moreover, neuroanatomical differences in involved lesion sites, as well as conceptual familiarity, gender, and cultural differences could also significantly modulate the pattern of category-specific disorders (for a review, see Gainotti 2010).

3.2.2 Foods

Among concrete concepts, foods items seem to have a special status as they include both biological products, such as *apples* and *peppers*, and manufactured aliments, such as *hamburgers* and *cake*s. By its nature, the food category is of theoretical interest to investigate the observed dissociations between living *vs.* non-living things. The question is whether knowledge about food is represented similarly to that of other "natural" entities or human-made objects. Since the early studies of category-specific deficits, a mixed pattern of results has emerged. Most brain-damaged patients are unable to recognize natural kinds, including food, whether natural or transformed, while retaining knowledge of non-living things. Other patients, however, reported semantic disorders limited to natural foods, especially *fruits* and *vegetables*, that dissociated from normal recognition of non-natural foods and animals (e.g., Hillis and Caramazza, 1991). Thus, the existing neurophysiological evidence does not allow drowing clear conclusions about how food concepts are represented in the brain. However, in many cases, the stimuli used do not appropriately reflect the food categories, making it difficult to compare the results of these studies (for a review, see Rumiati and Foroni 2016).

In recent years, interest in food processing has been considerably growing, and research provides novel insights into how food is represented conceptually. For example, Foroni and colleagues (2013) developed a FoodCast Research Image database (FRIDa) of food and non-food items. In this study, a sample of healthy participants rated about 900 images depicting different categories of objects, including foods (natural and transformed), artifacts (e.g., tools, musical instruments, kitchen utensils, scenes), and natural non-edible things (e.g., rotten food, animals). In addition to the standard variables of familiarity, ambiguity, arousal, valence, and typicality, the authors introduced other variables specifically related to food, such as perceived caloric content, level of transformation, and distance from edibility (i.e., the perceived time required to turn a given food into an edible product). The inter-correlations analysis of the ratings clearly showed that food is a distinct category from natural items and artifacts, as they show similar patterns only in a few dimensions. Interestingly, significant differences occurred when looking at correlations that concerned the level of arousal. On the one hand, artifacts were rated as more arousing when less familiar; and natural items were considered more arousing when more typical. On the other hand, the level of food arousal increased with the increase in perceived calories and the level of transformation of food but decreased with distance from edibility. Thus, participants associated positive valence with foods that provide more nutritional energy (high-calorie foods), that are more processed, and require less effort to be consumed. These results suggest that food recognition is primarily based on crucial information for our physical survival and guides our eating choices.

Consistent with the theoretical perspective of grounded cognition, several studies have shown that food items or words spontaneously re-enact our past experiences in relevant modalities and, in particular, evoke gustatory features, pleasure and reward signals, and relevant background situations in which a given food is actually consumed. For example, Papies (2013) compared features produced for tempting foods (e.g., chips, cookies) and natural foods (e.g., rice, cucumber) and found that the former elicited a high percentage of features related to eating situations and contexts (58%, e.g., “at night”, “on the sofa”), especially taste, texture, and temperature features (31%, e.g., “crunchy", “tasty”); whereas the latter were mainly represented in terms of visual features (45%, “yellow”, “seeds”), which, instead, played only a minor role for tempting foods (19%). Furthermore, results showed that food categorization was modulated by hedonic and nutritional features, with participants categorizing tempting foods as highly attractive but unhealthy and non-tempting foods as less attractive but healthy.

Similar findings were obtained by Keesman et al. (2018) in a study that examined the drinks domain. When listing typical proprieties of beverages, participants associated more frequently alcoholic beverages with social contexts of consumption (e.g., “with friends”, “at the bar”) and pleasant outcomes (e.g., “having fun”) compared to non-alcoholic beverages, such as soft-drinks and water. Interestingly, this pattern of results was marked among individuals who frequently consumed alcohol, suggesting that the conceptualization of beverages reflects real drinking behavior.

Finally, neuroimaging research has identified specific neural activity underlying concepts of foods, which activate brain areas corresponding to modality-specific food features (i.e., gustatory, olfactory) and engage the ventral and dorsal pathways involved in regulating the affective and behavioral response to a wide range of eating phenomena (e.g., Simmons, Martin, and Barsalou 2005; Barrós-Loscertales et al. 2012; for a review, see Chen, Papies, and Barsalou 2016). Overall, these studies suggest that eating experiences, together with taste and texture features, play a central role in the conceptual representation of food, which can be seen as a multilayered subset of concrete entities.

3.2.3 Tools

In the realm of non-living things, much of the research has focused on the conceptual representation of artifacts, and in particular manipulable tools. Since the initial work of Warrington and McCarthy (1987), many neuropsychological studies have shown that brain damage in the motor and premotor cortex leads to disproportionate deficits in recognizing artifacts compared to animals or other living things. Interestingly, in these patients the difficulty in retrieving conceptual knowledge did not equally affect the entire class of artifacts but was more narrowly restricted to the subclass of small manipulable objects (e.g., hammers, screwdrivers) compared to large manipulable ones (e.g., vehicles, buildings).

A similar dissociation has been found in brain imaging studies. In a set of fMRI experiments (Chao, Haxby, and Martin, 1999; Chao and Martin, 2000), healthy participants performed multiple tasks assessing the perceptual (i.e., passive viewing picture) and conceptual processing (i.e., silent picture naming and property verification tasks) of animals, faces, houses, and manipulable objects. Across all the tasks, differential activation to animals and small tools was present. While viewing and naming animals (and faces) lead to activity in regions encoding information about visual object form (i.e., fusiform gyrus and posterior temporal lobe); viewing and naming tools elicits enhanced activity in regions assumed to be involved in storing information about visual-motor patterns (i.e., ventral temporal cortex) and motor mechanisms engaged during hand actions (i.e., left posterior parietal cortex and left ventral premotor cortex). This finding led to suppose that tools constitute a distinct conceptual domain within objects category represented thought specific motor-based information stored in corresponding brain regions (review in Martin, 2007).

The link between the representation of tool concepts and motor systems is further corroborated by the large literature on object affordances. Both behavioral and neuroimaging studies have shown that the observation of tools automatically re-enacts information on action possibilities that the object provides (i.e., affordance), such as the grasping hand posture and kinematic movements required to carry out its appropriate function (see Ellis & Tucker, 2000; Tucker & Ellis, 2004, for a recent meta-analysis, see Azaad et al., 2019). Recently, other studies have shown that object categorization might be flexibly influenced by the physical component of objects (e.g., functional/manipulative grip), by the everyday contexts in which they are commonly experienced (e.g., Kalénine et al., 2014; Wokke et al., 2016), and by social and cultural practices (e.g., Becchio et al., 2010; Gianelli et al., 2013) (review in Borghi, 2018).

Across various disciplines such as psychology, cognitive science, and neuroscience, scholars seem to converge on the view that knowledge of tools is rooted in the sensorimotor experiences connected with manipulative actions during their use.

3.3 Domains of abstract concepts

Changing the topic of discussion from concrete domains to abstract domains, the path to provide a precise classification becomes much more tortuous. One of the main reasons for this difficulty lies in an intrinsic characteristic of abstract concepts, namely their heterogeneity.

To illustrate, let's compare the concrete concept “flower” and the abstract concept “beauty”. Even though the instances of “flower” are not identical, since flowers may differ in some elements (e.g., flowers have a large or small size, different colors), they somehow share several characteristic features (e.g., all flowers have petals, a stem, a fragrance) that make it possible to assign them to the general category of flower. In contrast, the instances of “beauty” are quite different: We typically use the word “beauty” to refer to objects, people, landscapes, artworks, but none of these occurrences of “beauty” is united by the same relevant traits. In short, abstract concepts are heterogeneous in that they are a “low-dimensional” category that groups a collection of items sharing only one or a few salient features (e.g., Lupyan & Mirman, 2013; Langland-Hassan et al., 2021).

To expound on what is at stake when dealing with abstract concepts, Borghi and Binkofski (2014) proposed an operational distinction between the notion of *abstraction* - i.e., the process leading to form hierarchically ordered categories - and *abstractnes*s that specifically refers to the detachment from the physical reality of the referents of the concepts being examined (see also § 1.3.1). Taking the above example: When we think about *flower*¸even though it requires a degree of abstraction, we can directly perceive and interact with its referent; instead, when we think about *beauty*, we may retrieve the collection of experiences associated with it, but its referents remain abstract. As we have seen in the course of this dissertation, this detachment from the experiential world constitutes the core problem for Embodied and Grounded (EG) theories of conceptual knowledge, which strive to explain how abstract concepts can activate multimodal simulations tied to sensorimotor and perceptual states in our body (see Chapter 1).

The challenge to interpret abstract concepts in an EG perspective is fueled by the fact that they have long been treated as a holistic domain, with fuzzy demarcation among possible categories. The widespread of this idea should not be surprising because when one looks at a sample of abstract concepts, such as “democracy”, “idea”, “pain”, “love”, it is not so obvious how to categorize them based on their common features; rather, each of these concepts seems to convey a different kind of information. This intra-class variability leads to a crucial difficulty in finding a coherent theory for the entire abstract domain.

On account of this, some promising insights have recently been gained by recent proposals called Multiple Representations Views (MRVs) (see Chapter 2). Briefly, these emergent views advocate for a pluralistic approach to studying abstract conceptual knowledge, recognizing that, besides perception and action, other fundamental resources of experience are involved in the grounding of abstract concepts, among which language, sociality, emotions, and inner states. Crucially, this pluralistic stance also acknowledges that the weight of these experiences might substantial changes across the concepts kinds and contexts; for instance, some concepts, whether abstract or concrete, might be primarily grounded in our sensorimotor systems or inner experiences (e.g., *pain*, *love*), while others might be more related to linguistic and social information (e.g., *democracy*, *idea*). To reach a successful theory of abstract concepts is therefore important to dismiss the notion of abstract concepts as a whole and start to consider them as a multifaceted category comprised of different sub-domains subtended by different representational constructs.

In the last years, the wealth of research addressing the topic of abstract concepts has contributed to unfolding their heterogeneity by providing evidence in favor of a categorical organization of abstract knowledge. To date, converging patterns of results demonstrated the existence of different kinds of abstract concepts, grounded in bodily and neural mechanisms engaged by corresponding experiences. In the next sections of this chapter, I will discuss the specificity of several abstract categories, in particular emotions, numbers, mental states, social and institutional concepts. Even if this list should not be considered conclusive, these abstract concept kinds were chosen because the substantial body of behavioral and neuroimaging studies on these domains allows drawing inferences on their multiple grounding sources.

3.3.1 Emotions

Emotional concepts, like *happiness* or *anger*, are certainly the most explored class of abstract concepts. Despite this, it is still contended whether the mechanism underlying their representation significantly differs or not from that of the general category of abstract concepts. In the last years, the growing interest in emotional words has contributed to enlarging the discussion, by providing interesting hints on their sources of grounding.

One of the most intriguing pieces of evidence is that emotional concepts show a peculiar rating pattern on different psycholinguistic criteria with respect to other types of concepts. For example, Altarriba and colleagues (1999) found that emotional concepts are characterized by low concreteness and high imageability compared to other abstract concepts, and by low imageability compared to concrete concepts. Other studies have shown that emotional words are generally processed faster and recalled more accurately than other abstract words, such as mental states concepts (e.g., Setti & Caramelli, 2005). This advantage in processing emotional concepts has emerged in either lexical decisions (Altarriba & Bauer, 2004; (Kousta et al., 2011) Siakaluk et al., 2016), semantic categorization (Newcombe et al., 2012), or word recognition tasks (Mazzuca et al., 2018). However, behavioral evidence is still controversial, as either a processing disadvantage (Estes & Adelman, 2008; Kuperman et al., 2014) or an advantage (Kousta, Vinson, & Vigliocco, 2009; Vinson et al., 2014) has been found for negative emotional words in adult's lexical processing, likely due to different tasks and criteria in stimuli selection (for a discussion, see Mazzuca et al., 2017).

According to some scholars, the special status of emotional words is also reflected in their early acquisition, which might play a role in the subsequent development of abstract knowledge (Affective Embodiment Account; Kousta et al., 2011; Vigliocco et al., 2009; 2014; see also discussion in § 1.3.3.4). The analysis of age-of-acquisition ratings in children and adults suggests that the first abstract words to be acquired have an emotionally connoted meaning (Kousta et al., 2011; 2009; Ponari et al., 2018) which might facilitate the acquisition and processing of abstract vocabulary. This hypothesis has been tested in some recent studies. For example, Lund, Sidhu, and Pexman (2019) asked 5- to 7- year-old children to complete an auditory lexical decision task with familiar concrete and abstract concepts semantically associated with negative (e.g., cut *vs.* pain), positive (e.g., smile *vs.* luck) and neutral (e.g., chair *vs.* grand) valence. The results of RTs indicated that 6- and 7-year-old children showed effects of valence only for abstract words, resulting in faster responses to negative and positive words than to neutral ones, whereas for concrete words the effect of valence was absent. Regardless of age, children responded more slowly to neutral abstract words that lack valence information, suggesting that emotional meaning may facilitate language acquisition, particularly for abstract words. Using a similar auditory paradigm, Kim, Sidhu, and Pexman (2020) examined the extent to which valence enhances children's and adults' recognition memory for abstract/concrete words which differed in valence (negative, positive, neutral). In both groups, valence effects were found only for recognition of abstract words: Children recalled negative abstract words more accurately than positive and neutral ones, while adults recalled better both negative and positive abstract words than neutral ones. Overall, these studies insist on the idea that emotional knowledge is an important mechanism to form many abstract concepts that, unlike concrete concepts, are less linked to sensorimotor knowledge.

An alternative approach argued that emotional words and concepts constitute a separate category, distinct from both concrete and abstract concepts and that their processing mainly re-enacts affective experiences by recruiting the same neural networks that underline the construction, regulation, and expression of emotions in general. To test this proposal, Wilson-Mendenhall et al. (2011) conducted an fMRI study in which participants heard emotion terms (*fear* and *anger*) and abstract terms that do not involve emotion (*observe* and *plan*) preceded by a description of physical danger or social evaluation context. Participants were then encouraged to construct mental imagery of the situations associated with a word. Results showed that the processing of two emotion terms activates brain regions subserving emotions (i.e., anterior cingulate cortex, fronto-temporal lobes, insula, orbitofrontal cortex, inferior parietal lobe). Notably, emotional terms engaged different areas in response to specific situations. The concept *fear*, for example, activate visceral and motor areas when processed in the context of physically dangerous situations, and areas implicated in social knowledge and cognitive control when processed in the context of social evaluations. These findings are consistent with an embodied approach to abstract knowledge, showing that emotional concepts, although lacking a concrete referent, are grounded in bodily and sensorimotor systems that are responsible for processing emotions.

Crucially for a perspective that emphasizes the sensorimotor grounding of emotional concepts, other studies have shown that facial expressions, arm, and hand movements play a fundamental role in representing the meaning of emotion-related words. In an fMRI study, Moseley and colleagues (2012) showed that silent reading of abstract emotional words denoting feelings (e.g., *rile* or *spite*) elicits the activation of the precentral motor cortex beyond limbic area that overlapped with somatotopic activation in motor systems trigged by face and arm action-related words (e.g., *chew*, *pinch*). Consistently, evidence in clinical populations has shown that brain lesions in focal left-hemisphere and precentral and motor areas result in impairments of emotion word processing during a lexical decision task (Dreyer et al., 2015) and that individuals affected by autism spectrum conditions have reduced activity in limbic and motor areas, reflecting their deficits in emotion expression and mentalizing (Moseley et al., 2015). Taken together, these results provide evidence for the grounding of emotional words in motor regions and body parts involved in the expression of emotions and inner states through actions.

Behavioral studies further confirm that peripheral bodily signals, particularly facial movements, are causally relevant in emotional language processing. Havas and colleagues (2010) conducted an experiment to test whether blocking facial mimicry affects the comprehension of sentences describing emotional content. Participants were presented with a series of happy, angry, and sad sentences, either before or after a cosmetic subcutaneous injection of botulinum toxin that temporarily impaired their frown muscles used to express negative emotions (i.e., corrugator supercilii). The authors found selective impairment in reading times for sad and angry, but not happy, sentences only in the post-injection session. These results were interpreted as evidence that emotional language involves the simulation of its content expressed through facial feedback, and that therefore hindering facial expressions leads to an interference with the ability to process sentences that trade on that emotion.

Studies investigating the role of the body in conceptual representation have shown that emotion-related words and sentences activate more the mouth and other bodily effectors than other concept kinds. Ghio et al. (2013) collected ratings on the association of different body parts (i.e., mouth, hand/arm, and leg) for a sample of 210 sentences related to mental states (e.g., “she pretend an interest”), emotions (e.g., “she shows her disappointment”) and mathematics (e.g., “she counts the sets”). Results showed that mathematics sentences were judged as significantly engaging the hand more than the mouth and legs, mental states sentences activate more selectively the mouth, while emotional sentences were more associated with the mouth, hand, and leg actions than the other two kinds of sentences, consistent with the hypothesis that emotions are grounded in multi-modal representations. Mazzuca et al. (2018) also compared abstract, concrete, and emotional words in a lexical decision task and a word recognition task in which participants responded by pressing a pedal while holding a device with their hand or mouth. In the lexical decision task, there was no significant difference between the activation of effectors with respect to the different types of concepts, likely due to the superficial processing level involved in the task. Instead, effectors had a significant effect on the recognition task, facilitating the recognition of abstract words in the mouth condition compared to the hand condition. Interestingly, emotional concepts exhibited a more variable pattern across conditions: They were processed faster than abstract concepts in both the mouth and hand conditions and did not differ significantly from concrete words, suggesting that this class of concepts cannot be properly assimilated with either concrete or abstract concepts.

The idea that emotional concepts and bodily mechanisms are strongly interwoven has been confirmed and extended by very recent studies showing that, in addition to sensory and motor experiences, interoceptive states are even more crucial for the grounding of emotional concepts. Semantic norms capturing the sensory basis of word meaning for a large set of stimuli indicated that interoceptive states, in contrast to other perceptual modalities, are particularly important in the characterization of emotional concepts in relation to concrete and other abstract words (Lynott et al., 2020). More recently, Barca et al. (submitted) whether individual interoceptive differences might affect the mental organization of emotional concepts by using a similarity judgment task on a set of 24 concepts with different valence (i.e., positive and negative) and level of arousal (i.e., high/low bodily activation). In this study, participants were presented with a central target word (e.g., *friendly*) and asked to use the mouse to select which of the other two words displayed on the screen (e.g., *brave* or *lonely*) have a similar meaning to the target word. For each trial, the select choice, response times, and trajectory of mouse movement were recorded through the mouse tracker software and then combined to compute a similarity index according to which two concepts have a great similarity when the response is selected faster and with smaller trajectory curvature indicating less uncertainty in the choice. The authors also assessed participants' affective and interoceptive characteristics using objective methods, such as heart rate variability, and other self-report questionaries measuring their interoceptive sensibility (Body-Perception Questionnaire), interoceptive awareness (MAIA), ability to experience positive and negative emotions (PANAS), and state depressive mood (Beck Depression Inventory). Preliminary results of the similarity index reported in topographical maps showed a clear distinction between words with high and low arousal, and between words with positive and negative valence. Even more interestingly, the organization of emotional concepts varied as a function of individual differences in interoceptive variables. Compared to the overall sample, the results of the subgroup of participants with low positive affectivity showed a different distribution of positive emotional words (e.g., respectful, reserved, social) along the arousal dimensions, resulting in a reduced level of physiological activation, which is likely due to the relation between low positive emotionality and social anxiety, depression, and the tendency of suppression emotion.

To sum up, the illustrated studies suggest that emotional concepts are characterized by an intermediate degree of concreteness/abstractness and that their representation taps into multiple sources of grounding. On the one hand, they are partly based on the external experience of sensory and motor processes involved in the perception and expression of emotions. On the other hand, the subjective inner experience of physiological and interoceptive bodily states seem to strongly contribute to the construction of corresponding emotional concepts. By this nature, emotional concepts should be considered as an independent category that differs in many respects from purely concrete and purely abstract concepts.

3.3.2 Numbers

Numbers are often used as an illustrative example of abstract concepts, for they are pure magnitudes or quantities that exist independently of the material objects to which they refer. The number expressed by the word *three*, for example, is an abstract symbol that is applied arbitrarily to support precise calculation and enumeration of various sets of entities: three glasses, three flowers, three dots, and so on. Despite their highly abstract nature, there is an intuitive sense for which numbers can be seen as embodied. Indeed, our everyday experience with abstract quantities is strongly supported by more concrete representations based on the natural disposition to map numbers into space and/or through bodily actions. Consider number estimation, which in certain circumstances simply requires us to localize elements in visual scenes, or the verbal sensory-motor routine of finger counting in order to establish one-to-one correspondences between objects and number names.

In the last decades, numerical cognition research has provided vast support for the view that numbers are special kinds of embodied concepts that are grounded, at least in part, on sensory and motor experiences. The next sections illustrate the main findings in favor of this view. In particular, I will first focus on some core signatures of the spatial representation of numbers, then on the influence of body movements (i.e., finger counting and gestures) on number cognition, and finally, I will briefly address the relationship between numbers and language.

3.3.2.1 Placing numbers into space

A rich body of evidence has demonstrated a close link between numerical and spatial representation, reflected in systematic performance in simple numerical tasks. Two classical pieces of evidence are the *numerical distance effect* and the *size effect* (Moyer & Landauer, 1967; Restle, 1970). The *distance effect* refers to a systematic increase of difficulty in numerical magnitude comparison, as the numerical distance between two numbers decreases. Thus, when asked to compare two numbers in order to decide which symbol refers to the larger magnitude, responses are faster and with fewer errors when the difference between the two symbols meaning is larger: comparing 3 and 9, for example, is usually easier than comparing 3 and 4. The *size effect* refers to the fact that comparison difficulty increases with the increase of number size, even if the numerical distance is held constant: for example, it is easier to decide which is the larger number between the pair 1 and 3 than the pair 7 and 9. Both the distance and the size effects have been replicated and generalized across several behavioral tasks (e.g., priming tasks, Dehaene & Akhavein, 1995; same-different judgment, Sasanguie et al., 2011), with various stimulus formats, such as Arabic numerals, two-digit numbers, and dot configurations (e.g., Buckley & Gillman, 1974) and have also been found in different species (fish, monkeys, pigeons; for a review, see Dehaene et al., 1998).

A dominant theoretical explanation for both size and distance effects relies on the famous analogy of the 'mental number line' (MNL) initially introduced by Restle (1970) to cover the idea that people typically represent numbers as spatially oriented entities along a horizontal axis, corresponding to their magnitude (see also Dehaene, 1997; Zorzi et al., 2002; Nuerk et al., 2011). Accordingly, numbers would be progressively located on a continuous line, but number discrimination is affected by a conceptual overlap between numerical instances, that depends on their semantic similarity and magnitude distribution. Thus, because close numbers have a similar representation and tend to overlap more, it is more difficult to distinguish smaller numerical distances than larger numerical distances (*distance effect*); and because larger numbers tend to have a wider distribution, comparison performances are easier for smaller numbers than for larger numbers (*size effect*). It should be mentioned that slightly different interpretations have emerged in literature, depending on accounts that postulate a linear or logarithmic representation of mental number line (for a discussion, see Fischer & Shaki, 2018). Briefly, the first (e.g., Gallistel & Gelman, 2000; Zorzi et al., 2005) states that all numerical distances are identical, but increasing imprecision occurs for large magnitude distribution; whereas the second (e.g., Nieder & Miller, 2003) holds that numbers distance is logarithmically compressed, thus the perceptual numbers discrimination increase with the increasing of items number, in accordance with principles that apply to perceptual discriminability of other physical stimuli (i.e., the perceptible difference between sets of stimuli increases proportionally with their size, see Weber-Fechner Law). Regardless of these theoretical divergences, it is widely agreed that spatial order is a crucial attribute that characterizes our conceptual representation of numbers.

Another core evidence that highlights the relevance of space for number cognition is the more recently discovered SNARC (S*patial Numerical Association of Response Codes*) effect. In the seminal study on this topic, it was found that participants who were asked to make an odd-even classification of numbers from 1 to 9 by pressing a left or right key responded more quickly with their left hand to small numbers (e.g., 1, 2, 3) and with their right hand to large numbers (e.g., 7, 8, 9) (Dehaene et al., 1993). This difference in reaction time is supposed to reflect the fact that people, at least in Western culture, conceptualize numbers along a horizontal mental number line, with small numbers preferentially represented in the left space and larger numbers preferentially represented in the right space. This explains the observed SNARC effect as a special case of spatial compatibility effect, in which spatial attributes of numerical magnitude are automatically processed even if they are irrelevant to the task, leading to better performance when stimulus location and motor response share the same spatial coding such as left or right. Thereafter, similar SNARC effects have been replicated with different stimuli, cognitive tasks, and using different responses (e.g., feet, Schwarz & Müller, 2006; eyes, Loetscher et al., 2008; Schwarz & Keus, 2004) (for a meta-analysis, see Wood et al., 2008; Fischer & Shaki, 2014).

Research has also demonstrated that the influence of the SNARC effect is bidirectional at both the sensory and motor levels. Regarding the sensory level, evidence shows that the perception of numbers induces a shift of attention to the left or right side, depending on the magnitude of the number. For example, in a line bisection task Fischer (2001) found that healthy individuals were biased to the left or to the right when estimating the midpoint of lines with single-digit flankers or uniform digit sequences that referred respectively to small or large numbers (e.g., 1111 or 9999). Consistently, Zorzi et al. (2002) reported that brain-damaged patients with spatial neglect for the left-side showed systematic biases in bisection of physical lines, with a leftward displacement of the midpoint for small numbers. In addition, Fischer et al. (2003) demonstrated that when asked to detect a target stimulus that could randomly appear either to the left or to the right of a centered digit, responses to right targets were faster when preceded by large numbers, and responses to left targets were faster when preceded by small numbers. Thus, perceiving digits influence the allocation of attention in the visual field that correspond to the digit position on a mental number line.

With regards to motor level, other studies reported an influence of body movements on numerical cognition, both in terms of number processing and number production. Fischer (2003) found that when participants classified digits as odd or even by pointing to the left or right button, the movement was faster when left-responses were made to small digits and right-responses to large digits, reflecting a classic SNARC effect. Interestingly, the same findings occur at the stage of response selection and even if responses are given only with one hand. For example, Daar and Pratt (2008) conducted a go-no-go experiment in which participants were free to choose either the right hand or the left hand to press one button when an even/odd number appeared on the screen. The authors found that participants were more likely to spontaneously choose their right hand to respond to large numbers and their left hand to respond to small numbers.

Subsequent research has shown that sensory-motor behaviors induce systematic bias in the generation of numbers, which are consistent with the SNARC effect findings. In their studies, Loetscher and colleagues (2008) reported that participants were systematically influenced by lateral head turns or eye movements when asked to pronounce numbers randomly: they produced more relatively small numbers while facing left, and more relatively large numbers while facing right. In a similar random generation task, Shaki & Fischer (2014) asked participants to simulate walking activity by making lateral turns in the left or right direction and found that directional selection influences number concepts activation, with left-turning lead to produce more small numbers and right-turning more large numbers (for similar findings in simple arithmetic counting, see Anelli et al., 2014).

It is noteworthy, however, that spatial-numerical associations are not limited to the horizontal axis from left to right. Research has recently accumulated evidence for the SNARC effect along a vertical dimension. In experiments investigating the conceptual representation of numerical magnitude with vertical response setups, typical results show that individuals associate small numbers with a lower response button and large numbers with an upper response button, leading to a faster performance on number processing in spatially corresponding conditions (for a review, see Winter et al., 2015). Furthermore, Hartmann et al. (2014) asked participants to randomly generate numbers while sitting in a chair that moved their whole body along the vertical axis and found that they were more likely to generate a higher number when passively moving upward and lower numbers when passively moving downward. In the same vein, Winter and Matlock (2013) found that look up and look down movements lead participants to generate a great proportion of higher and lower numbers, respectively. Further, Lugli et al. (2013) have investigated the influence of motions during mental arithmetic, showing that the proportion of correct operations correlates with the direction of movement associated with the type of calculations. Specifically, performing ascending/descending active movements (i.e., taking the elevator) but not passive movements (i.e., taking the stairs) led participants to perform more additions when moving upward and more subtractions when moving downward compared to the opposite directions.

Importantly, it is thought that evidence for vertical spatial-numerical associations is more stable and stronger than for horizontal spatial-numerical associations. Indeed, evidence suggests that the horizontal SNARC effect is highly influenced by cultural factors, in particular by reading and writing habits. Shaki, Fischer, and Petrusic (2009), for instance, compared three groups of participants with different reading habits on a parity judgment task and obtained a classical SNARC effect in Canadians who read and write numbers from left-to-right, a reverse SNARC effect in Palestinians who habitually represents numbers from right-to-left, and no reliable spatial association in Hebrews who have mixed habits for reading words numbers (from right to left) and digits (from left to right). Moreover, even reading a short text in languages, such as Russian and Hebrew, characterized by different writing directions (left-to-right and right-to-left, respectively) was found to systematically modulate the SNARC effect in bilingual populations (Shaki & Fischer, 2008). In contrast, the vertical SNARC effect seems unrelated to reading direction; for example, the association between small numbers with lower space and large numbers with upper space was consistently found in top-to-bottom Japanese readers, as well as left-to-right German readers and right-to-left Hebrew readers (e.g., Ito & Hatta, 2004; Hung et al., 2008; Shaki & Fischer, 2012). A possible explanation of these findings is that the vertical SNARC effect reflects the universal structure of the word, such as the correlation between quantity and height whereby “more is up” (e.g., adding objects from the pile, the level goes up); whereas the horizontal SNARC effect shows more situational sensitivity, likely because it arises from cultural acquired practices (for a discussion, see Winter et al., 2015; Fischer & Shaki, 2018). Indeed, the vertical dimension is mostly used to represent quantities in linguistic contexts, as testified by several metaphoric expressions such as “soaring costs”, “plummeting shares”, “falling prices” (see Lakoff & Johnson, 1980). Consistently, Woodin and Winter (2018) have recently proved the dominance of vertical conceptualizations of quantity in linguistic stimuli: People preferentially associate vague quantity words, like “more”, “less”, with vertical axis, whereas exact numerals “2”, “7” are associated with a horizontal axis from left to right.

The literature discussed corroborates the idea that numbers are a kind of abstract concept grounded in sensory-motor experiences. Evidence of horizontal and vertical SNARC, as well as the size and distance effects, clearly indicates that conceptual representation of numbers, at least at their elementary level, is not based solely on symbolic manipulations but rather is fundamentally influenced by sensory-motor patterns that reflect our experiences of perceptual-like qualities of numbers, in a way that is modulated by cultural factors.

3.3.2.2 Numbers and embodiment

One way to clarify how number concepts might be grounded in sensorimotor systems is to consider their origins in body-based representations. All over the world, number systems and number words derive historically from body-parts names (Ifrah, 1998), and the most common numerical system across cultures is the decimal system (Comrie, 2013), followed by the base-20 number system, mainly because our body has basic notational devices for symbolizing numbers, namely the hands and feet with their ten fingers and toes, which we use as a resource to map numerical quantities on a physical-spatial extent.

Finger counting is a universal strategy for learning and developing numerical knowledge. Children spontaneously use their fingers to establish a one-to-one correspondence with any set of items (Dehaene, 1997), and the ability to mentally represent and discriminate fingers as single entities in 6-year-olds is a good predictor of their future mathematical skills (e.g., Domahs et al., 2008; Noël, 2005). In adulthood, finger representation is still automatically retrieved when relatively smaller numbers (1 to 10) are processed. It has been argued that the finger counting habit is an important factor that shapes the spatial nature of numerical representation and processing and probably is at the basis of the SNARC effects and their cross-cultural variations mentioned in the previous paragraph (see Fischer & Brugger, 2011; Fischer, 2008). Evidence of faster responses to small numbers (1 or 2) with the left hand and to larger numbers (8 or 9) with the right hand (i.e., the SNARC effect) has been observed mainly in studies with participants from Western societies, thus it might reflect the finger counting habits of these populations, who generally start counting with the left hand. In contrast, people in Middle Eastern cultures, who typically start counting with the right hand, consistently show a reverse pattern of the SNARC effect (Lindemann et al., 2011).

A variety of studies have investigated the extent to which numbers elicit the activation of the hand effector and finger representations. Behavioral evidence from a rating study (Ghio et al., 2013) showed that compared to abstract and emotional sentences, arithmetic sentences were evaluated as involving mostly the hand rather than the mouth. Others have shown that representing numerosity is strongly associated with fingers postures. Di Luca and Pesenti (2008), for example, demonstrated that young adults were faster to name numeral finger configurations when they were congruent with canonical finger counting habits than when they showed arbitrary finger configurations. Sixtus et al. (2017) asked participants to classify auditorily presented numbers according to their magnitude as larger or smaller than five while either viewing or adopting finger posture. An advantage in response latencies was found when the magnitude category matched the current finger counting postures. However, this congruent effect emerged when participants actively performed a motor behavior to replicate the finger postures, but not when they merely perceived them. This suggests that the association between numerical concepts and finger counting lies primarily in the involvement of motor codes to which this activity corresponds.

Neuroscience evidence confirms that number representation in adults is influenced by individual finger counting habits, and activates hands and fingers. In an fMRI study, Tschentscher et al. (2012) presented digits 1 to 9 and the corresponding words to adult participants who differed in finger counting habits: one group usually starts counting small numbers with the left hand, the other group with the right hand. An overall activation was found in the premotor cortex, but small numbers (i.e., 1-5) mainly activated left-lateral premotor regions in the right-starter group and right-lateral premotor regions in the left-starter group. This lateralization effect of motor cortex activation evoked by small numbers indicates that the cortical representation of numbers reflects individual hand preference to start counting. Further evidence from transcranial magnetic stimulation (TMS) revealed an increase of the corticospinal excitability in the right-hand motor circuits during numerical judgments, and especially for small numbers from 1 to 4 (Sato et al., 2007), or during a silent counting task using either numbers or letters (Andres et al., 2007). Consistently, Rusconi and colleagues (2005) found that rTMS over the left angular gyrus interfered with tasks involving finger movements and with tasks involving numerical processing, confirming a strong link between the number representation and access to fingers schema.

A related body of evidence has shown that number representation modulates hand actions, depending on specific size-based numerical associations. A classical finding is that when asked to compare the numerical magnitude of two numbers, such as 3 vs. 9, participants respond more quickly to larger numbers when it is presented in a congruent physical large font than when presented in an incongruent physical small font, indicating an association between physical size with numerical quantity (Henik & Tzelgov, 1982). More recent studies have observed links between number processing and actual hand movements, such as congruency effects between number magnitude and grasp aperture: Small numbers activate precision grips, and large numbers activate power grip (e.g., Moretto & di Pellegrino, 2008; Lindemann et al., 2007). In addition, there is evidence that observing manipulable objects also influences numbers processing in parity tasks, with facilitation for small numbers over larger numbers when preceded by graspable objects compared to ungraspable objects (e.g., Ranzini et al., 2011; Badets & Pesenti, 2011). Interestingly, Andres et al. (2008) found that even seeing graspable blocks of the same size with different numbers written on them led participants to expand their grip aperture in association with the larger numbers. This confirms that numbers are represented as spatial entities; thus, the numbers associated with a larger space tend to activate larger movements.

Finally, studies of more naturalistic contexts have demonstrated that people spontaneously move their hands when communicating about numerical quantities. For example, experiments with math teachers and students showed that producing gestures enhances the comprehension of mathematical concepts (e.g., Goldin-Meadow, 2005; (Marghetis & Núñez, 2013). Analysis of TV news broadcasts revealed that English speakers tend to move their hands vertically upwards or downwards to refer respectively to “high number” and “low numbers”, while they produce pinching gestures to talk about small/tiny numbers (Winter et al., 2013). This data has been further explored by Woodin et al. (2020) in a study examining different aspects of gestures produced by American speakers while talking about numbers. In line with previous evidence, the authors found that numbers produced different hand configurations according to their size: tiny/small numbers elicit primarily close-handed gestures associated with precision grips, while large/huge numbers evoke an extreme proportion of open-hand gestures associated with power grips. They also found that the relation between gestures and numbers is reflected in terms of hand distance from the torso used as a reference point on the horizontal axis: Tiny/small numbers are characterized by narrow distance and inward movements, whereas large/huge numbers by wide distance and outward movements.

In conclusion, this large amount of evidence for a strong involvement of the hand and finger effectors in the processing of numbers argues for an embodied representation of numbers, which seems to be a very special kind of abstract concept, less detached from sensorimotor experience than other.

3.3.2.3 Numbers and language

What exactly is the contribution of language to numerical cognition is a debated topic. Some state that numerical thinking, like other cultural abilities, arose from the progressive development of human linguistic competence (e.g., Chomsky, 2006); other theories, emerged within cognitive neuroscience research, propose that the ability to deal with number concepts is founded upon some pre-linguistic intuitions of magnitudes linking numerical quantities and space (e.g., Dehaene, 1997). However, these two accounts are not necessarily exclusive, and it seems possible that only some of the numerical abilities depend on the language, whereas others may rely primarily on visuo-motor processing. In line with this view, research has suggested that numbers elicit different kinds of representations that rely on distinct cognitive processing and systems: a non-symbolic system that encodes approximate representations of small quantities and a verbal system that encodes exact large numerical quantities (e.g., Lemer, Dehaene, Spelke, and Cohen, 2003).

Since early studies, psychologists have referred to the notion of “subitizing” to describe the human ability to identify small quantities presented non-symbolically, for example, a set of objects or dots, and to accurately estimate its numerosity in the range of 1-4 without counting (Mandler & Shebo, 1982; Dehaene & Cohen, 1994). Several studies proved that such ability is present both in infants and other species (e.g., pigeons, rats, fishes, monkeys; Sulkowski & Hauser, 2001) that just as adult humans can rapidly detect numerosity of objects in the environment. In a famous study, Wynn (1992) showed that 5-year-old infants pay more attention to elements in the visual scene when the numerical outcome is implausible, suggesting that they have access to a basic representation of number concepts and calculations. For example, if two objects come up on the scene in succession, infants infer that 1 plus 1 makes 2; thus, in case after this sequence of events there is only one object, they spend more time examining the scene because they expect the precise numerical outcome of two objects. This subitizing mechanism is supposed to depend on the circuits of visual systems, which are responsible for localizing and tracking objects as discrete entities in space and time.

Research into perception discusses links between mental representation of numerical quantities and space, as well as between time and space, in relation to a generalized magnitude system that codes shared proprieties of these three domains in the same neural substrate, often postulated to lie within the inferior parietal cortex, an area functionally involved in processing magnitude information in the external words that are then used for action (ATOM; A Theory Of Magnitude, Walsh, 2003; Bueti & Walsh, 2009). This account also predicts some core signatures of numerical cognition, such as spatial-numerical associations and size-based numerical associations, in terms of common neural processing underlying these magnitudes. Notably, this single system clearly supports a limited form of intuition about numbers, and specifically, it encodes approximate representation of small quantities.

Shifting to precise and non-approximate quantities, the role of the linguistic system becomes progressively more relevant. Unlike infants and animals, adults humans can compute exact operations with numbers like multiplications, divisions, etc. Further, some high-level domains of mathematics, such as algebra, seem possible only by employing a rigorous number lexicon and syntactic rules akin to natural language syntax. Consistently, the processing of mental arithmetic calculus was found to activate brain regions in the left hemisphere that encode linguistic forms of numbers (e.g., Dehaene et al., 1999). It has been thus suggested that linguistic competence fosters and supports numerical representation, particularly the comprehension of large numbers (e.g., Dehaene, 1992). Interesting insights into the relationship between numbers representation and language come from studies of populations with poor number vocabulary, limited to number words for 1-2, or until 5 digits. These populations lack exact counting abilities, even though they can still represent approximate quantities (Gordon, 2004; Pica et al., 2004). Recent evidence showed that preschool children who possess a wider numerical language are facilitated in understanding and recalling numbers, even in a non-verbal task (Negen & Sarnecka, 2009). These findings confirm the idea of a double numerical cognitive system: one language-independent system for the discrimination of analogic magnitudes and low numbers, likely grounded in perception and action, and a language-based system for processing exact quantities and high numbers that relies on verbal codes to retrieve arithmetic facts.

Based on the arguments and evidence discussed so far, number concepts can be considered a domain of knowledge that encompasses several levels of representation in which multiple dimensions are involved. Much of the research has focused on numbers included in the range of 1-10, establishing a clear link between their representation and bodily-based and spatial experiences. Yet, when considering high numbers and/or sophisticated numerical operations, additional linguistic abilities come into play, such as manipulating complex symbol systems. In that respect, numbers are both embodied and abstract concepts.

3.3.3 Mental states

Concepts denoting cognitive processes that occur in our mind, such as *thought*, *memory*, *regret*, *idea*, constitute a separate class of abstract concepts, often referred to as mental states concepts. Although the literature on mental state concepts is not as extensive as for other abstract domains, some works have provided evidence on their semantic grounding.

Feature listing studies have highlighted the importance of introspective and subjective experiences for mental states concepts, which are frequently associated with episodic memories involving complex relational patterns of experiential, emotional, and social situations. For example, the concept “indifference” evokes another agent, its intentions, belief, and relation to some state of affairs (e.g., Barsalou & Wiemer-Hastings, 2005; Wiemer-Hastings & Xu, 2005). A more detailed analysis emerges from a study by Setti and Caramelli (2005), in which a rating task and a definition production task were used to investigate differences between four sub-categories of abstract concepts largely related to mental state concepts, namely “nominal kinds” (e.g., error), “states of the self” (e.g., worry), “cognitive processes” (e.g., memory), and “emotions” (e.g., fear). Results showed that cognitive processes obtained the lowest concreteness and imageability ratings, suggesting that they can be defined as more abstract than other categories. In addition, analysis of definitions produced revealed that cognitive processes were defined by a great variety of conceptual relations, mainly thematic information related to specific events, actions, and means (e.g., memory – to retain mental information; attention – to concentrate). They also differed significantly from emotional concepts, which yielded to super-ordinate, cause, and evaluative relations (e.g., fear – feeling; disappointment – due to someone or something).

Because of the high level of abstractness of mental state concepts, one would assume that they are completely devoid of sensorimotor grounding. Recent evidence shows that this is not the case. Both behavioral and neural studies have demonstrated that modality-preferential sensorimotor areas, specifically facial and mouth motor areas, are involved in the processing of mental state abstract concepts. For example, Ghio et al. (2013) found with an explicit rating task that sentences describing mental states, such as “she contemplates the alternative”, were more likely to be associated with the mouth than with other effectors (i.e., hand, legs). In a recent fMRI study, Dreyer and Pulvermüller (2018) scanned hemodynamic activity within motor systems during the passive reading of four semantic categories, i.e., abstract emotional and mental concepts and concrete foods and tools concepts. The authors found that emotional abstract words, such as “love”, activated different foci of the motor cortex (e.g., hand, legs, mouth) to the same extent, tools concepts showed a preferential activation in motor and premotor areas associated with hand movements. In contrast, abstract mental concepts, such as “logic”, elicited a stronger activation of the face/articulator motor cortex, similarly to foods-related and face-related concepts that afford to mouth actions. Notably, these findings are consistent with the view that linguistic experience is a key component of abstract concepts representation (Borghi & Binkofski, 2014; Borghi et al., 2018). Accordingly, this position predicts that the more concepts are perceived as abstract, the stronger the engagement of the mouth, reflecting the recruitment of verbal information, including others' explanations and the inner monitoring of word meanings (see discussion in § 2.4.5.3). These mechanisms might be more pronounced with mental state concepts, as their semantic content is directly related to metacognitive processes (Borghi et al., 2019; Borghi, Fini, and Tummolini, 2021).

Finally, clinical evidence has suggested a link between the representation of mental states concepts and the “Theory of Mind” (ToM) processing, that is the human ability to understand and infer other people’s mental states, which includes thoughts, intentions, and desires (Premack & Woodruff, 1978). For example, Baron-Cohen et al. (1994) found that patients with autism spectrum disorder (ASD), known to have deficits in understanding other’s mental states, have a specifical impairment in recognizing mental-related words (e.g., think) compared to body/action-related words (e.g., jump). Additional neuroimaging data with healthy subjects showed that processing of mental states concepts leads to increased activity in the orbito-frontal cortex, traditionally associated with ToM processes (e.g., Gallagher & Frith, 2003; for a meta-analysis, see Schurz et al., 2014). Similarly, Harris et al. (2006) compared ASD adults with a group of control participants in a valence judgment task for a set of concrete and abstract words belonging to mental states (e.g., doubt) and metaphysical categories (e.g., fate). They found that the group of ASD subjects performed worse on mental abstract concepts than on the other two concepts kinds; and showed reduced activation in left frontal areas, likely due to language and communication deficits frequently observed in ASD. These findings suggest that semantic knowledge of mental states concepts may rely on similar processes that support social and communicative skills.

3.3.4 Social concepts

With the term “social concepts”, scholars generally refer to a broad class of abstract words whose content is semantically related to a social dimension. Typical members of this category are concepts describing people’s personality traits (e.g., kindness, arrogance), human behaviors in social contexts (e.g., protest, crime), and a detailed set of interactions among individuals (e.g., friendship, conflict, cooperation). Despite the high variability of social concepts, several studies have examined the structure and neural substrate that subtend the representation of these kinds of concepts compared to both concrete and other kinds of abstract concepts.

Results of featuring listing tasks indicate that social abstract concepts elicit a variety of conceptual relations, including agents, actions, social aspects of situations, and contextual considerations (e.g., Roversi et al., 2013; Borghi et al., 2016). Dimension rating studies indicate that affectivity, internal states, and interpersonal interactions characterize a great proportion of abstract concepts, and specifically those that have a social-related meaning (e.g., Troche et al., 2014; 2017; see also Harpaintner et al., 2018).

At the neural level, it has been suggested that the left anterior temporal lobes (ATL) might be the decisive neuroanatomical locus to social concepts. The scientific literature on the function of the ATL, however, is still controversial. Some scholars pointed out that the ATL contributes to conceptual knowledge at the supramodal level, and its primary function is that of a semantic representational hub, integrating linguistic form and semantic information across the cortex, regardless of its specific content and modality (e.g., Lambon Ralph et al., 2017; Patterson et al., 2007). Others proposed that the ATL activity play a crucial role in various aspect of social cognition, such as people recognition and social traits; and it is specially engaged in processing conceptual information related to emotional and social contents (for reviews, see Olson et al., 2013; Olson et al., 2007; Simmons & Martin, 2009).

More recent findings provided support for a tight relation between semantic representation of abstract social concepts and neural regions associated with social cognition, including the ATLs. For example, Mellem and colleagues (2016) demonstrated with an MRI study that the activation of specific anterior regions of the ATL (aSTG/STS) increases as a function of constituent sizes of linguistic stimuli (i.e., number of words) but not by non-words. Crucially, these regions are preferentially activated with semantic contents related to sociality: A strong activation was present during the processing of social-emotional sentences (i.e., sentences describing human interactions in highly emotional situations) over sentences with inanimate object concepts. Consistently, Wilson-Mendenhall et al. (2011) found that the social-related concepts, such as “convince”, activate neural networks associated with social cognition (e.g., medial prefrontal cortex, anterior superior temporal sulcus), while math-related concepts, such as “arithmetic”, activates areas related to numerical processing (e.g., bilateral intraparietal sulcus). Recently, Rice et al. (2018) compared data of three neuroimaging studies on responses to different kinds of social vs. non-social stimuli within ATLs. They found activation in the ATL for recognition of people's faces, and that specific regions in the aSTG responded selectively to abstract socially relevant abstract words but not to socially relevant concrete words (e.g., famous names).

Further fMRI and clinical findings support the view that activation of ATL occurs not only on linguistic material but on social semantic knowledge. Zahn et al. (2007) directly tested this hypothesis comparing the brain neural activity trigged by two classes of concepts: one describing positive or negative human social behaviors (e.g., “honor” – “brave” or “tactless” –

“impolite”) and one describing general animal functions (e.g., “nutritious” –“trainable”). Participants were presented with a pair of words from each class and were asked to evaluate whether the words were semantically related or not (similarity judgment task). The results show that social concepts consistently activate superior portions of the anterior temporal lobe. Notably, regression analyses demonstrated that this effect could not be ascribed to the difference in the abstractness of stimuli, which were controlled in terms of imageability (a dimension that generally correlates with concreteness/abstractness). Rather, it is due to the difference in activation between socially relevant concepts and non-social concepts used as control. Subsequent studies further corroborate the hypothesis that superior ATL is causally involved in processing social concepts, showing that patients with FTLD, who have frontal and temporal lobes atrophy, exhibit significant impairment in the understanding of social concepts compared to animal function concepts (Zahn et al., 2009; 2017). These results were replicated and extended in a study by Ross and Olson (2010) investigating neural activity in the ATL elicited by a “social task” and a lexical task that share common social components. Specifically, the lexical task was a similarity judgment task previously performed by Zahn and colleagues, including social and non-social words as stimuli. The social task consisted of video animations in which geometrical forms interact as agents in a social relation, such as being “friends” or not. The results showed overlapping ATL activations between the two distinct tasks, suggesting that the neural network in the ATLs is activated by retrieving general semantic information, regardless of being linguistically or visually presented.

Another line of research provided additional evidence that social concepts differ from other classes of abstract concepts. Studies on neurodegenerative diseases showed that patients with primary progressive aphasia associated with lesions in the ATL had selective impairment in social concepts but not in other abstract concepts, whereas patients with Alzheimer's only preserved comprehension of emotional words (Catricalà et al., 2014). Recently, Catricalà and colleagues (2020) investigated different neural correlates of social (e.g., sociability) and quantity (e.g., immensity) concepts, by using the TMS method in a category priming task. The authors found that applying TMS over the superior anterior temporal lobe (ATL) selectively modulated the processing of social concepts, confirming the causal role of the ATL in representing social knowledge. In contrast, applying TMS over the right intraparietal sulcus (IPS) modulated prime effects for quantity concepts, consistent with previous findings linking the ISP to the representation of numbers and magnitudes.

In line with the perspective emphasizing that different grounding mechanisms might contribute to the representation of specific abstract concepts to different extents (e.g., the WAT theory, see Chapter 2), the evidence presented here suggests that, among other dimensions, the mechanisms underly social cognition and language processing are essential components for social concepts representation.

3.3.5 Institutional concepts

Within the broad class of social concepts, a specific subset includes words used mainly in the field of law and jurisprudence. Institutional, legal concepts can be roughly characterized as referring to a kind of social facts that have a normative effect in regulating human behavior and organizing society. For the sake of clarity, consider the case of *marriage*. In common sense, marriage is an event involving two people who spontaneously recognize their affective union, which is often celebrated through rituals and social practices. Besides this socio-cultural character, marriage is primarily a legal act sanctioned by the authority of a given community by means of a set of rules that establish the mutual rights and duties between individuals and their offspring. In this respect, the validity and legitimacy of marriage derive from the fact that it is an *institution* regulated by a particular legal system. Indeed, many aspects of marriage may vary across countries, depending on the jurisdiction in question, such as the property regime, or age, kinship, and gender restrictions. Because of this historical and contextual nature, institutional concepts – such as marriage – are also subject to a continuous redefinition of their meaning, as testified by the recent debate on civil marriage or same-sex marriage. In this respect, legal institutions are, at least partially, dependent on the individual's mental states, that is, on how these kinds of entities are conceptualized.

Some legal theorists have recently called for an interdisciplinary approach to the study of legal concepts that takes into account the cognitive mechanisms underlying their conceptual structure and representation (for a recent discussion, see Roversi, 2021). A growing line of research is the so-called "experimental jurisprudence", which addresses questions of classical jurisprudence using empirical data (a review in Tobia, 2021). These studies typically use questionnaires to examine how fundamental legal concepts, such as *rules*, *causation*, *intent*, *contract*, or *consent*, are understood and categorized by judges, law students, and ordinary people. This method detects common intuitions about legal concepts by presenting them in different scenarios relevant to legal interpretations. For example, using the classic example of the fictional legal rule "forbidding vehicles in a public park" (Hart, 1958; Fuller, 1958), it was found that the interpretation of this rule varies depending on which type of vehicle is considered more prototypical by the participants, resulting in either a more inclusive or more restrictive criterion for applying the rule. Hence, the no-vehicles rule is more straightforward to apply to ordinary cars or bicycles than to no prototypical vehicles, such as toy cars or rollerskates (Tobia, 2020; see also Struchiner, Hannikainen, and Almeida 2020). In short, this perspective combines some paradigms of cognitive linguistics with conceptual analysis, an influential method in many areas of philosophy that involves reasoning starting from the theorist's intuitions about hypothetical cases or "thought experiments" to test the predictions of one or more theories.

Other proposals focused on the conceptual representation of legal institutions have been inspired by embodied cognition research programs, especially from Conceptual Metaphor Theory developed by Lakoff and Johnson (1980; see § 1.3.3.1). Accordingly, many theorists contended that metaphors are an important cognitive tool for understanding institutional concepts, which can be seen as the outcome of metaphorical mapping from a more abstract to a more concrete domain of experiences (e.g., "law is a vertical relation", "state is an ordered system of bodies", "the balance of justice") (among others, see Roversi, 2016; Larsson, 2017; Jakubiec, 2021). More relevant to the arguments of this dissertation is a recent line of research that embraces a slightly different perspective in line with novel trends in the EGC panorama. This approach attempts to connect the inquiry on the ontological nature of law and legal institutions with cognitive psychology applied to institutional concepts, by adopting the framework of recent embodied theories of abstract concepts in order to examine the distinctive features of institutional concepts as compared to other kinds of concepts.

Roversi, Borghi, and Tummolini (2013), for example, investigated the cognitive structure of institutional concepts, and their relations with artifacts. The authors compared the properties listed for concrete and abstract "standard artifacts" (e.g., hammer vs. poetry), concrete and abstract "institutional artifacts" (e.g., signature vs. ownership), and concrete and abstract "social entities" (e.g., party vs. disagreement) in a property-generation task.

Correspondence analysis on the produced features for each category revealed that the major differences oppose social entities with institutional and standard artifacts. Specifically, social entities elicited a higher proportion of contextual features, namely situations, entities, or events that co-occur with the target concept (e.g., party-concert), whereas institutional artifacts were conceptualized in terms of normative relations, and evoked exemplifications and paradigmatic properties (e.g., ownership-testament); finally, standard artifacts produced mainly partonomic relations (e.g., hammer-handle). The results also indicated that the abstract-concrete distinction is more relevant for social entities than for institutional and standard artifacts. In other words, the weight of exemplification and normative relations for institutional concepts, and of partonomic relations for standard artifacts does not change substantially across abstract and concrete cases. In contrast, the relevance of contextual factors for social entities is modulated by the abstract/concrete dimension: Abstract social entities primarily evoke situational relations and mental associations, while concrete social entities are highly characterized by temporal and spatial relations. These findings suggest that institutional concepts are peculiar in many respects: On the one hand, they differ from other social constructs; on the other hand, they seem to share common features with human-made objects, such as that they are produced for some purpose and depend on human understanding and agency.

The authors framed this empirical evidence within an artefactual and natural conception of legal institutions developed in the legal-philosophical literature (e.g., Roversi, 2018; Burazin, 2016; Burazin et al., 2018) and contemporary social ontology (e.g., Searle, 1995). For this discussion, it suffices to say that this view conceives of legal institutions as an outcome of human activity, namely, as a set of entities intentionally created to serve particular functions. Thus, they could be understood as artifacts in a proper sense. Like other artifacts, legal artifacts are inherently relational objects that are not defined solely by their material structure: Just as a nail is not simply a metal object shaped like a nail, a parliament is not the building in which members of parliament meet. However, differently from simple material artifacts, legal artifacts have no ontologically objective essence, but rather they are immaterial entities that depend on the intentional states and beliefs of their creators or authors (compare the earlier example of *marriage* with standard artifacts like *hammers*). Crucially, even their existence is guaranteed in virtue of a collective acceptance of the relevant constitutive rules, i.e., a shared set of values often based on formal definitions and linguistic negotiations between members of a given community (for an ontology of institutional artifacts, see also Searle, 2010; Thomasson, 2003).

Most noteworthy, such a description of institutional concepts resonates with recent multiple representation views of abstract concepts (see Chapter 2). In particular, according to the Words As Social Tools theory (WAT, Borghi and Cimatti, 2009; Borghi and Binkofski, 2014; Borghi et al., 2019), the grounding of abstract concepts can be traced not only to patterns of physical and motor interactions but also to linguistic social interactions that contribute to their acquisition and representation. In this sense, legal institutions are a type of abstract concept characterized by physical-material and linguistic social attributes, as their semantic content is collectively defined to fulfill specific expressive functions that have practical, concrete effects in society.

Recently, Roversi, Pasqui, and Borghi (2017) explored the role of physical and social dimensions in grounding institutional concepts using a priming task. Participants were shown a series of animations of physical or social interactions (geometric vs. socialized elements) corresponding to legal concepts (e.g., contract – contact and transmission), concrete concepts of artifacts (e.g., knife-divide), and abstract concepts (e.g., anger-violent). After each animation, participants were presented with a sentence that included the relevant concepts and asked to evaluate whether it was meaningful or not. Results showed slower RTs for institutional concepts, suggesting that legal concepts are more difficult to process than other abstract concepts. However, there was no significant interaction between kinds of concepts and animations, likely because the insert images were schematic and did not reflect real-life situations; therefore, it was difficult for participants to connect the meaning of the concepts to the animations.

Although this brief overview of legal theories and cognitive studies focused on institutional concepts cannot be considered exhaustive, it reveals that they are multi-layered concepts in which material, symbolic, and social components contribute to their representation. By this nature, institutional concepts represent an interesting case study to test the multidimensionality of abstract concepts. Further research should assess how institutional concepts differ from other abstract concepts in terms of a wider range of dimensions, and whether the relevance of either concrete or abstract determinants varies across individuals and contexts. Both these questions are objects of the empirical studies presented in Part II of this dissertation.

3.4 Third remark. The blurred boundaries of concepts

This chapter was devoted to a description of some of the most explored conceptual domains in the literature on semantic knowledge. In addition to long-standing studies on concrete categories of living things, artifacts, and foods, I reviewed and discussed in detail recent influential works investigating abstract categories of emotional, numbers, mental states, social and institutional concepts. In doing so, I pointed out that the domain of abstract concepts is not uniform but, in analogy to that of concrete ones, can be subdivided into classes depending on their distinctive characteristics. Through a careful inspection of different abstract domains, research has demonstrated that they differ in terms of content, mechanisms and neural underpinning. In line with the pluralistic approach proposed by Multiple Representation Views (MRVs), current evidence supports the claim that varieties of abstract concepts exist and that multiple systems are engaged in their representation. Just as different kinds of concrete concepts were found to be grounded in different modalities, different kinds of abstract concepts seem to tap into different sources of grounding, corresponding to the dimensions of experience on which they rely. Some re-enact primary inner and introspective states (emotions, mental states); others are grounded in exteroceptive experiences mediated by bodily movements (numbers), while others rely more on linguistic and social inputs (social and institutional concepts).

Although abstract and concrete concepts kinds can be studied separately, it is worth keeping in mind that the boundaries between categories are much more blurred than is often assumed. Recently, new methodological tools have contributed to revealing a more flexible organization of our conceptual system. Prior works have typically analyzed concepts posing a-priori classification, such as selecting linguistic stimuli according to standard psycholinguistic criteria (e.g., high/low concreteness, imageability) or grouping them into categories with common features (e.g., fear, anger, vs. hammer, lamp). Recent studies have instead adopted a more data-driven approach to describe the conceptual structure, which consists of identifying clusters of concepts without reference to a priori labels.

A consolidated method is k-means cluster analysis (i.e., Hierarchical Cluster Analysis), an algorithm that allows to group concepts based on their similarity values on key dimensions, usually measured in terms of Euclidean distance between words represented as points in a vectorial space. The rationale is that semantically closer concepts share underlying representational structure. This procedure has been recently used by several scholars (e.g., Crutch et al., 2013; Troche et al., 2014; 2017; see also Harpaintner, Trumpp, and Kiefer, 2018) with the aim of assessing the Multiple Representation Views claim that word meaning is spanned across a multidimensional space in which a variety of systems/dimensions may contribute at a different degree to the representation of both abstract and concrete concepts. This hypothesis was mainly tested in rating studies, in which participants evaluate on a Likert scale to what degree a semantic dimension is relevant for the representation of a given word.

For example, Troche and collaborators (2014) obtained ratings for 200 abstract and 200 concrete nouns on the relatedness of each word to 12 separate cognitive dimensions, i.e., polarity (positive or negative valence), sensation, action, mental activity, emotion, social interaction, time, space, quantity, morality, ease of teaching and ease of modifying the word). The selected dimensions were chosen with the aim of exploring their relevant role in describing the meaning of abstract and concrete concepts in a multidimensional perspective. To this end, the authors first performed a Factor Reduction analysis on the original set of variables and found three latent constructs, corresponding to perceptual salience, magnitude, and affective associations. Then, they employed the Hierarchical Cluster Analysis (HCA) to observe how words grouped across this reduced set of factors. Inspection of the three-dimensional space revealed a considerable amount of overlap between abstract and concrete concepts when considering the affective association/social cognition dimension. In detail, this means that an increase in affective-social associations leads to binding concepts regardless of their semantic domain. For example, concrete concepts like *chocolate*, *father* were closer together to abstract concepts like *love*, *trust* (high affective-social concepts), while abstract and concrete concepts like *instance* and *banana* (low affective concepts) were topographically far apart (see also Crutch et al., 2013; Troche et al., 2017).

Binder et al. (2016) provided a more comprehensive conceptual representation collecting ratings for 535 English words on 65 experiential attributes based on neurobiological information processing, roughly including sensory modality, motor, spatial, temporal, social, and cognitive components. Through factor analysis, the authors identified 16 latent dimensions and used them to capture significant differences between a priori categories of artefacts, living things, and abstract entities. Comparisons analysis showed that living things differ significantly from artefacts, with the former characterized by higher scores on dimensions related to motion and emotional attributes, while the latter scored higher on the spatial dimension. Interestingly, abstract entities obtained higher scores than two concrete categories on attributes related to temporal, causal, social, communicative, and emotional experiences, suggesting that they are relevant components of abstract conceptual knowledge.

To examine the underlying category structure in more detail, the authors performed two Hierarchical Cluster Analyses separately for 335 concrete nouns and 99 abstract concepts included in the total set of stimuli. Results revealed a more fine-grained division within categories. In the domain of concrete concepts, for example, musical instruments and occupations formed distinct clusters, the animals divided into subgroups of aquatic animals, small animals and large animals, while the plants and foods contained subgroups of beverages, fruits, transformed foods, vegetables, and flowers. Within abstract concepts, six distinct clusters also emerged: The first two subgroups called “Beneficial and Neutral” included words with positive or negative valence and mental attitudes concepts (e.g., gratitude, optimism); the second group consisted of “Causal” concepts mainly associated with social consequences (e.g., fate, power); the third subgroup included words denoting quantity (e.g., sum, infinity); the four and five clusters included emotional states and social situations concepts, mainly connotated negatively (e.g., guilt, denial), and finally the six comprised words denoting time periods (e.g., spring, day).

A similar procedure was applied by Harpaintner, Trumpp, and Kiefer (2018) on the abstract domain in a feature listing task. The authors investigated the semantic content of 296 abstract words by asking participants to generate properties for each of the items. Using descriptive and hierarchical cluster analyses, they demonstrated that the large set of abstract concepts can be grouped into different subcategories, according to their dominant semantic featural composition: The first cluster was characterized by a high proportion of sensorimotor features (e.g., observation, fitness); the second by properties referred to emotions, internal states, and social situations (e.g., nightmare, argument); finally, in third cluster, verbal associations were the most predominant features (e.g., theory, dignity). Interestingly, in addition to the features generally found associated with abstract concepts, participants generated a substantial proportion of the sensory and motor features. Then, the authors examined the relevance of sensorimotor grounding for abstract concepts meaning in an fMRI study comparing brain activation for a subset of 64 abstract concepts, characterized by their dominance of visual (e.g., beauty) or motor features (e.g., fight) in a lexical decision task. The results revealed patterns of neural activations for abstract concepts that partially overlap with the corresponding modal brain areas in sensory and motor systems. Specifically, processing visual abstract concepts engaged lingual and fusiform gyrus in temporal and occipital brain areas usually found active in the visual perception of real object scenes; whereas motor abstract concepts activated the left precentral and postcentral gyrus in bilateral fronto-parietal regions, often involved during the execution of hand movements (Harpaintner et al., 2020). This finding suggests that brain activity does not necessarily reflect the a priori categorization of words as abstract or concrete. In fact, sensorimotor features that are thought to be associated only with concrete concepts seem to be relevant even in the representation of abstract concept, at least some whose meaning is closely connected with perception and action processes.

Further evidence also demonstrated that abstract categories share common neural activation with concrete concepts. In a neuroimaging meta-analysis comparing the neural correlates of different kinds of abstract concepts, Desai, Reilly, and van Dam (2018) found that the brain representation of emotional, numerical, moral concepts and concepts referring to Theory of Mind (TOM) is distributed across different brain areas. Even though each domain shows distinct neural signatures in some unique regions, all four abstract concepts activate areas significantly overlapping with those traditionally associated with the processing of concrete concepts (i.e., inferior parietal, posterior cingulate and medial prefrontal cortex). Based on the similarities in activation between abstract and concrete concepts, the authors proposed that concepts are enclosed in a space in which episodic, situational information, introspective states and sensorimotor features contribute in their grounding to different respects. Concrete object representation, for instance, relies to a great extent on sensorimotor properties, but other dimensions related to episodic memory and emotional states may also play a role in grounding specific concepts, as in the case of emotionally salient objects such as *knife* or event-based concepts such as *picnic*.

Findings from recent studies contribute to explicit that the distinction between abstract and concrete concepts is not so sharp, because properties that are traditionally considered as concrete sometimes support the conceptual representation of abstract concepts and vice versa. In this respect, the challenge to explain abstract concepts representation implies to recognizing that a clear analysis of sub-categories is crucial in order to characterize their grounding.

In a nutshell, in this chapter, I advocate for a more complex definition of abstract conceptual knowledge, which is not based on the classical dichotomy of abstract vs. concrete concepts. Furthermore, I try to substantiate the idea that studying abstract concepts as a cohesive category would mean overlooking essential differences within the category itself. On the contrary, a possible key to interpreting abstract concepts in an EGC perspective is to move forward with a more fine-grained classification based on their grounding sources, taking into account that multiple systems might be employed and re-enacted depending on the type of concept and the situation in which it occurs.

In line with these considerations, in the next chapter I will discuss another distinctive trait of abstract concepts, namely their context-dependent meaning. Drawing from theoretical speculations about the nature of concepts as stable or flexible representational structures, I will present evidence showing that overall concepts are flexible entities, but abstract concepts are even more variable across contexts, languages, and individuals. Hence, I will argue for the necessity to adopt novel experimental paradigms able to capture the use of (abstract) concepts in communicative and interactive situations.

CHAPTER 4

RE-FRAME CONCEPTS INTO CONTEXT

4.1 On the flexible nature of concepts

The topic of conceptual stability-flexibility has animated the scientific debate in analytic philosophy and linguistics for a long time, where it was an issue whether words carry a “core meaning” which is invariantly accessed each time the word is used (for recent discussion, see Machery, 2015; Casasanto & Lupyan, 2015). Traditional accounts typically assumed that words have a one-to-one mapping to a stored representation of meaning in memory; much like a definition in a dictionary or “mental lexicon”; thus implying that the conceptual representation associated with a word is retrieved in situationally invariant fashion (Collins & Loftus, 1975). That is to say, the semantic features that characterize the concept “chair” are always the same regardless of the fact that it is referred to chairs situated in my kitchen or in a contemporary art museum.

This theoretical stance appears highly problematic when considering the extreme variability inherent in a word’s meaning. As famous Wittgenstein’s example has elegantly shown, no stable set of features can cover the multifarious uses and meanings of the word “game”, whose semantic properties change as produced in different contexts (video games, football, chess) (for details, see § 1.1.1.1). Indeed, Wittgenstein adds: “For a large class of cases—though not for all—in which we employ the word "meaning" it can be defined thus: the meaning of a word is its use in the language” (PI §43). Perhaps, the phenomenon of lexical ambiguity is the most basic evidence of conceptual flexibility. Under different circumstances, the same word can be interpreted very differently: The word *bass*, for example, can refer to either a species of fish or a musical instrument. Even the interpretation of unambiguous words is often co-determined by the context in which they are instantiated. In a classic experiment, Barclay et al. (1974) demonstrated that changes in sentential context produce sizable effects on the interpretation of target words. For example, the familiar, unambiguous words *piano* is better recalled when cued by an expression that emphasizes properties that are related (e.g., "something heavy") rather than unrelated ("something with nice sound") to the event described by previously shown sentence *The man lift the piano.*

One of the most important contributions to the inquiry of the context-dependent nature of concepts comes from the early work of Barsalou (1982, 1983, 1985, 1987). In a seminal paper, Barsalou (1983) noted that, unlike common taxonomic categories such as birds, *ad hoc categories* (i.e., formed on the fly) such as "foods not to eat on a diet" or "things to pack in a suitcase" violate the correlational structure of the environment and therefore appear to be more influenced by situational constraints (for recent developments on this topic, see Barsalou, 2021). The main reason for this is that common categories refer to a distinct set of entities that share significant correlated features, especially physical ones (e.g., birds have wings, feathers, usually fly, build nets, etc.), whereas ad hoc categories typically include exemplars with considerably dissimilar features (e.g., "things to pack in a suitcase" might include shirt, shoes, toothbrush). Strikingly, people generally tend to think about these heterogeneous instances as a unique category.

Barsalou's studies have demonstrated that both taxonomic and ad hoc categories exhibit an internal graded structure in that they include members that vary in typicality. For example, just as the typical exemplar for *birds* might be *sparrows,* the typical exemplar for *food not to* *eat on a diet* might be *cheeseburgers*. According to Barsalou (1985), the internal coherence of ad hoc categories is guaranteed by other salient characteristics rather than just the degree of similarity among members (see the notions of “family resemblance”, “typicality”, and “central tendency” in the classic works by Rosch & Mervis, 1975). In the case of ad hoc categories, an item appears more typical for a category not because it is more similar to its prototype but because it has the highest values in terms of frequency of instantiations (i.e., how frequently specific members are used to instantiate the respective category) and “ideals” (i.e., the attributes that exemplars should have to optimally achieve goals associated with the category). Thus, *cheeseburgers* can become typical members of *food not to eat on a diet* because it does *not* approximate the goal of “minimal calories”, which is the “ideal” for that category. In this respect, some ad hoc categories can become well established in memory, just like taxonomic ones, while others may vary depending on the particular constraints of each situation (e.g., the typical members for *things to pack in a suitcase* change depending on the destination, but probably still include a distinctive set of entities).

Overall, what is relevant to the construction of ad hoc categories is what goal they serve. In fact, they are also called *goal-derived categories* to emphasize the fact that they are generated temporarily to archive a specific purpose in a given situation. As a consequence, instances of ad hoc/goal-derived categories are highly context-dependent as they become salient only when a relevant context is available. This is not the case for taxonomic categories, whose items are usually more stable and can be easily accessed even in the absence of relevant context (Barsalou, 1982). More recently, Casasanto and Lupyan (2015) argued that even the most stable concepts are ultimately constructed as ad hoc categories, as all information carry out by concepts are context-depended. This perspective embraces a radical notion of conceptual flexibility, in that concepts are thought to vary (a) from one microsecond to the next within a given instantiation, (b) from one instantiation to the next within an individual as function of the local context, and (c) from person to person and group to group as a function of people's experiential history (p. 553).

Studies of taxonomic and ad hoc categories have indeed shown the extremely flexible character of the categorization process, which varies considerably across different individuals and within the same individual over time (Barsalou, 1987). An exemplary case was reported in a study by Barsalou & Sewell (1984), who found that people dynamically reshape a category when examined through different points of view: When participants were asked to judge the typicality of exemplars in a category (e.g., bird) from the perspective of the average American citizen, they named typical exemplars (e.g., robin and eagle) that differed significantly from those they mentioned when expressed the same judgment from the perspective of the average Chinese citizen (e.g., swan, peacock).

More recently, embodied and grounded cognition approaches have fostered the idea that concepts are flexible constructs. Accordingly, concepts would emerge from distributed modality-specific brain systems, including regions associated with perceptual, motor, mental, introspective, linguistic, and emotional processes, which are flexibly recruited to represent feature-specific information about a given category in a specific situation (Kiefer & Barsalou, 2013) (see Chapter 1). A large body of behavioral and neuroimaging evidence has proven that the contribution of modality-specific features in encoding a concept generally depends on task conditions and is dynamically tied to contextual factors (for a review see, Lebois et al., 2015; Yee & Thompson-Schill, 2016).

Findings from studies on the so-called “modality-switch effects” (see § 1.2.1), for example, showed that the modality in which stimuli are presented to participants affects conceptual activation, with faster responses when the presentation and content modalities of target words/sentences are congruent (e.g., “Butter is yellowish” presented visually) compared when they are incongruent (e.g., “Butter is yellowish” presented aurally) (e.g., Scerrati et al., 2015). Similar effects also occur when the concept-property verification task is preceded by pure perceptual processing in different modalities (i.e., perceiving visual, tactile, or auditory stimuli without any semantic meaning) (Van Dantzig et al., 2008). Along the same line, the relationship between the sensory modality activated by the semantic content of a word and the ongoing task has an impact on conceptual processing. For example, Connell and Lynott (2014) examined the processing of words associated with visual or auditory perceptual strength (e.g., small *vs.* husky) in lexical decision and reading aloud tasks. Their results showed that preactivating the visual system through the presentation of strongly visual words facilitated performance in the lexical decision task, whereas preactivating the auditory system through the presentation of strongly auditory words facilitated performance in the reading aloud task.

The first neural evidence of conceptual flexibility comes from a study by Hoenig, Sim, Bochev, Herrnberger, and Kiefer (2008), who used fMRI and ERPs to investigate the modulation of activity in sensorimotor brain regions during conceptual processing. In a semantic-fit task, participants were asked to verify either visual or action-related features for target words referring to artifacts and natural objects. The main results showed a crossover interaction between semantic category and attribute type in modality-specific brain areas such as the posterior inferior/middle temporal, ventral premotor, and posterior parietal cortex. The brain activity in these regions increased when non-dominant features for a given category were directly probed by the task (i.e., visual features for artifacts and action-related features for natural objects), indicating that access to conceptual knowledge is strongly modulated by the attribute type. Crucially, this activation emerges early as 116 ms after stimulus onset, testifying rapid access to conceptual features, and thus a functional activation and not only a consequence of conceptual processing. These results confirm that concepts comprise semantic features that are flexibly recruited from modal brain areas as a function of task demands.

Further neurocognitive evidence attested the high plasticity of our conceptual systems. For example, Kiefer et al. (2007) found that by simply training participants to diagnose different features of a novel object (e.g., by highlighting perceptual or action-related features) under different conditions (e.g., by pointing at the objects or by pantomiming actions toward them) the same object elicits different brain activities in frontal motor and occipito-parietal visual-motor regions, indicating that even a short-term learning experience leads to differences in conceptual object processing.

At the same time, there is evidence that previously stored knowledge about objects influences conceptual tasks. Behavioral findings showed that knowledge of potential actions to be performed with objects facilitates categorical judgments when objects are perceived in their natural visual environment, but not when the same objects are depicted in unusual contexts (Kalénine et al., 2014). Analogously, neural evidence shows that performing actions systematically with one hand or the other elicited bilateral activation of the premotor cortex in right-handers and left-handers during lexical decision tasks on manual-action verbs, such as *throw* or *write* (with respect to non-manual actions verbs) (Willems et al., 2011).

Interestingly, neuroimaging studies have also shown that individuals' cognitive style modulates the neural activity underlying conceptual object processing. In an fMRI study, Kraemer et al. (2009) asked participants to perform a similarity judgment task involving either image-based features (e.g., a red triangle with stripes) or word-based features (e.g., red, stripes, triangle) of an object. Before the imaging session, participants were submitted to self-report surveys, which assessed the extent to which they used visual and verbal reasoning styles. The authors found a positive correlation between modality-specific activity and individual tendencies: Participants who preferred a visual cognitive style showed more activity in regions of the visual cortex (fusiform gyrus), whereas participants who preferred a verbal cognitive style showed more activity in regions associated with phonological processing (supramarginal gyrus). Similarly, Hsu et al. (2011) found that retrieving detailed color knowledge about objects activates brain regions of color perception (left fusiform gyrus), and this activity is greater in subjects who process information visually than verbally. These findings have been interpreted in terms of differences in individuals' cognitive control abilities that lead them to focus attention on different features of a concept (Kan & Thompson-Schill, 2004).

More recently, Mazzuca et al. (2021) directly investigated the flexibility inherent to the conceptual domain of "disease" through an analysis of semantic features elicited by the relatively new concept of COVID-19 in Italian participants during the first wave of the pandemic. Their results showed that COVID-19 is strongly related to the emotional sphere of fear associated with health and social scenarios (i.e., hospital, quarantine, solitude). Interestingly, compared to a set of concepts related to disease, COVID-19 was conceived as less mortal than severe illnesses (e.g., tumor) but as more mortal than mild illnesses (e.g., flu), suggesting that the introduction of novel concepts molds existing conceptual relations in a semantic domain.

Evidence of conceptual flexibility such as that described may cast doubt on how people can share concepts or, in general, how mutual understanding is possible. If concepts never consist of fixed representations but rather reflect the evolving contexts in which they are constantly updated, varying across time and individuals, communication should be problematic. However, as Connell and Lynott (2014a) noted, one way to address this potential criticism is to appeal to language as a valuable source of invariance (see also Yee, 2019). As already discussed (Chapter 2, § 2.4), verbal labels are not mere vehicles of meaning but contribute to shaping our conceptual representations; thus, even though speakers likely never activate exactly the same concept, using the same word to denote it facilitates communication. Moreover, the physical and contextual environment in which words and utterances are expressed often provides valuable cues for interpreting their meaning and identifying shared referents. In many cases, however, successful communication depends on on-the-fly coordination among interlocutors that establish and redefine the meanings of concepts to ensure that they have enough common ground knowledge to archive the current communicative goal. This practice is made possible precisely by the fact that concepts are flexibly tailored to the current context.

4.2 Conceptual flexibility: the case of abstract concepts

In this section, I delve deeper into the contextual flexibility of abstract concepts. In doing so, I assume a broad notion of "context" as to include not only physical situations but also linguistic and cultural environments, as well as individual preferences/abilities. The literature review has no pretense of being exhaustive, but it is strictly aimed to show that the extent to which these factors influence conceptualization depends on the considered domain.

Specifically, I will argue that the meaning variability might be more pronounced with abstract domains than concrete ones, likely due to their high reliance on linguistic and social practices that widely change from one context to another and even from person to person.

4.2.1 Cross-cultural and cross-linguistic variability

One of the main questions that animated the research in cognitive sciences for a long time is, to put it quite simply, whether the different languages we speak affect our thought and perception of reality. The debate has traditionally been framed by two opposing stances: “universalist” and “relativist”. The universalist view holds that cognitive processes are universal in human beings and linguistic structures are mapped into pre-existing conceptual distinctions that arise from physical regularities in the environment, and therefore when languages do differ semantically, those linguistic differences do not affect cognition (e.g., Pinker, 1994; Pullum, 1991). In contrast, the relativist view, often known as the Sapir-Whorf hypothesis, maintains that the language and its structures shape thought (Sapir, 1929; Whorf, 1956). Over the years, the consensus has oscillated between these two poles, supported by evidence that described either consistent similarities or striking variability in conceptual domains across different languages and cultures (review in Malt & Wolff, 2010; Malt & Majid, 2013). Although the universalist/relativist debate is far from settled (e.g., Evans & Levinson, 2009), scholars generally agree to rule out a strong version of the linguistic relativity hypothesis, now referred to as “linguistic determinism”. Indeed, the claim that the language we speak completely constrains what we think and our worldview seems too radical to be accepted. Nevertheless, a weaker version called neo-Whorfianism is gaining support in the current literature (for a theoretical discussion, see Reines & Prinz, 2009). Accordingly, the central question is not *whether* language determines thought but in *what* cases linguistic variations influence thought processes.

Recent research in semantic typology comparing differences and similarities across languages has convincingly demonstrated that semantic categories do not reflect unique, invariant proprieties of the world but are instead “plural”, not only because of the polysemy of some words but also because of their social and cultural underpinnings, whereby some features may appear salient for a given category in a certain number of cultures and not in others (review in Goddard & Wierzbicka, 2013; Kemmerer, 2019). To give an example: English words expressing moral concepts (“right”, “wrong”, “fairness”), emotions (“suffering”, “pain”), as well as ordinary concepts (“morning”, “lunch”) have no equivalent translations across languages spoken around the world (e.g., Wierzbicka, 2013; 2014).

From a cross-linguistic perspective, many linguists have argued that the extent to which words meaning are universal or language-specific might depend on grammatical class, with open-class words (i.e., nouns, verbs, adjectives) being more variable across languages compared to closed-class words (i.e., conjunctions, propositions, articles) which would be, instead, more stable due to their limited range of meanings (e.g., Talmy, 1988; Haspelmath, 2003). Another proposal posited a noun-verb distinction based on a different perceptual dominance. In particular, it has been suggested that relational terms, such as verbs or propositions, should show more cross-linguistic variability than object nouns because they are less constrained by environmental factors (Gentner, 1981; Gentner and Boroditsky, 2001). Results from a comparative study on 12 Germanic languages showed that naming elements of words referring to colors (e.g., blue), body parts (e.g., forearm), and containers (e.g., bowl) were considerably similar, while the words expressing spatial relations (e.g., in, around) showed the most variation in meaning, in keeping with the view that grammaticized terms are more likely to change across languages compared to the meaning of nouns (Majid, Jordan, and Dunn, 2015).

The degree of linguistic variations, however, might not only pertain to grammatical class. As Borghi (2019) noted, an additional factor that should be considered when framing evidence on linguistic relativity is the level of abstractness of the underlying concepts. In line with the main tenets of WAT theory (see § 2.4.5), Borghi claimed that linguistic and cultural differences have a stronger influence on the representation of abstract domains than concrete ones. The argument follows from the different representational mechanisms that underlying the two kinds of concepts: Whereas in the case of words denoting concrete entities, perceptual inputs and environmental structures drive and facilitate the categorization and acquisition processes, leading to more stable conceptualization; in the case of abstract words, where environmental constraints are less strong, language and social practices play a crucial role in shaping the boundaries of categories, so that variation across languages might be more marked (Borghi, 2019, p. 432).

In support of this, there is evidence that with more perceptual and concrete domains, the effect of languages is present but often limited to verbal tasks. In an influential study with containment objects, Malt et al. (1999) found that the spoken language influenced performance on naming tasks but not on sorting tasks, suggesting that perception of the physical and functional similarity among objects remains relatively constant despite differences in lexical patterns. Similarly, studies investigating the categorization of everyday motion events, such as those expressed by the verbs cut/break (Majid et al., 2008) or walk/run (Gennari et al., 2002; Malt et al., 2008), have shown that although there are subtle differences in the number and kind of words used to describe these events, the way they are represented is fairly convergent across languages.

An interesting case is that of domains that stand on an intermediate level between concreteness and abstractness. For example, among sensory modalities, auditory and olfactory senses are generally conceived as more abstract and less constrained by perceptual strength than others (Lynott, Connell, Brysbaert, Brand, & Carney, 2019). In keeping with their high abstract character, researchers found that the representation of musical pitch and odors vary consistently across languages. Dolscheid et al. (2013) found that, after training on a pitch-reproduction task, the performance of Dutch speakers, who usually represent pitch with "high/how" metaphors, resembled that of Farsi speakers, who usually represent pitch with "thin/thick" metaphors, indicating that these language-based representations of auditory stimuli can be rapidly modulated. Research comparing the production of olfactory words across languages found that speakers of Dutch have few specific words to describe odors, mostly referring to their concrete sources of origin (e.g., musty - banana, a house that isn't aired), while speakers of Jahai (i.e., hunter-gatherers from the Malay Peninsula) used more often fluent abstract expressions (e.g., fruity, floral), and this qualitative difference is reflected in a time advantage in verbalizing odors for Jahai over Dutch speakers (Majid et al., 2018; see also Majid & Burenhult, 2014). This result suggests that the alleged universal difficulty in describing odors is, in part, a culturally relative fact.

A second example concerns the concept of "gender", where its embodied/concrete elements and socio-cultural/abstract aspects become differently relevant as a function of social and cultural aspects. Preliminary results from a free-listing task by Mazzuca et al. (2020) showed that when asked to list words referring to gender, Dutch participants mainly produced words related to the bodily sphere (e.g., hormones, reproduction), Italian participants mentioned more frequently words linked to social, political, and cultural spheres (e.g., stereotype, equality), probably due to the gender-related issues in Italian political debate, whereas English participants listed words associated with both biological/physical components and socio-cultural factors of gender. Moreover, the results of ratings on the extent to which a set of abstract and concrete words are related to gender report differences between groups: Dutch participants rated more concrete words as more associated with gender, while Italian participants showed the opposite pattern and English participants lying in the middle. Thus, the concept of gender is conceived as more abstract or more concrete depending on the cultural environment.

On the other hand, linguistic and cultural differences seem to have a major impact on the categorization of the more abstract domains of experience. For example, Goddard (2010) found that words for emotions (e.g., sad, grief), epistemic/cognitive states (e.g., know, doubt), and the non-physical parts of a person (e.g., mind, soul) display a substantial variation in meanings across Western and Eastern languages, likely due to culture-specific constructs. In this respect, the abstract notions of space, time, and numbers are paradigmatic examples of conceptual variability. Indeed, as discussed earlier in this dissertation, the effects of spoken languages on their representation have been extensively documented (for discussion on time and space, see § 1.3.3.1; for numbers, see § 3.3.2). Given their importance, it is worth mentioning a few key findings for each of these domains.

With regards to time, there is much evidence that the representation of time in many languages is mapped onto spatial metaphors (Boroditsky, 2018). However, linguistic expressions for time-space mapping vary considerably between spoken languages. Research from Boroditsky and colleagues (Boroditsky et al., 2011; Fuhrman et al., 2011) has shown that English speakers mainly use horizontal metaphors to talk about sequences of events in a time window (past/future, left/right), while Chinese Mandarin speakers systematically use vertical metaphors (past/future, up/down). Interestingly, linguistic differences in the representation of time also affect non-linguistic tasks. For example, when asked to estimate the time it takes to grow the length of a line or the quantity in a container, English speakers refer to time in terms of length (long time), while Greek speakers refer to quantity (largo tiempo) (Casasanto, 2008).

Likewise, the lexicon of spatial relations does not follow universal patterns. Indeed, linguistic communities use at least three distinct frames of reference (FoR) to describe the objects' location in the space (Pederson et al., 1998). Many languages rely on *relative* FoR corresponding to a viewer-centered perspective based on body axes (e.g., "the book is to the left of the cup", where "left" is used in reference to the speaker's location), or *intrinsic* FoR referring to object-centered position (e.g., "the book is to the left of the cup", where "left" is used to describe the relationship between the book and the cup). Some languages, such as Tzeltal, mainly use *absolute* FoR, describing the location in relation to stable geographical landmarks (e.g., "the book is to the east of the cup"). Other substantial differences emerged in relation to spatial categories. Bowerman and Choi (2001) showed that spatial semantic categories in Korean are not expressed as support or containment (thus, using the English preposition *on* or *in*), but rather in terms of "fit" between objects (i.e., *tight* or *loose*).

The role of language in the numerical domain has been an object of extended debate. Prominent views distinguish between the numerical system linked to subitizing, which allows approximate calculation of low quantities (1-4, without symbols or counting), and a linguistically based system for large exact quantities (Dehaene, 1997) While subitizing is a rather universal mechanism, there is clear evidence for the importance of language in the development of numerical abilities. Populations who do not possess words for exact numbers have difficulty in tasks that involve precise calculation with numbers that go above 5 (Pica et al., 2004; Gordon, 2004). The effects of linguistic variations have been extensively documented in numerical association effects. For example, the SNARC effect (spatial-numerical-association of response code) is modulated by counting or reading habits, reflecting a specific spatially oriented "mental number line": In Western cultures, small numbers are associated with the left side of the space and large numbers with the right side, whereas in Arabic or Hebrew cultures the opposite is true (Shaki & Fischer, 2008). Native language also influences performance in nonverbal arithmetic tasks based on magnitude comparison, like the unit-decade compatibility effect, which refers to faster odd/even decisions when the unit and tens digits of a two-digit number have the same parity (e.g., 42 < 57) than when the unit and tens digit differ in parity (e.g., 47 < 62). This effect is less pronounced in languages in which the order of units and tens in numbers follow the sequence of digits in digital notation (e.g., English, 47 "forty-seven") than in languages in which this order is inverted (e.g., German, 47 "seven-forty") (Pixner et al., 2011).

As this brief summary shows, linguistic variations seem to increase as a function of the abstractness of words. While concrete domains are overall more stable across cultures and languages because the environment puts many constraints on how categories are formed, abstract domains are shaped mainly by linguistic experience, so the influence of spoken language on thought is great. For clarity, it should be noted that the hypothesis discussed here has not been fully confirmed by recent findings. Thompson, Roberts, and Lupyan (2020) examined the semantic alignment of various domains across 41 languages and found that artifacts, actions, and natural kinds showed only moderate alignment, while domains such as numerals, temporal, and kindship terms showed relatively high alignment across languages, and this effect was predicted by cultural similarity and geographic proximity. However, as the authors note, the highest semantic alignment concerns domains that cannot be neatly categorized as abstract or concrete, but as having a high “internal coherence”, likely due to the fact that they are products of cultural evolution tied to stable environmental aspects (consider, for example, the base-10 number system; temporal terms such as “day”, “week”, “winter”; or kinship relations based on gender or generation such as “son”, “aunt”, “daughter”) (p.13). This further supports the proposal of reconsidering the abstract-concrete dichotomy in favor of a more systematic investigation of the multi-layered character of concepts, in which physical, linguistic, and cultural aspects may converge, but at a different level and to a different extent.

4.2.2 Individual differences and Expertise

In the previous paragraph, I have described evidence demonstrating that language and cultural practices to which we are exposed affect the way we represent and categorize objects and events surrounding us. Besides these external elements, another potential source of conceptual flexibility lies in intrinsic factors of the individual. Indeed, even speakers of the same language could have a different understanding of the same word due to differences in cognitive ability, the richness of the lexicon, or their long-term experience. To illustrate, the meaning of “planet” can change drastically depending on whether it is recognized by a physicist, an astrologer, or a child, even though they probably have the same reference to the word (i.e., a celestial body that orbits the sun).

Although it is widely recognized that conceptual representations, even the most salient properties, are not fixed but vary from individual to individual, research does not always consider the effects of individual differences on semantic processing. Most psychological studies, including language research, use mainly young (student) adults from western, educated, industrialized, rich, and democratic (WEIRD) societies to make general claims about human cognitive processes (Henrich et al., 2010). Even when comparative studies are conducted, it may be challenging to interpret differences. Collecting evidence across more diverse populations is, therefore, pivotal to better understand the mechanisms underlying semantic representation and its flexible nature.

Along this line, some recent studies have explored the longitudinal change in the mental lexicon. For example, Dubossarsky et al. (2017) collected free association data on 420 cue words from over 8,000 individuals, ranging from 10 to 84 years of age. Their results indicated that the strength of shared associations evolves in a nonlinear (U-shaped) relation over the life span, with a more convergent network in early life and less structured and more variability in the late life, consistent with the idea that the number of words association increase with individuals age. In a recent review, Wulff et al. (2019) found substantial changes in the structure of lexicon networks across older and younger adults, likely attributed to differences in environmental exposure, prior learning experiences, attentional encoding, decay/consolidation of representational content in memory, and mechanisms of search and retrieval from the representation. Further empirical evidence has demonstrated that differences in the lexical-semantic organization across the life span influence behavioral performance in the corresponding ages. In their study, Krethlow et al. (2020) used a free association task with six-age groups (from 10 to 80 years) to compute measures of lexical-semantic network richness and prototypicality. After showing that these measures differed significantly between the considered groups, the authors assessed their explanatory power in a picture-naming task with a new sample of participants within the same age groups. Consistently, they found that age-specific lexical-semantic factors predicted the accuracy and speed of word production in the same age group, whereas other variables commonly used in studies with young adults (e.g., lexical frequency, familiarity, number of phonemes) did not predict the performance of other age-groups. Overall, these works underscore that population-age-based construct should be included as an additional measure of word semantics.

Apart from age-related differences in lexical processing, one might wonder whether individual differences in word meaning are somehow modulated by the semantic content of the words. Based on the arguments discussed in this dissertation, one would expect abstract words to be more susceptible to intersubjective variation than concrete words since they do not refer to external referent entailed in perceptual, narrow contexts but rather heterogeneous situations. Though research in this area is still in its early stage, recent studies seem to support this view. For example, Pexman and Yap (2018) examined the relationship between participants' vocabulary knowledge and semantic decision responses for abstract and concrete words included in the Calgary Semantic Decision dataset, using distributional models with several lexical and semantic variables. Their results showed that participants with higher vocabulary scores are more influenced by words' concreteness; thus, they are more able to access task-relevant semantic information, resulting in faster decisions for prototypically concrete and abstract words. In contrast, participants with relatively low vocabulary scores were more strongly influenced by the age of acquisition and word frequency, resulting in a relatively weak representation of these stimuli.

Further evidence comes from a very recent study by Wang and Bi (2021), who directly investigate whether individual variation patterns differ for abstract and concrete words. To this end, the authors presented Chinese speakers with relatively similar cultural and educational backgrounds, with a list of 90 words covering concrete domains (i.e., animals, face/body parts, and artifacts) and abstract domains (i.e., abstract words with and without emotional association, e.g., *identity* vs. *violence*, respectively) and asked them to either judge semantic relationships between words or think about their meaning while undergoing fMRI. Both behavioral and neuroimaging data showed that the degree of variability in word meaning increases with word abstractness and that this variation can be predicted by the association strength of words with sensory experience and linguistic descriptiveness. Specifically, the more sensory experiences associated with a word, the more likely it is that different people will show high agreement on its meaning; in contrast, the less a word is associated with sensory experiences and is more difficult to define by language – as in the case of abstract concepts – the more likely people show high disagreement. These findings are in line with the proposal that abstract words require a sophisticated vocabulary to be mastered and that productive information exchanges and discussions might be necessary to achieve mutual understanding about their meaning during communication (WAT theory, see § 2.4.5).

Another factor that drives meaning variability effects is the individuals' level of knowledge and expertise. As a matter of fact, each person accumulates different experiences in the course of his/her life that led to the construction of specific skills and proficiency in a particular field, which may result in different conceptual representations. Let's take the "planet" example again: A physicist who knows planetary science can describe the composition, motion dynamics, and formation of planets, while an astrologer usually refers to planets to describe or predict their influence on people and events. In this respect, their expertise is reflected in the fact that they focus on certain aspects of "planets" and not others.

In literature, the effect of expertise on the categorization of concrete entities and objects has been extensively documented. Studies investigating the representation of biological categories, such as birds (e.g., Bailenson et al., 2002; Tanaka & Taylor, 1991; Johnson, 2001) or fishes (e.g., Shafto & Coley, 2003; Burnett et al., 2005), have shown that novices tend to classify exemplars solely on basic-level categories, whereas experts refer more often to sub-ordinate level categories (e.g., sparrow, sardine), also related to their contextual applications and ecological factors. Moreover, there is evidence of inter-expert variations within the same domain. In their famous research on experts' categorization and reasoning about trees, Medin and colleagues (Medin et al., 1997; Lynch et al., 2000) found that taxonomists, landscape workers, and park maintenance personnel organized their knowledge according to goal-related aspects relevant to their respective roles.

The ability of experts to rapidly access specific information from their conceptual repertoire is also reflected at the neural level. In an fMRI study, Hoenig and colleagues (2011) reported greater activation of the auditory association cortex in professional musicians when they identified pictures of musical instruments than when they identified pictures of other objects, while no differences emerged for musical laypersons. Similar findings have been obtained for sports activities: Compared to nonplayers, ice hockey players showed more activation of premotor regions reading sentences describing actions associated with the ice hockey than sentences describing everyday actions (Beilock et al., 2008). This data confirm that reiterated cognitive activities affect conceptual brain systems, enhancing the capacity to discriminate category-relevant features.

Whether the individuals' expertise leads to similar or different effects for abstract domains is still unknown, but there is recent evidence on the interplay between the expertise and the information elicited by concepts at different degrees of abstractness. In their study, Bechtold et al. (2019) reported experience-dependent effects on conceptual processing of abstract mathematical concepts. Specifically, math experts and non-math experts performed a lexical decision task on mathematical and nonmathematical words, while event-related potentials (ERPs) were acquired. The authors found a significant interaction between the two groups and the type of words on the amplitude of N400 and LPC indexes. During the processing of mathematical words, math experts showed a reduction of N400 compared to non-experts, indicating less effortful conceptual processing; and a higher LPC possibly reflects a retrieval of experiential information in the area of their competence. Instead, processing nonmathematical words did not differ between groups. Similarly, another fMRI study showed that in professional mathematicians, but not in laypeople, semantic judgments of advanced mathematical statements triggered activation in number processing and calculation brain areas (Amalric & Dehaene, 2016).

In the domain of art, several behavioral evidence has confirmed that the level of expertise modulates the aesthetic evaluation of artworks (e.g., Hekkert & van Wieringen, 1996a; 1996b). Neuroimaging studies suggest that aesthetic judgment is predominantly associated with memory-related areas and regions implicated in the processing of reward, which activity tends to increase with expertise (Kirk et al., 2009). Furthermore, Leder et al. (2014) provided evidence that expertise modulates physiological responses to works of visual art. Using facial electromyographic measurements during aesthetic evaluation, they found an attenuated emotional reaction in art experts compared to laypeople, likely due to their use of higher-order cognitive processes to classify artworks.

Further research might clarify to what extent these findings can be interpreted as a general effect of the expertise, probably linked to training or familiarity, or whether specific effects emerge depending on the considered domain. In general, a careful study of individual differences in the processing of specific classes/types of abstract words might offer great potential for testing and supporting the notion of conceptual flexibility as assumed by grounded cognition approaches.

4.2.3 Other sources of conceptual variability

The previous sections deepen into the role of cross-linguistic/cultural variations and individual differences in the representation of abstract concepts. However, it is noteworthy that the way in which we form and use concepts can be influenced by a variety of factors, ranging from personal and sociocultural experiences (i.e., sex/gender, personality, religious and political beliefs) to physical or mental disabilities (i.e., neuropsychological syndromes, motor or sensory impairments) (for a review, see Littlemore, 2019). Below, I will briefly outline the role of some of these factors in relation to the grounding of abstract concepts.

At a broad level, the experience of being embedded in a sociocultural environment, with its norms and traditions, greatly affects our conceptual knowledge. Among other things, political and religious orientations are key factors that shape people's attitudes and behavior and modulate the concept we use to describe and construct the world. For instance, in religions, linguistic metaphors tend to relate spirituality and morality to verticality (i.e., God is associated with *up*, Devil with *down*; Meier & Robinson, 2004; see also § 1.3.3.1), and this vertical schema seems to be more pronounced in individuals with strong religious beliefs than atheists or agnostics (Li & Cao, 2017). Interestingly, the type of religion and its relationship with God modulates the use of metaphors involving movements: Christians, who focus on intimate human relations, use the metaphor of "traveling *with* God", while Muslims, who focus on a personal journey of research and reflection, use the metaphor "traveling *toward* God" (Richardson, 2012).

Similarly, there is evidence that political stance influences the way people conceptualize complex and abstract ideas. In a series of experiments, Thibodeau and Boroditsky (2011) presented fictional scenarios about crime to American participants and found that when crime was metaphorically framed as "beast preying on the city" participants tended to be more hostile towards foreigners and proposed solutions such as jailing criminals and enacting enforcement laws; in contrast, when crime was metaphorically framed as a "virus infecting the city", they were more likely to recommend strategies to improve education and reduce poverty. Interestingly, responses were modulated by participants' political affiliation: Republicans favored more punishment solutions to deal with crime and were less swayed by metaphors than Democrats and Independents. Although political ideology usually coveys abstract meaning, it is also linked to biological and embodied experiences. Research on political psychology has found a strong correlation between political attitudes and feelings of disgust, which are often associated with immoral behavior ("morality is cleanness", Zhong & Liljenquist, 2006). These studies show that conservatives are significantly more sensitive than liberals to associating moral disgust with physical disgust (i.e., body odor) (e.g., Inbar et al., 2009; Liuzza et al., 2018). This is likely because people who are more concerned with conformity and purity tend to have strong negative attitudes toward socially deviant groups and are more easily disgusted (review in: Petersen, Tybur, and Stewart, 2020).

The notion of gender is another prominent example of how biological assets and sociocultural factors influence conceptualization. Although research on this topic is still ongoing (e.g., van Anders, 2015; Fausto-Sterling, 2019; Lindqvist et al., 2021), there is clear evidence that the experience of sex/gender is modulated by the society we live in and the language we are exposed. Studies have shown that social stereotypes about women and men are automatically activated and influence response latencies in language processing. For example, Banaji and Hardin (1996) found that participants identified the gender pronoun more quickly when prompted by target nouns that matched gender expectations (e.g., feminine pronouns and "nurse") compared to stereotypical gender mismatch (e.g., masculine pronouns and "nurse") (see also Boroditsky & Schmidt, 2000; Pesciarelli, Scorolli, and Cacciari, 2019). Grammatical gender was also found to influence categorization processes. For example, when Spanish and French speakers were asked to assign male and female voices to inanimate objects, they systematically assigned gender according to their native language (Sera et al., 2002) whereas this is not the case for German speakers, whose grammar is not based on a gender-binary distinction but also includes gender-neutral pronoun (for a systematic review, see Samuel, Cole, and Eacott, 2019).

The role of language in forming gender stereotypes has been further explored in a recent cross-linguistic study by Lewis and Lupyan (2020), which focused on the "career-gender bias" that associates men with career and women with a family. The authors analyzed the prevalence of statistic co-occurrence of *men-career* and *women-family* word pairs in 25 world languages and related these data to native speakers' psychological biases as measured by the Implicit Association Test (IATs). Results showed that language statistics predict the magnitude of the career-gender bias: Speakers of languages with greater associations between men-career and women-family tended to have stronger stereotypical gender associations on the IAT. Further analysis of the structural features of languages revealed that the strength of gender stereotypes weakly correlates with the presence of grammatical gender systems (e.g., in Spanish, “enfermero” -nurse-MASC, “enfermera”-nurse-FEM), but correlates positively with the extent that languages mark gender in occupation words; thus, languages with more lexicalized gender forms (e.g., waiter- MASC and waitress-FEM) tend to have stronger implicit gender associations. This evidence is consistent with the idea that language plays a role in shaping social stereotypes.

Another line of research has recently introduced new measures to classify gender identity and sexual orientation, including non-binary gender systems (e.g., Galupo et al., 2014; Joel et al., 2014). In this vein, there are interesting findings from recent studies examining the role of sociocultural settings and sexual preferences in the conceptualization of gender. As discussed earlier (§ 4.2.1), Mazzuca et al. (2020) found strong differences between Dutch and Italian participants in words associated with the target concept “gender”, with the former relying more on biological aspects while the latter referred to social and political contents, instead of English participants produced a mixed pattern. In addition, the authors found differences driven by participants' sexual orientation: Heterosexual participants were more likely to emphasize binary distinctions and linguistic associations such as *female/male*; whereas homosexuals participants were more likely to associate gender with words such as *fluidity*, *rights*, or *freedom*. Similarly, Schudson et al. (2019) reported that in a US sample, cisgender heterosexual participants used more often biological content to define the words *woman* and *man* compared to transgender, homosexual, and genderqueer participants, who encoded sociocultural aspects in their definitions. These studies suggest that understanding of gender is raised from a mixture of biological, embodied factors and a socially constructed system of meanings.

Other differences due to physical and psychological conditions can radically affect the way in which people use and represent concepts. Individuals diagnosed with psychological and neurological disorders such as schizophrenia and Autistic Spectrum Disorders (ASD) tend to have difficulty in communication and social interactions compared to the healthy population (Dvir et al., 2011). For the aims of this dissertation, one would wonder whether such clinical populations have selective difficulties with abstract concepts, for which social and linguistic inputs are thought to be pivotal for their acquisition and mastery (WAT, Borghi et al. 2018; 2020, see Chapter 2, § 2.4). Some evidence sheds light on this issue.

Schizophrenic patients – who often experience auditory verbal hallucinations (AVH) and abnormally use inner speech (Petrolini et al., 2020) – have great difficulty understanding figurative expressions that require a high degree of abstraction (i.e., metaphors, idioms, proverbs, see Mossaheb et al., 2014; Bambini et al., 2020). To date, however, there is no clear evidence whether this is a general impairment in figurative language or whether it is selectively limited to abstract concepts.

ASC disability has been associated with poor linguistic and social competencies (this is less true for high-functioning autism, such as Asperger individuals). Evidence has shown that ASC individuals tend to benefit from visual modality in many tasks that healthy individuals solve verbally (e.g., recall, false belief, spatial recall; Kunda & Goel, 2011). However, they do not differ from control subjects in categorizing basic and superordinate concepts (e.g., Tager-Flusberg, 1985; Eskes et al., 1990), but their mastering of abstract concepts could be limited; for example, they have difficulty with mental state terms, such as "believe" (e.g., Leslie & Thaiss, 1992). Prominent theories interpret autism as a lack of ability to monitor their one's own and other mental states, leading to a delay in the Theory of Mind (TOM, Baron-Cohen et al., 1995; see also § 3.3.3). Others have pointed to a link between autism and auditory deficits, that can impair them in engaging joint attention and joint action (review: O'Connor, 2012). Thus, ASC's difficulties in exploiting social and linguistic input might result in scarce ability to use and process abstract concepts. However, further empirical studies are needed to prove this correlation (for a brief review, see Borghi et al., 2018).

Conceptual variability in abstract concept representation has also been studied in relation to sensory impairments that are closely related to the deprivation or absence of linguistic and auditory interactions, as is the case in deafness. The Deaf and Hard Hearing (DHH) population is characterized by diverse backgrounds: only 1-2% of deaf children receive sign language education, the majority have both hearing parents, and deafness onset is before age 3, while a minority have deaf parents and are exposed to sign language from birth (Haualand & Allen, 2009). Despite this heterogeneity, there is evidence that deaf people typically underperform hearing people on language comprehension tasks. Studies comparing the reading comprehension of a large sample of deaf and hearing students of different school ages found that there was an advantage of perceptually over linguistically acquired words in both groups (MoA, Modality of Acquisition, see § 2.4.5.1); however, this difference decreased over the years only for hearing participants due to an effect of instruction and improvement in linguistically acquired words, like abstract ones (Wauters et al., 2006; 2008). The finding of a selective difficulty of DHH in acquiring abstract than concrete concepts is consistent with theories suggesting that they have different MoA, with concrete words acquired mainly through perception and abstract words acquired primarily through linguistic information.

However, these studies are limited to written texts and do not report the proficiency of participants in sign language. Indeed, it is likely that difficulties with abstract concepts are less pronounced in children who have deaf parents and use sign language early than in deaf children with hearing parents who learn sign language late because of lacking a shared communicative mean (Cuccio & Caruana, 2019).

Linguistic research now widely recognizes sign language as real natural language that fulfills all communicative functions and has all basic linguistic components (syntactic, grammatical, phonological, and lexical systems), even though it is produced in the visual modality (e.g., Stokoe, 1980). However, the modality of communication, i.e., whether it is spoken or signed, could also have an impact on conceptualization. The way sign languages encode abstract concepts into signs can offer relevant insights for understanding the dimensions involved in their grounding and representation. To address this issue, Borghi, Capirci, Gianfreda, and Volterra (2014) analyzed different kinds of abstract concepts from the Italian Sign Language (LIS, Lingua dei Segni Italiana), the visual-gestural language used within the Italian Deaf community (for similar analysis on the concept of politeness in ASL, American Sign Language, see Roush, 2011). Although in sign languages the body is always involved in conveying meaning, the authors highlighted that this involvement occurs at different levels for abstract concepts. Many signs in LIS use body parts in an iconic way to refer to underlying metaphors, such as “knowing is seeing”, “the head as a container of mental activities”, and “the chest as a container of feelings and emotions”. For example, signs linked to mental activities, such as TO KNOW, TO LEARN, and TO FORGET, are all performed with movements near the signer’s forehead. Interestingly, signs denoting purely abstract concepts, such as TRUE, LANGUAGE, are conveyed in LIS toward linguistic information using a strategy known as “initialization”; i.e., reporting the initial letter of the corresponding words in the written alphabet. This initial evidence is in line with the view that the representation of abstract concepts involves multiple factors, differently distributed depending on concept kinds (see Chapter 2); and supports proposals stressing the importance of linguistic information in their acquisition and processing (WAT, Dove, 2019).

The arguments and evidence discussed show that exploring possible sources of variation in human experience, at both sociocultural and individual levels, might be relevant to developing more compelling theories of concepts, particularly for abstract concepts that are less constrained by the physical environment and depend crucially on our ability to co-construct meaning in social and linguistic ways.

4.3 Towards a shift of paradigms: from isolated to situated concepts

The emerging view of concepts as flexible, dynamic, and context-dependent constructs requires to rethink and update the methods used to study them. In what follows, I discuss some of the methods most commonly employed in conceptual knowledge research, from the more traditional methods that focus on single, decontextualized words, to novel statistical measures that offer insights into the variability of words in context, to interactive methods exploited in pragmatics, semiotics, and recent neuroscientific works. I will not argue that these methods are mutually exclusive, but rather that research could particularly benefit from the use of new paradigms that involve two or more participants to capture the flexibility of concepts and their actual use in the dynamics of real dialogue and conversations. This shift of perspective could be a promising avenue to account for abstract concepts whose mastery requires sophisticated forms of social and linguistic interactions.

4.3.1 Traditional methods

Investigations of concepts can be particularly tough. *De facto*, there is no such thing as "a concept" that can be directly measured. Nevertheless, scholars contrived several research methodologies to study how our conceptual knowledge is organized and structured. One of the most common methods is the feature listing (free-listing) task, in which participants are asked to name properties or provide definitions for a target concept (e.g., Barsalou and Wiemer-Hastings, 2005; Harpaintner et al., 2018; Ponari et al., 2018). This approach leads to a reliable description of semantic relations within concepts, but it also has some limitations. For example, subjects tend to list only prototypical features and, in general, far fewer features are generated for abstract concepts than for concrete concepts, which does not reflect the complexity of the underlying conceptual representation.

Several studies investigating differences between concepts use rating procedures to collect explicit evaluations on the degree of importance of a variety of psycholinguistic or semantic dimensions for a word's meaning, such as concreteness, imageability, valence, modality of acquisition, perceptual strength, Body-object interaction (e.g., Altarriba et al., 1999; Lynott et al., 2019; Tillotson et al., 2008; Della Rosa et al., 2010). By combining this method with online data collection, researchers have obtained normative data on thousands of concepts from a large number of participants (e.g., concreteness norms by Brysbaert et al., 2003; sensorimotor norms by Lynott et al., 2020; Body-object interaction norms by Pexman et al., 2019). Such studies are particularly fruitful to validate existing theories of abstract and concrete concepts, assessing the role of specific dimensions deemed relevant for their representation. Moreover, these data can easily be used to identify clusters of concepts according to their similar semantic information, as recent works using multiple ratings have shown (for examples of data-driven approaches, see § 3.4). Despite their high explanatory power, the findings from dimension rating studies should be taken with caution. Because the dimensions are tested only on single, isolated words, it cannot be excluded that their weight changes or becomes less relevant when the words are embedded in a context, such as in a sentence or a discourse.

Other frequently used methods to study concepts are experimental paradigms in which behavioral data (i.e., response time and accuracy) or neural data (i.e., brain activity) are collected while subjects are engaged in semantic relatedness tasks, such as lexical decision tasks, categorization tasks, property verification tasks, or recognition tasks (see review in Conca et al. 2021). Undoubtedly, these paradigms, carried out in idealized laboratory settings, are essential to isolate and establish causal mechanisms underlying conceptual processing or cognitive abilities in general. In the case of embodied effects, for example, they can provide strong demonstrations that language processing involves sensorimotor simulations and activates modal-brain areas (see the evidence discussed in § 1.2.1 and § 1.2.2). However, much of the effects observed in these studies are based on single words or simple sentences without context, and therefore cannot be generalized to naturalistic language phenomena. This can lead to potentially misguided theories that focus on mechanisms driven by concepts in isolation. Overall, a major limitation of the above methods is that they do not provide comprehensive information about how concepts, and thus word meanings, vary across contexts.

On that note, researchers have developed new methodological measures to detect contextual flexibility. For example, Solomon, Medaglia, and Thompson-Schill (2019) introduced a new feature-based network model that captures the relationship between features within a concept. The statistics encoded in this model are able to predict the measures of conceptual stability and flexibility that correspond respectively to the set of features that are either strongly connected (i.e., core features) or sparsely associated with one another (i.e., periphery features). Crucially, the spread of activation through the network varies according to the appropriate instantiation of concept; for example, features included in the apple network can be flexibly adjusted to represent apple picking (crunchy + fresh) or apple pie (soft + baked).

Other studies largely focused on abstract and concrete concepts representations have used measures extracted from language corpora and norms to quantify contextual variability effects in linguistic tasks. For instance, Recchia and Jones (2012) collected data for a large set of concrete and abstract concepts on *semantic richness* constructs, including the number of features (NF), the number of semantic neighbors (NSN), contextual dispersions (CD) (Pexman et al., 2008; 2013). Examining semantic richness effects on lexical decision data, they found that NF facilitated the processing of the most concrete concepts due to their strong association with physical characteristics of objects; while NSN facilitated the processing of the most abstract concepts for which linguistic associations serve as scaffolds to recognize their meaning (for related works, see Zdrazilova & Pexman, 2013; Muraki et al., 2020).

Similarly, Hoffman et al. (2013) used latent semantic analysis on a large text corpus to estimate *semantic diversity* (SemD), a measure of the variability of the contexts in which a word can be used. This metric is strictly correlated with abstractness: Abstract concepts have significantly higher SemD values than concrete words because they tend to appear in a wider range of linguistic contexts. Notice that others have used the notion of *context availability* (Schwanenflugel, 1991) and, more recently, of *situational systematicity* (Davis et al., 2020) to address the similar idea that abstract concepts evoke more dispersed elements of situations. To illustrate, the word *table* typically occurs in limited contexts related to eating or studying, often in conjunction with words like chair; on the contrary, the word *chance* can refer to lucky or risky situations or to the possibility of doing or achieving something in the future. Indeed, selecting among competing meaning of abstract concepts require higher demands on control processes in semantic comprehension task (Hoffman, 2016).

Even though all these measures provide clues on how words are intertwined with linguistic and situational contexts, I suspect they do not reflect how flexible our concepts are when used in real-world situations. In a nutshell, the methods discussed, despite their specificity, risk overlooking the fact that concepts are comprehended, produced, and used in a social dimension. As we will see below, an appropriate way to address this gap is to start studying concepts in social interactive contexts.

4.3.2 Interactive methods

In the broadest sense, whenever people use language, they are taking a social activity. You can discuss with a friend the best series to watch on Netflix, call up your mum for a recipe, or ask a colleague about his/her research topics. In all these cases, language is more than the sum of speaking and listening; rather, it is a cooperative action that individuals do for a given aim. As convincingly argued by Herbert Clark (1996): "We cannot hope to understand language use without viewing it as *joint actions* built on individual actions. The challenge is to explain how all these actions work (pp. 3-4).

In the last decades, many researchers have taken Clark's hint seriously and started to study verbal communication as it develops in social interactions. It is now recognized that language production and comprehension are tightly interwoven processes, as people engaged in conversation monitor each other's language use and make adaptations to their own speech based on the language used by interlocutors to achieve a common goal of mutual understanding (Pickering & Garrod, 2004). Research adopting this approach has fostered the emergence of novel experimental paradigms based on the assumption that language must be investigated at the level of dyadic interactions (e.g., Barr & Keysar, 2006; Brennan, 2005).

Recent studies on interpersonal coordination in dialogue, for example, used the word-by-word paradigm, a task in which two participants interact to produce a sentence, taking turns for each word (e.g., Himberg et al., 2015; Fjaellingsdal et al., 2020). Main findings showed that joint sentence production entails a prediction of the other's upcoming word; indeed, when such prediction is violated by unexpected words, individuals take longer to generate their own turn (Fjaellingsdal et al., 2020). This confirms that interactive language use requires a constant overlap of language comprehension (predicting what our partner will say) and language production processes (planning and executing an appropriate response). Interestingly, using a similar word-by-word task via a chat-based interface, Lelonkiewicz and Gambi (2020) found that the inter-turn interval between produced words is reduced when two real agents interact but not when the same task is performed by a single person. This result suggests that reducing variability is a coordination strategy used by speakers to make their turns more predictable in order to facilitate successful communication, similarly to the process of mutual coordination observed in joint motor actions (review in Knoblich et al., 2011; Galantucci & Sebanz, 2009).

Another emergent line of research called experimental semiotics (Galantucci, 2009) has begun to investigate how novel forms of communication spontaneously evolve among dyads or groups. Research in this area has introduced tasks that involve gestures, graphical representations, and cooperative games through which participants have to develop an efficient communication system, avoiding the use of pre-existing linguistic symbols (i.e., letters or numbers). Perhaps the most compelling finding of experimental semiotics is that a symbolic system (i.e., signs that bear a conventional relation to their referents) quickly emerges when there is a direct interaction between pairs of agents, while it is not the case when signs are developed by individuals who interact with an offline partner. This provided clear evidence for the crucial role of social interactions in the development of human communication.

In the same vein, neuroscientific research is increasingly focusing on the investigation of cognitive and neural processes within interactive social contexts (i.e., second-person neuroscience; Hasson et al., 2012; Schilbach et al., 2013; Redcay & Schilbach, 2019). Growing numbers of scholars in cognitive, social, and affective science use new naturalistic methods, such as fMRI or EEG hyperscanning techniques, to measure brain activity from multiple participants simultaneously (review in Czeszumski et al., 2020). In particular, studies on verbal communication reported inter-brain synchrony between participants while having a face-to-face dialogue but not in a monolog situation (Jiang et al., 2012). Interestingly, there is also evidence that brain-to-brain synchrony is sensitive to semantic content. For example, a recent study showed that the narration of emotional stories elicited an emotional alignment between speaker and listener that is reflected in selective neural synchronization in regions associated with processing valence and arousal states evoked by the words (Smirnov et al., 2019).

These novel interactive behavioral and neuroscientific paradigms could be useful tools for research on concepts allowing researchers to analyze their features not as isolated items but in light of the social dynamics in which language is fundamentally embedded. This seems even more crucial in the case of abstract concepts, which are strongly influenced by social aspects of language use both during acquisition and processing (see Chapter 2, § 2.4).

So far, only a few studies have investigated differences between abstract and concrete concepts in interactive settings. An example is a recent study by Zdrazilova, Sidhu, and Pexman (2018), who exploited a modified version of a communicative game to investigate the type of information people generated in order to convey the meaning of an abstract or concrete word to a partner. The study consisted of a "Taboo" task in which pairs of participants took turns helping their partner to guess an abstract or a concrete word, without using the word itself. The authors then examined both verbal language and gestures associated with the different kinds of concepts. Analysis of speech production corroborates previous findings that participants used objects and entity relations to describe concrete words, while with abstract concepts, they produce more frequently introspective expressions, referring to people and their roles in situations. In addition, gestures analysis revealed that abstract concepts evoke more metaphorical and beat gestures and less iconic gestures than concrete concepts. For example, to convey the meaning *of beverage*, participants often depicted the actions of drinking something from a container; instead, when communicating *decision* some participants moved one hand upward and the other downward like a seesaw to convey the idea that one has to weigh something carefully.

Other works that implemented interactive paradigms provided initial evidence that linguistic exchanges involving abstract concepts increase cohesion between interlocutors. In the already mentioned study of Fini et al. (2020) (for details, see § 2.3.2), participants performed a guessing task receiving suggestions from two experimenters, one for abstract words and one for concrete words. Then, they were invited to perform a joint motor task with an avatar that embodied the experimenter while their movements were measured through kinematic techniques. Results showed that participants asked for more hints with abstract than concrete words, and the need for others' help prompted them to act more in sync with the Avatar associated with the person who gave them suggestions on abstract concepts than concrete words.

In another study, Fini and colleagues (in preparation) used the Inclusion of Other in the Self Scale (IOS) to measure the psychological distance between interlocutors who were engaged in a conversation through an online platform starting from abstract and concrete words. Participants performed the task either in dyads (social condition) or independent sections (individual condition). Preliminary results showed that psychological closeness is higher when participants were conversing with a confederate compared with the condition in which they were not conversing. In social conditions, conversations on abstract topics were perceived as more demanding as compared to conversations on concrete topics. Further, the more participants rate the other's contribution as relevant to the conversation about abstract concepts, the more she/he felt psychologically close to the interlocutor, while this was not the case for conversation cued by concrete concepts. These findings are consistent with the idea of "social metacognition" advanced by Borghi et al. (2018, 2020, 2021) that processing complex abstract meaning might require deferring on others to dispel ambiguities; hence speakers prepare themselves for a constructive dialogue to negotiate a common reference of knowledge, and this seems to enhance both physical and mental synergy between agents.

Interactive paradigms such as those described have the advantage of analyzing how concepts are actually used in situational interactive contexts and bringing out their pragmatic functions. Ultimately, they open up new possibilities for carefully examining which dimensions are relevant for understanding the meaning of abstract and concrete concepts during real conversations and linguistic interactions.

4.4 Fourth remark: Taking context into account is better than ignoring it.

The literature reviewed in this chapter reveals the flexible, context-sensitive, and experience-depended nature of our conceptual representations. Concepts are not uniform, universal constructs but vary dynamically in functions of a significant amount of contextual information tied to the experience, including elements of physical context, linguistic and cultural environments, as well as the people's prior knowledge. Even though variability and flexibility can be considered the hallmark of all concepts, current evidence suggests that the content underlying the meaning of abstract concepts varies more than that of concrete concepts, not only across languages and cultures but also across individuals. Indeed, whereas the referents of concrete words such as *chair* or *bottle* remain relatively stable across different physical and social environments, the events, situations, and internal states described by abstract words such as *justice* or *freedom* tend to change over time and to be redefined in light of sociocultural developments and personal life experiences. Thus it stands to reason that different people have idiosyncratic representations related to abstract concepts (for similar arguments, see Falandays & Spivey, 2019; Troyer & McRae, 2021).

A more general and yet very useful framework to explain the interplay between abstract/concrete concepts and contexts is the notion of *situated conceptualization*, recently proposed by Barsalou (Barsalou et al., 2018; see also Barsalou, 2015; 2020). Conceptualizations can be understood as more flexible than concepts, as they emerge from the integration of knowledge derived from the processing of elements in a situation and from self-relevant prior experiences that allow to categorize and explain the current situation, predict likely events in it, and to select actions that produce appropriate outcomes (Barsalou et al., 2018, p. 2). Importantly, this proposal suggests a revision of the standard division between abstract and concrete concepts in favor of more flexible conceptualizations. At a general level, processing of concrete concepts involves elements external to the individual, such as settings, objects, agents, and actions; whereas processing of abstract concepts usually emerges from elements internal to an individual, such as goals, values, beliefs, and emotions, or from the integration of the relationship between internal and external elements, especially in complex situations. However, even though there are major differences between these general domains, both internal and external situational elements are typically co-activated for all concepts kinds. Thus, depending on specific situations, conceptualization may reflect “more abstract” or “more concrete” components of a given entity, regardless of its specific construction. A “concrete” entity such as “sofa” can be associated with color or materials (yellow, leather) but also with goals (resting) or emotions (comfort); on the other hand, an “abstract” entity or event such as “justice” can refer to mental states and emotions (the belief of doing the right thing) as well as to physical actions (prisoners being released) or concrete aspects of situations (equal opportunities for education and employment regardless of race, gender, ethnicity, etc.). As defined by Barsalou (2015), situational conceptualizations establish associative networks in long-term memory that people retrieve to interpret current and future events. This view can offer an account for individuals and groups differences, as it is likely that people accumulate different memories of specific phenomena that lead to different conceptualizations. In this regard, the high variability of abstract concepts could be due to the extent to which they reflect individual habitual conceptual patterns for processing elements that are less integrated into the immediate external/physical contexts, rather into social, linguistic, and cultural practices that they are more flexible and able to change frequently.

Whereas at the theoretical level the influence of contextual elements on abstract concepts representation is widely recognized, the empirical methods used to investigate them often overlook this crucial aspect. As discussed in section § 4.3, most of the studies so far have investigated them in isolated conditions, out of context. Typically, researchers use single words or simple sentences presented in a computer-based format and infer the underlying conceptual representation from behavioral and/or neural measures of the information elicited by these stimuli. Certainly, these experimental approaches are useful to examine the semantic proprieties and dimensions that characterize different kinds of concepts. However, studying concepts in isolation might lead to incomplete or misleading accounts for at least three reasons.

First, as many authors noted, studying conceptual processing only on single words risks assuming that some kind of “default” (static) representation related to word meanings exists and is automatically activated, independently from the context. On the contrary, the words’ meaning is inextricably interwoven with the situations in which they occur, and conceptual representations flexibly adapt to support actions in the ongoing context (Barsalou et al., 2018; Lebois et al., 2015; Yee & Thompson-Shill, 2016; Casasanto & Lupyan, 2015). Second, as mentioned earlier, single words can be conceptualized more concretely or more abstractly, depending on the kinds of situational elements that are relevant in a specific setting. Thus, studies that do not take into account the critical dependence between concepts and contexts in which they are acquired, retrieved, and used might remain anchored to the artificial distinction between abstract and concrete concepts, omitting the variability entailed in their domains, whose boundaries shift depending on the situations to be interpreted and individual goals and beliefs. Finally, studies that focus on decontextualized words and individual conceptual processing fails to provide an accurate account of how concepts are used in their natural form.

In other words, they do not sufficiently consider the fact that language and concepts operate in a social environment, namely in discourse contexts (Borghi, 2020).

Nowadays, several authors increasingly argue that it is important, if not essential, to move beyond single words studies and focus on real-time words processing in a more naturalistic setting. Promoting the use of interactive methods to study concepts could allow for careful investigation of word production and comprehension processes in the dynamics of real dialogues and conversations, as recent works using interactive paradigms have shown (§ 4.3.2). Note that this does not mean that the current findings from studies based on traditional methods, such as ratings or features listings, should be discarded. Rather, they can be used to formulate predictions about the relevant dimensions that might characterize conceptual processing in ecological situations, and they can likely be integrated with other psycholinguistic variables to assess the pragmatic elements of language. In keeping this view, I believe that the study of (abstract) concepts in interactive social contexts could represent a promising step for driving the field forward. As Barsalou stated: “We will establish a more complete understanding of concepts if we study them in the context of *situated action* […] i.e., not only mean action *per se*, but all the cognition that supports it, including the comprehension of situations and the production of predictions that make human action possible.” (Barsalou et al., 2018, p. 1-2).

PART II

EXPERIMENTAL EVIDENCE

Part II Outline

In this work, I address the issue of abstract concepts for theories of conceptual representation, with a special focus on Embodied and Grounded Cognition (EGC) approaches. In the first part, I have reviewed the most influential proposals on abstract concepts advanced in EGC framework and outlined new research trends in this area. I have argued for Multiple Representation Views, in particular the Words as Social Tools (WAT) theory, to account for abstract concepts representation in their varieties and flexibility. Drawing on the previous discussion, I pinpoint three main considerations.

(1) The simple notion of "abstract" concepts should be rethought in light of their multidimensionality and heterogeneity. A more fine-grained definition might result from differentiating the abstract domain into subclusters, which would span over a semantic space in which embodied/physical (perception and action), internal (emotion, interoception, metacognition), and linguistic/situated (language, sociality) dimensions coexist but assume a different weight depending on the concept kinds.

(2) Although all concepts vary as a function of contextual factors, abstract concepts are more variable than concrete concepts across individuals and situations. Therefore, individuals that have developed expertise in a specific domain of abstract concepts might rely on a different set of dimensions and situational elements to represent them.

(3) Given that the high complexity and indeterminacy of abstract concepts meaning might require a strong reliance on other's knowledge, investigating them in interactive paradigms would be the most ecological setting to better understand how we convey their meaning during linguistic exchanges.

The second part of this dissertation comprises five experimental studies inspired and supported by these claims.

Chapter 5 reports evidence on different kinds of abstract concepts and their grounding sources (point 1). Using multiple ratings on a large sample of abstract words, we identified four distinct clusters according to their dominant latent factors (Study I). To further validate this classification, we used an interference paradigm in which interoception, sensorimotor, and linguistic experience were engaged during a difficult rating task on a subset of words selected within the four clusters of abstract concepts and well-known categories of concrete concepts (Study II).

Chapter 6 presents studies that zoom in on the role of expertise and situational contexts in shaping concepts, using institutional concepts as a case study (point 2). The previous rating study was extended to people with different levels of law expertise to examine how individual experiences affect the representation of institutional concepts (Study III). In a picture priming study, we investigate how linguistic and social situational primes affect the extent to which law experts and laypeople process institutional concepts (compared to theoretical abstract concepts, tools, and foods concepts) (Study IV).

Chapter 7 introduces a new interactive paradigm to investigate concepts in a communicative context (point 3). Specifically, abstract and concrete sentences were used as cues to simulate a conversation with a partner to explore whether the semantic contents and conversational dynamics evoked vary with the type of sentences (Study V).

CHAPTER 5

KINDS OF ABSTRACT CONCEPTS

STUDY I

Varieties of abstract concepts and their multiple dimensions [12]

Introduction

The capacity to learn and use abstract concepts (from now ACs), such as “freedom”, is one of the most remarkable human abilities. ACs are ubiquitous, and they represent a great part of our speech (Lupyan & Winter, 2018). In the following we will use the working definition of ACs proposed by Borghi and Binkofski (2014): compared to concrete concepts (from now CCs), ACs typically lack a single object as referent, they are more detached from sensory modalities (Barsalou, 2003), and they refer to more complex situations in which multiple objects/entities are present (Pulvermüller, 2018b). Notice that here we will focus on abstractness and not on abstraction (Borghi et al., in press), i.e. on “truly” ACs (e.g. “freedom”). We thus avoided using general concepts, such as superordinate ones (e.g. “animal”), because they have concrete denotations, i.e. refer to a variety of concrete exemplars (e.g. “lions”, “dogs”, “birds”). In our view CCs and ACs are not dichotomously opposed: concepts typically have both abstract and concrete features, even if in different proportions (Wiemer-Hastings, Krug, & Xu, 2001).

The interest for ACs representation is growing in both psychology and cognitive and social neuroscience (see special issues, Bolognesi & Steen, 2018; Borghi, Barca, Binkofski, &

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[12] This paper was published on *Language and Cognition*, and can be accessed through this link: doi:10.1017/langcog.2019.23

Tummolini, 2018b). However, current literature is afflicted by two main limitations. The first is the tendency to consider ACs altogether, without taking into account their distinctions; the second is that there is no uniformity in the criteria adopted to select them. We will address these two issues separately.

ACs are not a monolithic whole but many kinds of ACs exist.

Traditional views both assumed the existence of a dichotomy between CCs and ACs, and also treated ACs as a monolithic whole. This is striking, especially in consideration of the long-lasting interest for sub-kinds of CCs. Since the seminal work of Warrington and Shallice (1984), many neuropsychological studies on CCs have been dedicated to investigate double dissociations such as that between concepts of living and non-living entities (review: Humphreys & Forde, 2001). Conversely, only recently behavioral and neuroscientific studies are starting to consider how different kinds of ACs are represented.

On the behavioral side, results of a rating task showed that emotional, math-related and mental states concepts differently engage the mouth and the hand effectors (Ghio, Vaghi, & Tettamanti, 2013; see also Ghio, Haegert, Vaghi, & Tettamanti, 2018). Evidence with feature production tasks further pointed out the differences between ACs. For example, Setti & Caramelli (2005) highlighted the differences in the conceptual relations evoked by concepts of nominal kinds (e.g. “error”), states of the self (e.g. “worry”), cognitive processes (e.g. “memory”), and emotions (e.g. “fear”). A study by Roversi, Borghi, and Tummolini (2013) showed that the abstract-concrete distinction is more marked within social than institutional and artefact concepts. A cluster analysis (Harpaintner, Trumpp, & Kiefer, 2018) revealed different kinds of ACs, grouped on the basis of the dominance of the considered features.

Finally, evidence was reported, suggesting that emotion concepts are peculiar with respect both to CCs and to ACs: they are typically processed faster and recalled better than CCs but worse than ACs, they elicit different kind of relations and they are acquired earlier than ACs (Altarriba, Bauer, & Benvenuto, 1999; Altarriba & Bauer, 2004; Barca, Mazzuca, & Borghi, 2017; Ponari, Norbury, & Vigliocco, 2018; Mazzuca, Lugli, Benassi, Nicoletti, & Borghi, 2018). As to the neural underpinnings of different ACs, fMRI evidence (Mellem, Jasmin, Peng, & Martin, 2016) showed that specific neural networks are engaged for social concepts processing, for number processing and for abstract emotional words (Dreyer et al., 2015; Moseley, Carota, Hauk, Mohr, & Pulvermüller, 2011). Desai, Reilly, and van Dam (2018) investigated the neural bases of number and emotional concepts, and of two higher order concepts, i.e. morality judgments and theory of mind: they demonstrated that each of the four kinds of concepts engage overlapping but also unique areas. Altogether, these studies suggest that ACs can be quite different from one another. Even though studies have started to explore ACs and their differences, so far no systematic attempt has been made to investigate the fine-grained distinctions between kinds of ACs. The first aim of our paper is to fill this gap identifying how different kinds of ACs are represented. To this end, we systematically scrutinized a high number of Italian ACs, asking participants to rate them on many dimensions.

ACs cannot be identified solely on the basis of concreteness or of imageability ratings.

The results of the numerous studies on ACs are sometimes difficult to compare, because of the different criteria adopted to identify them and because many dimensions are correlated. Stimuli are often selected on the basis of abstractness and concreteness ratings, but in some databases these ratings are provided on a single scale (e.g. Paivio, 1991; Barca, Burani, &

Arduino, 2002), in others on two different scales (e.g. Della Rosa, Catricalà, Vigliocco, & Cappa, 2010). Furthermore, sometimes concreteness and abstractness are not explained, sometimes defined in different ways: for example, Brysbaert, Warriner, & Kuperman (2014) defined abstract words as having “meanings that cannot be experienced directly but which we know because the meanings can be defined by other words” (p. 906), and concrete words as words that “refer to things or actions in reality, which you can experience directly through one of the five senses” (p. 906); in contrast, Juhasz & Yap (2013) operationalized this distinction in terms of “the extent to which a word evokes a sensory and/or perceptual experience” (p. 160); importantly the results obtained are only mildly correlated (r = .4) (Lupyan & Winter, 2018). Furthermore, for some years stimuli were selected on the basis of imageability ratings, implicitly equating abstractness with low imageability. This choice was primarily due to the influence of the Dual Coding Theory proposed by Paivio, according to which abstractness was explained by low imageability. In reality, abstractness is highly correlated but not equivalent with imageability (Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2011).

To render things more complex, Connell & Lynott (2012) have recently shown with a sample of both concrete and abstract English words that the concreteness effect is explained better by perceptual strength of the each of the five senses separately, than by concreteness and imageability. In sum: ACs and CCs cannot be explained exclusively in terms of their difference in abstractness/concreteness and imageability. Rather, we are inclined to think that the best way to represent concreteness/abstractness is a multidimensional space, in which different concepts are distributed as a function of their similarity along a variety of dimensions (Crutch, Troche, Reilly, & Ridgway, 2013; Troche, Crutch, & Reilly, 2017).

To make a long story short: the distinction between CCs and ACs is far from being clear-cut, and deserves further scrutiny. Furthermore, we have seen that relying solely on abstractness/concreteness norms or alternatively on imageability norms has many limitations, and that previous studies are sometimes difficult to compare because of the different adopted criteria. Collecting norms in which different dimensions aside concreteness-abstractness and imageability are introduced is thus pivotal, in order to investigate in depth the subtle nuances that might distinguish different kinds of abstract concepts. Given the theoretical relevance of this challenge, our work offers both a methodological and a theoretical contribution. We will address them in sequence.

Methodological contribution.

Our study will assess how ACs are represented using ratings on many dimensions. Compared to previous ones, our study a) presents many more semantic dimensions, b) it is exclusively focused on ACs.

a) To our knowledge no database so far includes so many rated dimensions as the present one. As to Italian databases, the two more used in this area are those by Barca et al. (2002) and by Della Rosa et al. (2010). Barca et al. (2002) provide norms and response times for 626 Italian concrete and abstract nouns. Their norms include many psycholinguistics variables (e.g. adult/child written frequencies, adult spoken frequency, length in syllables and letters, lexical stress), while the semantic variables which are more relevant to us, aside familiarity, are concreteness/abstractness (computed on a single scale), imageability and Age of Acquisition (AoA). Della Rosa et al. (2010) provide norms on 417 Italian words, both concrete and abstract, on a number of semantic variables relevant to define abstractness: aside familiarity, they are concreteness and abstractness (separately computed), imageability, contextual availability, Age of Acquisition (AoA) and Modality of Acquisition (MoA). A third database, which is less directly relevant to our work, is by Montefinese, Ambrosini, Fairfield, & Mammarella (2014) who provided affective norms for 1,121 Italian words, taken either from Affective Norms for English Words (ANEW; Bradley & Lang, 1999) or from Italian semantic norms (Montefinese, Ambrosini, Fairfield, & Mammarella, 2013).

b) The present database differs from previous ones also because it is exclusively focused on ACs. We decided to use only ACs in order to capture even subtle differences among them, and to identify sub-kinds of ACs through cluster analysis. Hence, we took into account the evaluation of participants rather than principled, a priori determined categories (for a study in which we verify how the rated dimensions fitted with a-priori determined categories, see Villani, Lugli, Liuzza & Borghi, in press).

Theoretical contribution.

The major novelty of our work is theoretical. Aside more traditional dimensions, the novel dimensions we introduced were selected based on the theoretical predictions of multiple representation theories on ACs. We believe that the most promising development in recent research on ACs has been the spread and success of these views (review in Borghi et al., 2017). According to them, ACs are grounded in sensorimotor system, similarly to CCs (Cuccio & Gallese, 2018; Pulvermüller, 2018a), but they also involve linguistic experience (Borghi & Binkofski, 2014; Dove, 2010; 2014; 2016; 2018; Lupyan & Winter, 2018; Recchia & Jones, 2012), social experience (Borghi, Barca, Binkofski, & Tummolini, 2018a; Borghi et al., in press), emotional experience (Vigliocco, Kousta, Vinson, Andrews, & Del Campo, 2013;

Vigliocco et al., 2014; Newcombe, Campbell, Siakaluk, & Pexman, 2012) and other inner experiences (interoception, introspection, metacognition) (Barsalou & Wiemer-Hastings, 2005; Dellantonio, Mulatti, Pastore, & Job, 2014).

The WAT (Words As social Tools) theory, a multiple representation view that we have recently proposed (Borghi & Binkofski, 2014; Borghi et al., 2018a; Borghi et al., in press), ascribes a major role to language and sociality. Specifically, it hypothesizes that more ACs are mainly linguistically acquired and induce in us a higher necessity to rely on others, because of their complexity and the feeling that our competences are inadequate (Shea, 2018). We will detail below the main dimensions we asked participants to rate, and the theoretical reasons underlying our choice.

The dimensions we considered.

In our study we presented 425 Italian abstract words to 304 participants, and asked them to evaluate them on a 7-point-scale on a variety of dimensions. Among the dimensions, first we included the most classical ones, that are typically used to select ACs: abstractness/concreteness, imageability (Paivio, 1991; Paivio, Clark, & Khan, 1988), and context availability (Schwanenflugel, Akin, & Luh, 1992). Notice that ratings on imageability and context availability were initially introduced to test the two more influential classical theories on ACs, i.e. the dual coding theory (DCT, Paivio, 1991) and the Context Availability Theory (CAT, Schwanenflugel, Akin, & Luh, 1992). According to DCT, ACs are processed and recalled better than CCs because they are more imageable, while, according to CAT, ACs are characterized by a lower number of associated contexts than CCs. Beyond these usually tested dimensions, we introduced novel dimensions based on predictions of multiple representation views. Some of these dimensions (e.g., metacognition, social metacognition) have never been used to classify ACs. We will describe them below.

Sensorimotor experience. To determine to what extent different kinds of ACs are grounded in sensorimotor experience, we asked participants to rate the perceptual strength of the 5 perceptual modalities and the extent to which each concept activates Body-Object-Interactions (BOI: Tillotson, Siakaluk, & Pexman, 2008; Siakaluk, Pexman, Aguilera, Owen, & Sears, 2008; Bennett, Burnett, Siakaluk, & Pexman, 2011). For perceptual strength we used the formulation of Lynott and Connell (2013), who obtained norms on 400 words on perceptual strength, and of Connell and Lynott (2012); while for Body-Object-Interaction (BOI) we used the formulation of Bennett et al. (2011), who collected imageability and BOI ratings for 599 multisyllabic English nouns.

Linguistic experience. We included two dimensions related to word acquisition, i.e Age of Acquisition (AoA) (Gilhooly & Logie, 1980) and Modality of Acquisition (MoA) (Wauters, Tellings, Van Bon, & Van Haaften, 2003; Wauters, Van Bon, & Tellings, 2006). These dimensions are critical for ACs, because we hypothesize that they are acquired later and more linguistically than CCs (Borghi & Binkofski, 2014).

Inner experience. We included the dimensions of emotionality, interoception and metacognition. Emotionality is crucial for two reasons: because according to a recent theory emotionality characterizes ACs more than CCs (Vigliocco, et al., 2013; Vigliocco et al., 2014); and because we intend to test the hypothesis that emotionality is more crucial for some ACs, i.e. the emotional ones. We also asked participants to rate the role of interoception i.e. awareness of inner body states (Connell, Lynott, & Banks, 2018) and of general metacognition, i.e. awareness of inner processes.

*Social experience.*We included two dimensions that pertain the social dimension: social valence (Barsalou & Wiemer-Hastings, 2005; Barsalou, Dutriaux, & Scheepers, 2018) and social metacognition. Recently we distinguished between general and social metacognition – the first notion refers to the awareness of inner processes, the second to the need to rely on others in order to complement our knowledge because we are aware of the inadequacies of our concepts (Borghi et al., 2018b; Shea, 2018).

Hand and mouth effectors. We asked participants to rate to what extent concepts involve use of the hand and the mouth. Recent evidence has indeed shown that the processing of ACs overall and particularly of very abstract ACs, such as mental states ones, involves the mouth motor system. Conversely, processing of CCs involves more the hand (Barca, Mazzuca, & Borghi, 2017; Borghi & Zarcone, 2016; Ghio et al., 2013; Dreyer & Pulvermüller, 2018).

Hypotheses

We formulated two hypotheses. The first concerns the relationships between the considered dimensions, the second is exploratory and regards the way in which from our data clusters referring to different kinds of ACs are obtained.

1) Relations between the rated dimensions. If ACs rely more than CCs on linguistic and social experience, then more ACs should be less related to sensorimotor and inner grounding (lower level of emotionality, Body-Object-Interaction, and perceptual modality strength) while they should be more related to linguistic and social experience. Specifically, we predict that more ACs would be acquired mostly linguistically (Modality of Acquisition) and, owing to their complexity, would rely to a larger extent on competence of others (social metacognition). We also predict that, within ACs, the more concrete ones would

evoke more bodily interactions with objects, while the more ACs would elicit more inner processes, particularly less embodied inner processes (metacognition more than interoception).

2) Kinds of ACs. We are interested in determining the latent variables underlying our data, and to identify how ACs group into distinct clusters. We thus performed an exploratory factor analysis in order to reduce the number of weakly correlated dimensions, and further cluster analyses that allowed us to verify how different concepts group together. Given the exploratory character of the analyses, we formulated only very general predictions. We predict that the degree of embodiment influences organization in clusters: there might be more embodied ACs, such as emotional and physical concepts, and less embodied ones, like institutional or philosophical ACs. Within more embodied ACs, we are interested in determining if some concepts are more grounded than others in exteroceptive and interoceptive experience. Within less embodied ACs, we are especially interested in determining the role of linguistic and social dimensions (MoA, social metacognition) in influencing clustering of concepts.

Method

Participants

304 participants (191 females, M age = 28.38, SD age = 8.77) volunteered for the study. Participants were not younger than 18 and their had either a middle or high education level: 216 declared to possess a degree, 88 a high school diploma. Every participant rated ACs only on one dimension. Every dimension was thus rated by at least 20 participants.

Materials

We selected 425 Italian nouns. These words include 286 words present in existent Italian databases on CCs and ACs and other 139 words. We selected only abstract nouns, trying to include concepts belonging to different categories (e.g. social, temporal, spatial, institutional, emotional concepts). In determining whether a word was abstract or not we used the criterion of abstractness introduced at the beginning of the paper. As anticipated in the introduction, to our knowledge two databases of Italian words are very relevant for us. From the Della Rosa et al. (2010) database we considered 200 abstract words selected for their values of abstractness [mean: 486; SD: 75; from 212 (i.e. “family”) to 635 (i.e., “concept”) of threshold in a range from 100 (less abstract) to 700 (more abstract)]. From the Barca et al. (2002) database we considered 86 words selected for their values of concreteness/abstractness [mean: 4.13; SD: 0.87; from 2.14 (i.e., “progress”) to 6.07 (i.e., “money”) of threshold in a range from 1 (highly abstract) to 7 (highly concrete)]. In selecting the remaining 139 words, we took care that all the 3 experimenters who evaluated them judged them as highly abstract. It is worth noting that the researchers' evaluation will be supported by the participants' rating: the mean values of abstractness was 3.99 (SD = 1.03), from 1.38 (i.e., “hole”) to 6.43 (i.e., “absolute”) of threshold in a range from 1 (less abstract) to 7 (highly abstract).

The sample we used might appear small, but it is larger than that of previous Italian databases, that included both CCs and ACs (Barca et al., 2002: 626 words, Della Rosa et al., 2010: 417 words), and similar to other English databases focusing only on ACs (e.g. Connell & Lynott, 2012; Lynott & Connell, 2013: 400 and 592 words, respectively) considering also that the English vocabulary is much broader than the Italian one.

Procedure

Participants were submitted to an online form (Google Forms) and were presented with the 425 words in a randomized order. They had to evaluate on a 7 point Likert scale the following 15 dimensions: concreteness (CNR); abstractness (ABS); imageability (IMG);

contextual availability (CAT); Age of Acquisition (AoA); Modality of Acquisition (MoA); Body-Object-Interaction (BOI); emotionality (EMO); perceptual strength in the five perceptual modalities (VISION; TOUCH; HEARING; SMELL; TASTE); interoception (INT); metacognition (META); social metacognition (MESO); social valence (SOCIAL); mouth involvement (MOUTH); hand involvement (HAND). We asked participants to provide evaluations of abstractness and concreteness without providing them with a definition of CCs and ACs, in order to avoid biasing them and to get a sense of how they spontaneously represent these categories. As described below, the ratings provided were highly consistent with those of the two previously discussed database. Notice that perceptual strength is considered as a single dimension, but it pertains the five sensory modalities.

Statistical analysis.

We analyzed our data using RStudio (version 1.1.453; RStudio-Team, 2015) and R (R-Core-Team, 2018). Concepts represented our units of analysis and we thus computed the average rating for each concept on each dimension and standardized them. In order to evaluate the level of agreement among the raters, we conducted an Intra Class Correlation analysis on the Concreteness and Abstractness ratings, which are the ones that we suspect that might have been evaluated most idiosyncratically. We found that, having the goal to use the average rating, we observed good agreement on the Concreteness (ICC(2, K) = .73.) ratings, and an excellent agreement (ICC(2, K) = .84.) on the Abstractness ratings. Moreover, we assessed whether the ratings provided by our participants on the same target words for the same dimensions (Abstractness and Concreteness) converged with the ratings provided by the pool from Della Rosa et al. (2010). We found a strong correlation in both dimensions (Pearson's rs >= .7, ps <

.001). We also found a milder (Pearson's r = .31) but statistically significant (p = .01) correlation between the concreteness ratings provided by our pool and the ones provided by the pool from Barca et al. (2002).

We conducted our analyses on the zero-order correlations by computing the Pearson's r correlation coefficient for each bivariate correlation across the rated dimensions using the Hmsic R package (Harrell Jr & Harrell Jr, 2018) and displayed them hierarchically clustered on a correlogram using the R package corrplot (Wei & Simko, 2017).

The main aim of our study was to identify clusters of ACs based on their Euclidean distance on the dimensions assessed, an analytical strategy that echoes the one adopted by Harpaintner and co-authors (Harpaintner, Trumpp, & Kiefer, 2018). A high level of correlation across dimensions may hamper the cluster analysis because two or more conceptually similar dimensions may weight twice, whereas they may be reduced to a unique component score. Therefore, we first reduced the number of dimensions using a Principal Component Analysis (PCA) approach using the R package psych (Revelle, 2017). Since we did not assume components to be orthogonal, components were rotated using an oblimin procedure, and component scores for each component were computed using the regression method. The use of the oblimin rotation was motivated by the fact that psychological/psycho-linguistics dimensions are often correlated, and therefore orthogonality is likely to be an unrealistic assumption. On top of that, CA requires only a lack of strong correlations, not a total lack of correlation, across variables.

Finally, because hierarchical procedures leave room to subjectivity, we chose to adopt a k-mean method, a partitioning method based on distance. We used Euclidean distances as a measure of distance because a) it is suited to interval type variables such as component scores

b) its interpretation is quite straightforward and it is typically chosen as the standard measure of distance (Everitt, Landau, Leese, & Stahl, 2001) in psycholinguistics (e.g., in Harpaintner et al., 2018). In order to determine the optimal number of clusters, we used the R package NbClust (Charrad, Ghazzali, Boiteau, & Niknafs, 2014), which provides 26 indices, such as Calinski and Harabasz index and Silhouette index. We set two as the minimum number of clusters and ten as the maximum number of clusters, and selected k-means as the clustering method.

Results

1) Relations between the rated dimensions.

In order to address the relations between the rated dimensions and how they account for the concreteness/abstractness of concepts, we will first discuss the correlations between abstractness, concreteness and the other considered dimensions, then illustrate how PCA analysis led to the emergence of a 3-components solutions.

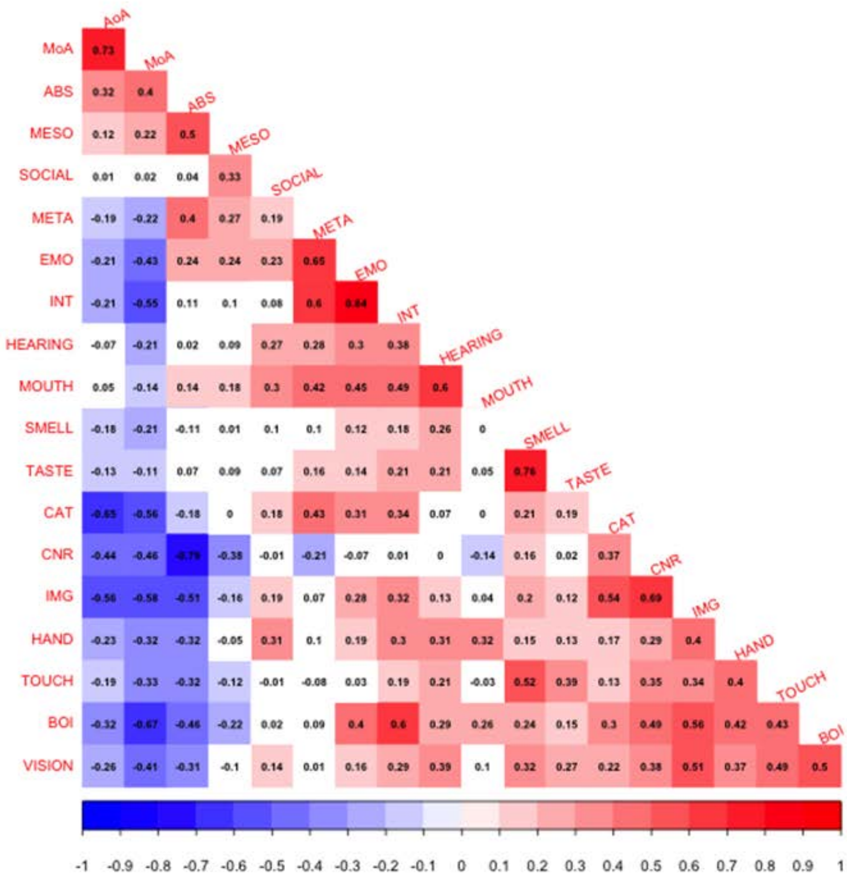

Figure 1. Correlogram with the zero-order correlations across dimensions. Colors represent the strength of the association (red = positive, blue = negative). Pearson's r correlation coefficients are reported at the center of each tile. Blank tiles represent non-significant correlations at an alpha level of .05 after correcting for multiple comparisons (Bonferroni correction). Abbreviations: concreteness (CNR); abstractness (ABS); imageability (IMG); contextual availability (CAT); Age of Acquisition (AoA); Modality of Acquisition (MoA); Body-Object Interaction (BOI); emotionality (EMO); perceptual strength in the five perceptual modalities (VISION; TOUCH; HEARING; SMELL; TASTE); interoception (INT); metacognition (META); social metacognition (MESO); social valence (SOCIAL); mouth involvement (MOUTH); hand involvement (HAND).

As it can be seen from the correlogram (Figure 1), abstractness has a positive correlation with social metacognition (r = .5), MoA (r = .4) and metacognition (r = .4), emotionality (r = .24) and mouth (r = .14). This pattern confirms our predictions, derived by WAT: ACs are grounded in linguistic and social experience (MoA, social metacognition) and evoke also inner processes (metacognition and emotion, but interestingly not the more embodied interoception); finally, the activation of language may occur through inner talk (mouth). This analysis also confirms the role of emotionality for ACs, in line with Affective Embodiment Account (AEA: Kousta et al., 2011; Vigliocco et al., 2013). As to negative correlations, abstractness is negatively correlated first with concreteness (r = -.79), then with imageability (r = -.51), BOI (r = -.46), hand (r = -.32), touch (r = -.32), vision (r = -0.31), and CAT (r = -0.18). Concreteness is positively correlated with IMG (r = .69), BOI (r = .49), vision (r = .38), touch (r = .35), hand (r = .29), and smell (r = .16), while it is negatively correlated with abstractness (r = -.79), then with MoA (r = -.46), AoA (r = -.44), social metacognition (r = -.38), metacognition (r = -.21) and mouth (r = -.14).

Overall, from the analyses on correlations we can conclude that more ACs are mainly characterized in terms of linguistic, social and inner experience (metacognition and emotion), and are considered as associated to the mouth effector. At the same time, they are characterized by the absence of exteroceptive experiences, such as visual and tactile/manual interactions with external objects. Conversely, less ACs elicit higher perceptual strength ratings in touch, vision and also smell, are associated with the hand and not with the mouth, and have low levels of linguistic, social and inner states properties. The results clearly confirm our predictions.

From a deeper reading of the correlogram displayed in Figure 1 through the corrplot R package (Wei & Simko, 2017), it is apparent that some dimensions hold a significant degree of shared variance, hinting that there might be latent factors that may account for similarities/dissimilarities across dimensions. A further exploration of the factor structure underlying the way the words were rated on several dimensions may serve a two-fold purpose: 1) exploring whether dimensions belong to the same underlying factor may provide some clues on which are the relevant macro-dimensions that organize the semantic processing of abstract words (hypothesis 1); 2) using the factor scores for each underlying factor may facilitate the identification of clusters of abstract words (hypothesis 2), as one of the requirements for conducting a cluster analysis is to use variables that are not highly correlated (Barbaranelli, 2007). In order to determine the appropriate number of components to extract, we ran a parallel analysis (PA) implemented in the psych package (Revelle, 2017) in R. PA "compares the screen of components of the observed data with that of a random data matrix of the same size as the original" (Revelle, 2017). PA based on PCA identified a three component solution, which was further explored using an oblimin rotation, to improve the interpretability of the results. After exploring the dimensions that loaded > |.3|, which can be interpreted as a medium effect size (Cohen 1988) into each of the three components, we named the components as follows: "Concreteness/Abstractness", "Inner Grounding and Social", "Sensorimotor" (see Table 1).

These components, combined, explained the 56% of the variance. The component "Concreteness/Abstractness" included the dimensions more associated to the way participants evaluated a word as concrete or abstract (in our case the two ratings were separate, but a single component grouped them); the second "Inner grounding and Social" mainly included dimensions referring to inner bodily and mental states - interoception, emotionality, metacognition, and mouth -, together with sociality. The "Sensorimotor" component included sensory modalities and the hand dimension. Interestingly, if we consider mouth and hand effectors, we can notice that the mouth is included in the "Inner grounding and Social" component, the hand in the "Sensorimotor" component, more related to external grounding. Moving from this component solution, we computed its relative component scores using the regression method. The three factor scores displayed negligible (a correlation coefficient r = .08 for the association between "Concreteness/Abstractness" and "Inner grounding and Social") to small correlation coefficients (a correlation coefficient r = .25) for the association between Concreteness/Abstractness and "Sensorimotor"). We will then use these scores to conduct our cluster analysis to unveil the different kinds of ACs that can be inferred from our rating data.

	CON	IG/SOC	SENS
ABS	-0.76	0.43	
CNR	0.83		
AoA	-0.72		
IMG	0.78		
BOI	0.62		
EMO		0.86	
MoA	-0.78	-0.35	
INT		0.80	
VISION	0.37		0.52
TOUCH			0.71
HEARING		0.43	0.47
SMELL			0.82
TASTE			0.78
SOCIAL		0.33	
META		0.83	
HAND	0.32		0.36
MOUTH		0.65	
CAT	0.58	0.39	
MESO	-0.49	0.41	

Table 1. The 3 components solution, with the dimensions that loaded > |.3|into each of the three components. Abbreviations dimensions: concreteness (CNR); abstractness (ABS); imageability (IMG); contextual availability (CAT); Age of Acquisition (AoA); Modality of Acquisition (MoA); Body-Object Interaction (BOI); emotionality (EMO); perceptual strength in the five perceptual modalities (VISION; TOUCH; HEARING; SMELL; TASTE); interoception (INT); metacognition (META); social metacognition (MESO); social valence (SOCIAL); mouth involvement (MOUTH); hand involvement (HAND). Abbreviations components: concreteness/abstractness (CON); inner grounding and social (IGSOC); sensorimotor (SENS).

The following network graph displayed through the *qgraph* package in R (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012) shows the relationship between dimensions between and within each component (Figure 2). Please, notice that, for visualization purposes, we ascribed some dimensions uniquely to the component where they loaded into most, although some of them almost equally loaded in more than one component. We are aware that, because of that, the PCA did not reach enough simplicity; however we want to emphasize that the current PCA mainly serves the purpose of reducing dimensions and compute component scores in order to explore the clustering of ACs through a cluster analysis (CA).

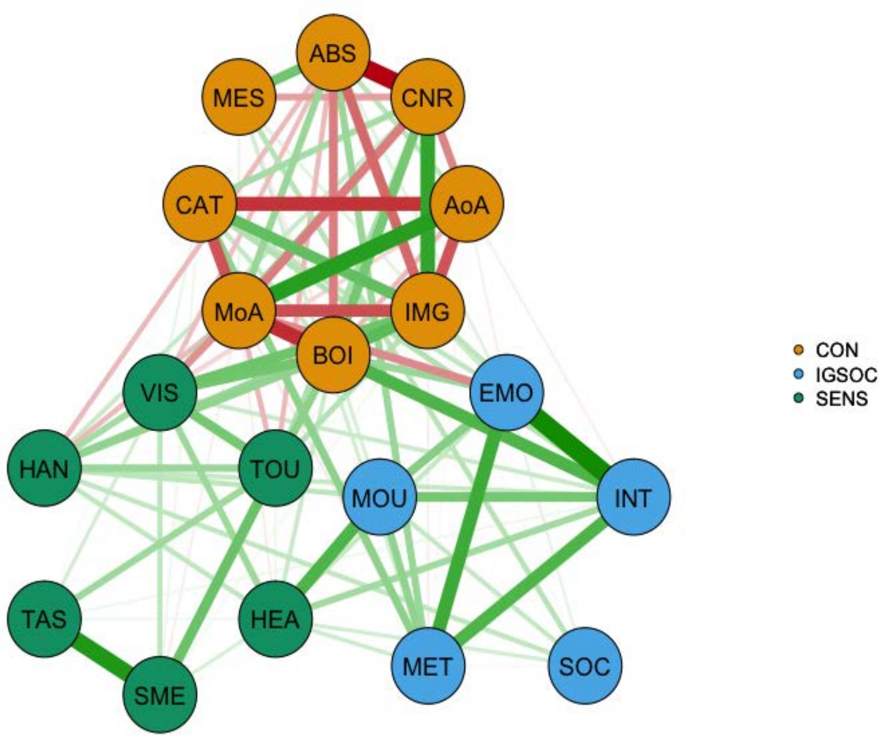

Figure 2. Network. The network graph on the relationship between dimensions between and within each component. Lines are displayed only for correlation

coefficients that are statistically significant at $p < .05$ after correction for multiple comparisons (Bonferroni correction). Green lines denote positive correlations, red lines denote negative ones. Line thickness is a function of the strength of the correlation. Abbreviations dimensions: concreteness (CNR); abstractness (ABS); imageability (IMG); contextual availability (CAT); Age of Acquisition (AoA); Modality of Acquisition (MoA); Body-Object Interaction (BOI); emotionality (EMO); perceptual strength in the five perceptual modalities: vision (VIS); touch (TOU); hearing (HEA); smell (SME); taste (TAS); interoception (INT); metacognition (MET); social metacognition (MES); social valence (SOC); mouth involvement (MOU); hand involvement (HAN). Abbreviations components: concreteness/abstractness (CON); inner grounding and social (IGSOC); sensorimotor (SENS).

Concreteness/Abstractness component*:* we found that concreteness is explained by the dimensions of Imageability, BOI, vision, and hand, while abstractness by social metacognition, MoA and AoA. The finding that Imageability and Context Availability predict abstractness is in line with the more influential classical theories on CCs/ACs, i.e. the Dual Coding Theory (DCT; Paivio, 1991) and the Context Availability Theory (CAT; Schwanenflugel et al., 1992). The role of Body-Object-Interaction in accounting for concreteness is instead completely new, and suggests that concreteness is more linked to an embodied dimension, but to an exteroceptive rather than to an interoceptive one (even if BOI is highly correlated with interoception, r = .60.). The BOI-interoception correlation holds across concepts, likely because also emotional concepts might activate both interoception and the tendency to act toward external stimuli. The differences between BOI and interoceptive ratings are higher for concepts referring to space, time, and math (e.g. “number”, “area”), characterized by higher BOI than interoceptive scores, and for concepts referring to the self (e.g. “infancy”, “maturity”, “destiny”) presenting the opposite pattern. Abstractness is instead linked to social metacognition, as predicted: the more abstract concept is, the more we seem to need others to help us to understand its meaning (Borghi et al., 2018a). Furthermore, in keeping with our predictions, MoA and AoA are included in the concreteness/abstractness component, indicating that, the more abstract concepts are, the more frequently they are linguistically acquired. Overall, the conjunct role of MoA, AoA and MESO highlights the crucial role of language and social interaction for grounding ACs.

Sensorimotor component*:* this component includes all perceptual modalities, together with the hand dimension. Interestingly, the two sensory modalities linked to interoception, i.e. taste and smell, are very highly correlated (r = .76). While all sensory modalities are highly correlated (all correlations above $|r|$ =.39), hand is more strongly correlated to touch (r =.49), vision (r = .37) and hearing (r = .31) than to more internal senses (smell r = .15; taste r = .13).

One could ask how much this sensorimotor component has to do with/predicts concreteness/abstractness. Connell and Lynott (2012) have namely found that perceptual strength explains results on the concreteness effect (advantage in processing and recall of CCs over ACs) better than concreteness/abstractness, and that a special role was played by vision. The present results show that all sensory modalities are included in an independent cluster, even if both touch and vision are highly correlated to concreteness. Our results are thus in line with those obtained by Connell and Lynott (2012), despite the difference in the considered language (English vs. Italian), and the fact that they used both CCs and ACs as stimuli. Furthermore, the fact that sensory modalities were not included in the concreteness/abstractness component confirms that ACs are rather detached from perceptual modalities (Barsalou, 2003).

Inner grounding & Social component: Within this component, the link between emotions, interoception and general-metacognition (reliance on inner processes) confirm**s**/suggests a strong linkage within dimensions pertaining inner bodily, cognitive and emotional processes/states. Interesting for us is the insertion within this component of the mouth (MOU) and social (SOC) dimensions. Social valence (SOC) is correlated to mouth (r = .30), emotionality (r = .23) and metacognition (r = .19) within this component (not to interoception, though), but it is also correlated both to hand (r = .31) and to hearing (r =.27) within the sensorimotor component. Finally, it is strongly correlated to social metacognition (MESO) of the concreteness/abstractness component (r = .33). The pattern of correlations that characterize SOC seem to refer to a sensorimotor circuit related to the use of language. This pattern is in keeping with the WAT's view that a strict interrelation between linguistic and social experience exists, and with the specific prediction according to which the mouth activation can be due to a motor preparation derived from the metacognitive awareness that our concepts are not sufficient, and we need to ask information to others (Borghi et al., in press). The strict relation between MOU and HEA also suggests a clear link to language activation, and the relation between MOU and HEA with dimensions concerning inner processes indicates that these processes may include either the mediation of inner speech or simulation of listening to someone else speaking.

One could ask how much inner grounding has to do with/predicts concreteness/abstractness. Emotionality, metacognition and mouth are all correlated with abstractness. In agreement with theories according to which emotionality represents a peculiar trait of ACs (Kousta et al., 2011; Vigliocco, et al., 2013), there is a strict relationship between abstractness and inner grounding, but to our surprise no correlation between abstractness and interoception was present. By looking more closely at the data, the lower correlation between abstractness and interoception is due mainly to words referring to bodily states (e.g. "pain", "cold"), characterized by high interoception and low abstractness scores, and by words referring to spiritual or institutional concepts (e.g. “immortality”, “republic”) which obtained high abstractness and low interoception scores. The difference with Connell et al. (2018) who found instead that interoception and abstractness were highly correlated can be due to the fact that they examined both CCs and ACs. More crucially, the link between the dimensions of metacognition, social metacognition (linked to sociality), mouth and abstractness confirms the predictions of the WAT theory, according to which linguistic and social aspects are crucial for ACs representation, and determine an involvement of the mouth motor system.

Overall, the inspection of the network confirms that there neither exists an abstract/concrete dichotomy nor a linear relationship between concreteness/abstractness, but that a multidimensional space exists (Crutch et al., 2013; Troche, Crutch, & Reilly, 2014), in which many dimensions together determine whether a concept is concrete or abstract.

1) Kinds of ACs.

The relative majority of indices (8) indicated a 4 cluster solution. The same solution was achieved by plotting the curve of within-cluster sum of square (WSS), according to the Elbow method. We therefore used a k-means clustering method to partition our 425 words into four clusters. The complete list of the 425 words distributed in the four clusters is available online at https://osf.io/4bztv/.

Figure 3 shows the boxplots for the component scores from each cluster, which was named after an inspection of the words that formed each, along with an evaluation of the component scores profile of each cluster.

The cluster plot (Figure 4) displays a bivariate plot visualizing the clustering (shown through ellipses) of our data. For the sake of clarity, we selected the six most representative words for each cluster (i.e. the ones with the smallest distance from the centroid). All observations are represented by points in the plot, using principal components.

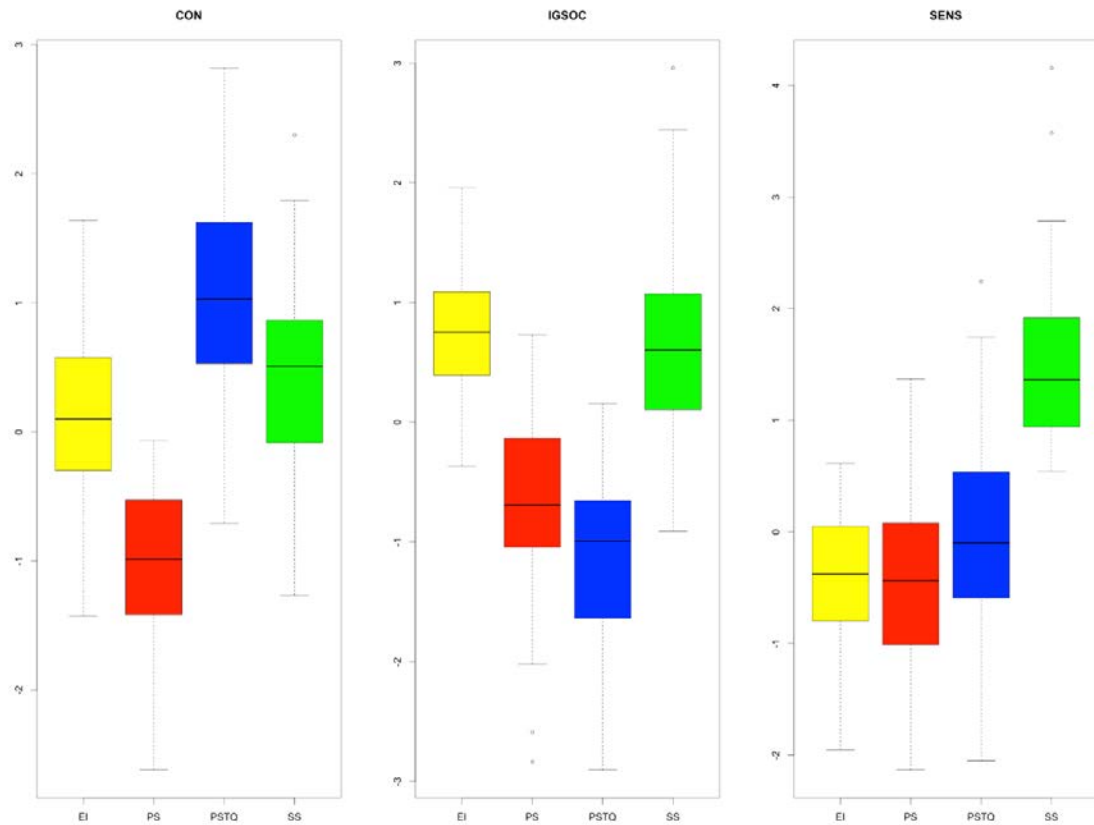

Figure 3. Cluster plot. Each panel shows the boxplots for the component scores from each of the four clusters. Abbreviations component: concreteness/abstractness (CON); inner grounding and social (IG/SOC); sensorimotor (SENS). Abbreviation clusters: physical, spatio-temporal and quantitative concepts (PSTQ); self and sociality concepts (SS); philosophical/spiritual concepts (PS); emotional and inner state concepts (EI).

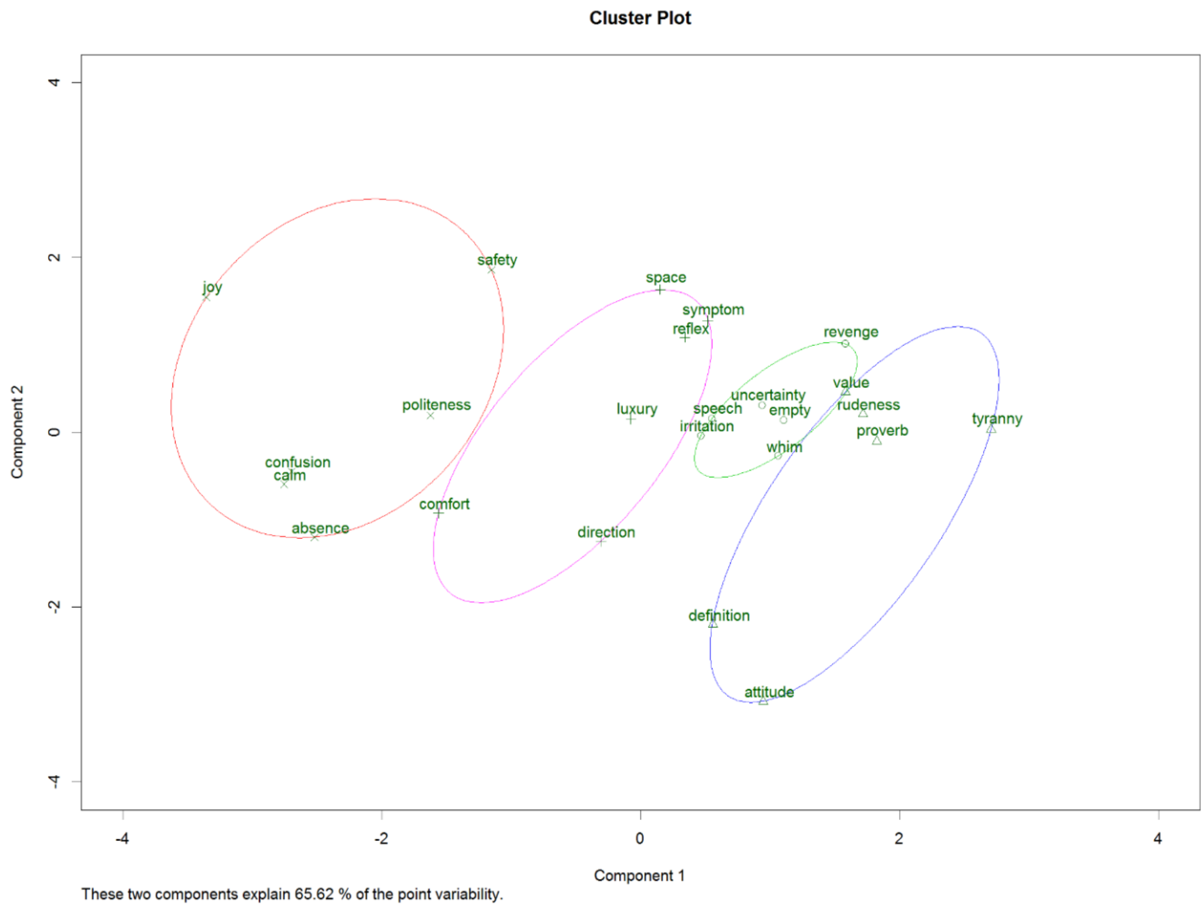

Figure 4. A bivariate plot that visualizes the clustering (shown through ellipses) of our data. The six most representative words for each cluster (i.e., the ones with the smallest distance from the centroid) are selected. PHYSICAL, SPATIO-TEMPORAL AND QUANTITATIVE CONCEPTS (reflex, direction, comfort, symptom, space, luxury); PHILOSOPHICAL/SPIRITUAL CONCEPTS (definition, tyranny, attitude, proverb, rudeness, value); SELF AND SOCIALITY CONCEPTS (politeness, absence, calm, confusion, joy, safety); EMOTIONAL/INNER STATES CONCEPTS (revenge, speech, empty, uncertainty, irritation, whim).

1. PHYSICAL, SPATIO-TEMPORAL AND QUANTITATIVE CONCEPTS (73 concepts) (represented in blue in Figure 3): this cluster is characterized by higher scores in the concreteness/abstractness component, resulting from high ratings in concreteness, Body-Object-Interaction, imageability and Context Availability. It includes concepts that refer to physical notions (e.g., reflex, image, mass, acceleration, shadow, gravity, matter, colour),

quantifiable bodily sensations (e.g. cold, shiver, vertigo, hot), quantities (e.g., litre, meter, dose, price, coin), numbers and operations (e.g., subtraction, sum, addition, number), quantifiable temporal concepts (e.g., beginning, day, end, season) and spatial concepts (e.g., space, place, destination, horizon, area).

2. SELF AND SOCIALITY CONCEPTS (81 concepts) (represented in green in Figure 3): this cluster is characterized by higher scores in the inner grounding and social component: the words it includes were rated as activating inner bodily sensations, emotions and mental states, social situations. It includes words related to psychological and physical characteristics of the self (e.g. charm, enthusiasm, ability, energy, curiosity, force, cheerfulness, elegance, beauty), mainly with a positive connotation, of social situations regulated by norms (e.g. politeness, kindness, hospitality, harmony, conflict, protest, seduction, game, safety), together with concepts related to social institutions (e.g., wedding, separation, family, civilization, culture, job, fashion), and to social situations characterized by the presence of more people (e.g. crowd, confusion, party).

3. PHILOSOPHICAL/SPIRITUAL CONCEPTS (125 concepts) (represented in red in Figure 3): this cluster is characterized by low scores in the concreteness, inner grounding and sensorimotor components. The words included here were evaluated as highly abstract, and refer to imagery entities (e.g. magic spell, mystery, utopia, enigma, luck, ghost, fate), religious words (religion, paradise, devotion, fervor, infinity, immortality, faith, salvation, absolution, idol, absolute), principles (e.g. value, purity, virtue, principle, belief), disciplines (history, philosophy, linguistics, logic, ethics), concepts linked to argumentation, reasoning and decision making (negation, affirmation, deduction, definition, reason, logic, implication,

analysis, hesitation); finally it includes mainly negatively connoted words, related to characteristics of the self (e.g., greed, rudeness, dishonesty, inexperience).

4. EMOTIONAL/INNER STATES CONCEPTS (146 concepts) (represented in yellow in Figure 3). This cluster is characterized by high scores across the three components: the words included here were not rated as very abstract and imageable, and were considered to be mainly acquired early (AoA) and perceptually (low MoA). This cluster includes concepts referring to emotions, at different level of complexity (e.g., anger, wonder, sadness, horror, fury, terror, panic, anguish, shame, surprise, hate, unhappiness, despair, envy, pride, dread, guilt, hope, melancholy, shame, wrath), mental states (e.g. depression, boredom, distress, peace, satisfaction, impatience, unconcern, panic, exasperation, madness), emotionally connoted social situations (e.g. revenge, whim, deceit, deal, commitment, responsibility, disagreement, loyalty, irony, mourning, competition, pact, curse, oath, drama, deceit, discussion, craftiness, respect, justification, scandal, tragedy, tolerance, quarrel, criticism, resistance, freedom) and characteristics of the self with respect to others (e.g. sincerity, patience, bravery, originality).

In order to determine whether some kinds of ACs are considered by participants to be more "embodied" than others, we can observe how the different concepts are distributed in terms of the three components (Figure 3).

CONCRETENESS/ABSTRACTNESS component: We can notice a clear opposition between PHYSICAL, SPATIO-TEMPORAL AND QUANTITATIVE concepts, characterized by high scores in concreteness, and the most ACs, i.e. PHILOSOPHICAL/SPIRITUAL concepts. The other two kinds of ACs are in the middle.

INNER GROUNDING & SOCIAL component: PHYSICAL, SPATIO-TEMPORAL AND QUANTITATIVE concepts are characterized by low scores in inner grounding, followed by PHILOSOPHICAL/SPIRITUAL concepts. On the contrary, both SELF AND SOCIALITY concepts and EMOTIONAL/INNER STATES score high on this component.

SENSORIMOTOR component: the role of sensorimotor experience and of perceptual strength is particularly marked for EMOTIONAL/INNER STATE concepts.

This different role of the three components for the four categories allows us to distinguish different forms of embodiment, one more linked to exteroceptive experience, one to interoceptive one. Interestingly, EMOTIONAL/INNER STATES and PHYSICAL, SPATIO-TEMPORAL AND QUANTITATIVE concepts can be considered more concrete and imageable than the other concepts, but the latter mainly rely on interactions with external objects/entities, while the first rely also on exteroception, but especially on inner grounding. In between, SELF AND SOCIALITY concepts rely both on external and inner grounding. Among the less embodied concepts, PHILOSOPHICAL/SPIRITUAL CONCEPTS rely more on inner than on external grounding.

Discussion

In this study we report results of ratings on 425 Italian abstract words evaluated on 15 semantic dimensions, selected in order to test the major current views on ACs. To our knowledge the present norms are the most extensive existent ones on ACs, in terms of the variety of considered dimensions.

Two general conclusions can be drawn from our results: the first is that defining concepts in terms of sole concreteness/abstractness is a simplification. The second is that different varieties of ACs exist, hence these should not be treated as unitary domain. We will discuss these two issues in turn, together with their implications for current theories of ACs.

Concreteness/abstractness is a simplification. Our cluster analysis allowed us to verify how the different rated dimensions characterize more abstract and more concrete ACs. Importantly, we found that the concreteness/abstractness component include many dimensions. ACs are perceived as more concrete, when they refer to interactions with objects, are highly imageable and contextually situated. Instead, we conceive ACs as less concrete and more abstract, the more we feel that others are needed to give us information on the conceptual meaning, the later these concepts are acquired through language. Furthermore, abstractness is highly related to the inner grounding & sociality component, that includes the social dimension, dimensions involving inner states and processes (emotion, interoception, metacognition), and sensorimotor aspects linked to a possible (inner) language (mouth), while concreteness is more connected with the sensorimotor component, characterized by the different perceptual modality and by the hand effector. This pattern suggests that concreteness/abstractness is more plausibly conceived as grouping different components that can be represented in a multidimensional space, rather than a dichotomous single dimension.

Implications for current theories on ACs. Our results confirm multiple representation theories, according to which ACs are not only grounded in sensorimotor system, like CCs, but are grounded to a larger extent in social, linguistic, and inner experience. Within such theories, the high correlation between abstractness and the linguistic modality of acquisition is in keeping with the multiple representation views according to which linguistic experience plays a major role, such as the WAT view (Borghi & Cimatti, 2009; Borghi & Binkofski, 2014), and the view proposed by Dove (e.g. Dove, 2010; 2014; 2016; 2018). The high correlation between abstractness and social metacognition, and the insertion of social metacognition, age of acquisition (AoA) and modality of acquisition (MoA) within the concreteness/abstractness component, fully confirms the predictions of the WAT view (Borghi et al., 2018a), and testifies that at the increase of the abstractness level we rely more on the competence of others (see also (Prinz, 2004; 2014; Shea, 2018) and that social and linguistic experience is crucial for ACs representation. Our results only partially confirm multiple representation views that propose an important role of emotions (Kousta et al., 2011; Vigliocco et al., 2013) and of other inner processes for ACs (introspection: Barsalou & Wiemer-Hastings, 2005; general metacognition: Borghi et al., 2018a; see Zdrazilova & Pexman, 2013, for similar results): emotionality and general metacognition are correlated to abstractness, but the inner grounding component is separate from that of abstractness. With respect to standard embodied and grounded views, our results show that different kinds of ACs are characterized by a different level of embodiment, suggest that a higher level of abstractness is more related to inner grounding than to interactions with objects/entities in the environment, and indicate that perceptual strength of vision is critical to determine conceptual concreteness.

Different varieties of ACs exist. Our results clearly indicate that ACs form different clusters, each differently characterized in terms of rated dimensions. Four different clusters were identified: PHILOSOPHICAL/SPIRITUAL concepts, EMOTIONAL/INNER STATES concepts, SELF AND SOCIALITY concepts, PHYSICAL, SPATIO-TEMPORAL AND QUANTITATIVE concepts. Some of the clusters correspond to ACs already identified in the current literature, such as emotional concepts (Altarriba et al., 1999; Altarriba & Bauer, 2004; Barca, Mazzuca, & Borghi, 2017; Ponari et al., 2018). The cluster of emotions includes the majority of “emotion-label” concepts, i.e. of words that directly refer to a specific affective state (e.g. “sadness”) (Pavlenko, 2008; Kazanas & Altarriba, 2015; Kazanas & Altarriba, 2016). "Emotion-laden" concepts, i.e. words related to emotions that do not refer to the specific emotions (e.g. "tears"), are spread across both the EMOTIONAL/INNER STATE cluster and the SELF AND SOCIALITY and PHILOSOPHICAL/SPIRITUAL clusters. In other cases ACs aggregated in novel ways: it is the case of PHILOSOPHICAL/SPIRITUAL ACs, that were grouped together, of numerical concepts, that clustered together with physical, temporal and spatial quantitative concepts, of concepts related to the self and to sociality that were grouped together. As discussed, these concepts differ in degree of embodiment and in kind of embodiment (inner vs. external grounding), ranging from PHYSICAL, SPATIO-TEMPORAL AND QUANTITATIVE concepts, grounded in experience with objects and entities, considered more concrete and imageable and evoking interactions with the environment, to EMOTIONAL/INNER STATES concepts, grounded primarily in inner experience.

The finding that different kinds of ACs exist, that they are differently represented and that they are characterized by different levels of embodiment, is likely to stimulate further studies in the field. Further research is needed to verify how these different concepts impact behavioral tasks and to investigate whether and how their neural representation differs (see Desai et al., 2018), and differences between abstract nouns, adjectives and verbs should be investigated. What is certain, however, is that it is now clear that some old views do not hold any more: the view that CCs and ACs are dichotomously opposed, the view that concreteness/abstractness represents a continuum per se, without considering other aggregated dimensions related to language, sociality, inner processes, and the view that ACs represent a monolithic whole.

STUDY II

Sensorimotor ad interoceptive dimensions in abstract and concrete concepts [13]

Introduction

Recent theories propose that abstract concepts, compared to concrete ones, might activate to a larger extent interoceptive, social and linguistic experiences. At the same time, recent research has underlined the importance of investigating how different sub-kinds of abstract concepts are represented. We report a pre-registered experiment, preceded by a pilot study, in which we asked participants to evaluate the difficulty of 3 kinds of concrete concepts (natural objects, tools, and food concepts) and abstract concepts (Philosophical and Spiritual concepts, PS, Physical Space Time and Quantity concepts, PSTQ, and Emotional, Mental State and Social concepts, EMSS). While rating the words, participants were assigned to different conditions designed to interfere with conceptual processing: they were required to squeeze a ball (hand motor system activation), to chew gum (mouth motor system activation), to self-estimate their heartbeats (interoception), and to perform a motor articulatory task (inner speech involvement). In a control condition they simply rated the difficulty of words. A possible interference should result in the increase of the difficulty ratings. Bayesian analyses reveal that, compared to concrete ones, abstract concepts are more grounded in interoceptive experience and concrete concepts less in linguistic experience (mouth motor system involvement), and that the experience on which different kinds of abstract and concrete concepts differs widely. For example, within abstract concepts interoception plays a major role for EMSS and PS

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concepts, while the ball squeezing condition interferes more for PSTQ concepts, confirming that PSTQ are the most concrete among abstract concepts, and tap into sensorimotor manual experience. Implications of the results for current theories of conceptual representation are discussed.

Pilot study

The current study builds on the method of a previous study in preparation (Borghi & Lugli, in prep; Lugli & Borghi 2017) and for the selection of materials on a recently published norming study (Villani et al., 2019).

In the study by Borghi and Lugli, participants of different groups were asked to rate the degree of pleasantness and difficulty of concrete and abstract concepts while performing a concurrent task. Participants were told that their evaluations would be used to contribute to select the verbal stimuli for an experiment, and were asked to what extent they perceived the presented words as difficult and pleasant, without any further specification. We chose to avoid orienting participants toward a specific meaning of difficulty, and to use the common sense of the word. However, we think that the cover story leads them to interpret difficulty in terms of "difficulty in processing". Participants were assigned to 3 different conditions: in the ball condition they had to rhythmically squeeze a ball, in the gum condition to rhythmically chew gum, and in the candy condition to suck a candy. These conditions were designed to verify whether actively moving the mouth interfered with abstract concepts processing, and actively manipulating a ball with processing of concrete concepts. The candy condition was intended as a control one. A higher processing difficulty should lead to an increase in rated difficulty and a decrease in rated pleasantness.

The rationale of our pilot experiment builds on this previous work, but with two important differences. First, we intended to test not only the effect of the mouth active movement (gum chewing) and of the hand active movement (ball squeezing) on difficulty and pleasantness ratings, but also the effects of interoceptive experience (Connell et al., 2018; Borghi et al., 2019a) and of social experience (Borghi & Cimatti, 2009; Borghi & Binkofski, 2014; Borghi et al., 2018a, 2019a) on abstract concepts processing. Hence, in the Pilot study we added to the gum and to the ball condition two further conditions, i.e., the interoceptive condition, in which participants were asked to hold an instant cold or warm pack, and the social condition, in which they were required to hold the hand of a confederate. Second, the main aim of the Pilot study was not to identify differences between abstract and concrete concepts, but more subtle differences within abstract concepts. To identify sub-kinds of abstract concepts, we relied on the study by Villani et al. (2019). In this norming study participants were asked to evaluate 425 Italian abstract words on 15 dimensions (i.e., Abstractness, Concreteness, Imageability, Context availability, Body-Object-Interaction, Modality of Acquisition, Age of Acquisition, Perceptual modality strength, Metacognition, Social metacognition, Interoception, Emotionality, Social valence, Hand and Mouth activation). We then performed a cluster analysis that led to the identification of 4 clusters of abstract concepts, i.e., Philosophical and Spiritual concepts (PS) (e.g., value, belief), Emotional and Mental State concepts (EMS) (e.g., anger), Social and Self concepts (SS) (e.g., kindness) and Physical Space Time and Quantity (PSTQ) (e.g., reflex, sum). PS concepts were more abstract than the others, i.e., acquired late (e.g. Kuperman et al., 2012) and through language, and more characterized by the tendency to ask the meaning to others (social metacognition), PSTQ concepts were more concrete, i.e., more imageable, more characterized by bodily interactions with the environment. SS and EMS were more characterized by inner grounding, i.e. interoception and emotional valence and metacognition, and by sensorimotor properties (taste, smell, etc.). Further details of four kinds of abstract concepts and their cluster distributions can be found at https://osf.io/4bztv/. As in the previous study by Borghi and Lugli (in prep.), participants were required to perform pleasantness and difficulty judgments on a 5-point scale. Both scores and response times were recorded. The reason why we choose to use pleasantness and difficulty ratings is due to the fact that, in the literature, a relationship has been found between abstraction and disfluency, and concreteness and fluency (Alter & Hoppeneyer, 2008, but see one experiment for a failure to replicate). Increased fluency augments preference for a given stimulus (Winkielman et al., 2003). For example, the increased fluency of pronunciation simulation, owing to the exposure, leads to an increase of word pleasantness (Topolinski & Strack, 2009).

Participants were assigned to 4 different conditions: ball condition (they were asked to rhythmically squeeze a softball), interoceptive condition (they were asked to hold an instant cold or warm pack); social condition (they were asked to hold the hand of a confederate); gum condition (they had to rhythmically chew gum). We predicted that judgments of difficulty would increase in the ball condition more with the more concrete PSTQ concepts than with the other abstract concepts, that the interoceptive condition would lead to an increase of difficulty and a decrease of pleasantness ratings especially with EMS and SS concepts, which are more directly related to social and emotional aspects, that the social condition would lead to an interference mostly with SS concepts, and that the gum condition would interfere mostly with judgements produced in the most abstract PS concepts.

Method

Participants

129 students (102 female, 18 left-handed; M_{age} = 24.2, SD_{age} = 3.7) of the University of Bologna participated voluntarily. All participants were recruited among the students of a Psycholinguistic course. They were randomly assigned to the four conditions, resulting in 30 participants for ball condition, 39 for interoceptive condition, 26 for social condition and 34 for gum condition. All participants assigned to each condition were tested together in a room equipped with computers.

Materials

60 concepts taken from the previously identified four clusters were selected. We considered the most representative words for each cluster (i.e., the ones with the smallest distance from the centroid; mean distance = 2.44, max. 6.75; min. 0.72) and selected them for their value of Abstractness in a range from 1 (less abstract) to 7 (more abstract). Of 60 concepts, 13 were selected from PSTQ cluster (Mean= 2.72, SD = 0.58), 21 from PS cluster (Mean = 4.96, SD = 0.97), 11 from SS cluster (Mean = 4, SD = 0.78) and 15 from EMS cluster (Mean = 4.29, SD = 0.65).

Procedure

Participants were asked to evaluate on a 5-point Likert scale the difficulty ranging from 1 = “very easy” to 5 = “very difficult” and the pleasantness ranging from 1 = “very unpleasant” to 5 = “very pleasant” of each word presented. Each participant was instructed to provide both difficulty and pleasantness ratings in different blocks; the order of the blocks was counterbalanced across participants. During the evaluation, they had to perform a concurrent task. They were randomly assigned to four different conditions: gum chewing (they were asked to chew gum following the rhythm of a metronome) (Topolinski & Strack, 2009; Topolinski et al., 2014), interoceptive (they were asked to hold an instant cold or warm pack, that kept the temperature until the end of the task), social condition (they were asked to hold the hand of a confederate), ball squeezing (they were required to manipulate a softball following the rhythm of a metronome). The order to the trials was fully randomized, with the exception to not repeat the same word twice in succession.

Data analysis and results

Because of the ordinal nature of the dependent variable (responses on a Likert-type format), we conducted our analyses using Cumulative link mixed models (logit link function) using the clmm function from the ordinal (Christensen, 2018) R library. We modeled participants and words as random intercepts in order to account for the dependence among observations. Ideally, we should have modeled random slopes for each participant and word in order to better control for the Type I error (Barr et al., 2013), but it led to severe convergence issues. RTs were added as a predictor in the model in order to control for the effect of speed on the pleasantness and difficulty judgments. A Model comparison through Likelihood Ratio Tests was conducted in order to test the overall effects of the Condition, the Cluster, and their interaction. We did not find any statistically significant effect for either the Condition, the Cluster or their interaction on pleasantness ratings (see Table 1). When analyzing difficulty ratings, we did find a main effect of the cluster (see Table 2). In fact, PS words were more likely to be rated as less difficult as compared to words belonging to other clusters. We did not find any other statistically significant effect for either the Condition or for the Condition x Cluster interaction. We expected to observe that the interference in the gum chewing condition should be stronger for PS abstract concepts, because of their high level of abstractness.

However, the planned contrast on interaction between cluster PS and Condition (gum vs. social, interoceptive and ball in PS clusters > gum vs. social, interoceptive and ball in other clusters) was not significant (*p* = .93).

Predictors	No.par	AIC	logLik	LR.stat	df	Pr(>Chisq)
RT	7	16981	-8483	4.37	1	0.037
Condition	10	16984	-8482	2.41	3	0.492
Cluster	13	16989	-8482	1.34	3	0.721
Condition x Cluster	22	17000	-8478	7.03	9	0.634

Table 1. Model comparison of the effects on pleasantness ratings. The table reports a Likelihood ratio test between models where a predictor at time was entered. AIC = Akaike Information Criterion. No.par = number of parameters of the model.

Predictors	No.par	AIC	logLik	LR.stat	df	Pr(>Chisq)
RT	7	16980	-8483	20.70	1	< .001
Condition	10	16982	-8481	3.67	3	.300
Cluster	13	16964	-8469	23.61	3	< .001
Condition x Cluster	22	16968	-8462	14.08	9	.120

Table 2. Model comparison of the effects on difficulty ratings. The table reports a Likelihood ratio test between models where a predictor at time was entered. AIC = Akaike Information Criterion. No.par = number of parameters of the model.

Experiment

Potential problems of the Pilot study were that we had limited ourselves to consider sub-kinds of abstract concepts, and concrete words were not introduced. In addition, the social manipulation might have not been successful because touching someone you do not know could render it very difficult to concentrate on the experiment. Finally, in three of four manipulated conditions participants were asked to use their hand – this might have reduced the differences between the conditions.

The present pre-registered Experiment was designed to overcome these limitations. We confined ourselves to difficulty rating, for which the results of the previous study were more clear-cut. We selected three kinds of concrete and abstract concepts, controlled the materials, and modified two of the four conditions. The conditions to which participants were randomly assigned were: ball squeezing, gum chewing, heart beating, and articulatory suppression. For the heart beating condition we asked participants to estimate their heart beat pace and at the end of the task to report if they had noticed any change; self-estimation of heart beating within a given time is a task often used to measure interoceptive awareness (Schandry, 1981; Garfinkel et al., 2015). In order to test whether processing of abstract concepts does not only involve the mouth but implies use of inner speech, we introduced an articulatory suppression condition, since AS is often used to test involvement of inner speech (Alderson-Day & Fernyhough, 2015). In the articulatory suppression condition participants were required to rhythmically pronounce the syllable “ba ba ba”. Finally, we introduced a control condition, in which participants were asked to evaluate the difficulty of the words without performing any additional task. The control condition was introduced primarily because the conditions might differ in terms of executive demands. Conditions that capture more attention could more easily lead to interference, while conditions that involve low processing load might not affect the results (Connell & Lynott, 2012). We introduced the control condition also to better understand whether an interference or a facilitation occurred with respect to the baseline. It is worth noting that the control condition was not present in the original design and in the preregistration; we introduced it because the reviewers asked for it. Differently from the other conditions, in the control condition participants were tested online, since the lock-down due to the spread of COVID-19 did not allow us to test participants in the lab.

Hypotheses

Hypothesis 1 (directional). Ball squeezing condition: if processing of more concrete concepts, and particularly of tools, involves to a larger extent the manual motor system, i) we predicted that this condition would interfere more with concrete than with abstract concepts, thus increasing the rated difficulty of the concrete concepts, compared to the other conditions. ii) The interference effect should be particularly strong for tools, increasing their perceived difficulty, and then for food items. iii) Within abstract concepts, we intended to explore whether the ball squeezing condition would create more interference with the more concrete among the abstract concepts, i.e., PSTQ.

Hypothesis 2 (directional). Gum chewing condition: if processing of abstract concepts activates the mouth motor system to a larger extent than processing of concrete concepts, then i) we predicted that the gum chewing condition would interfere more with abstract concepts than with concrete concepts of animals and tools, leading to an increase in difficulty of more abstract compared to more concrete concepts. Within concrete concepts ii) we predicted that gum chewing would modulate the food items to a larger extent, either determining a decrease or increase of difficulty (facilitation or interference), because of the relationship between food items and mouth motor system.

Hypothesis 3 (directional). Articulatory suppression condition: if processing of abstract concepts not only activates the mouth motor system but specifically involves inner speech, then i) we predicted that the articulatory suppression condition would interfere more with abstract concepts than with concrete concepts, increasing the perceived difficulty of the first with respect to the second, and in particular ii) for the more abstract concepts, i.e., PS.

Hypothesis 4 (directional). Heart beating condition: if processing of abstract concepts not only activates the mouth motor system but also the interoceptive dimension to a larger extent than processing of concrete concepts, then i) we predicted that the heart beating condition would interfere more with abstract concepts than with concrete concepts, increasing the difficulty of the first and reducing that of the second. This should occur in particular with abstract concepts that involve more the emotional and social dimension, i.e., with EMSS (see results by Connell et al., 2018, showing that interoception characterized primarily emotional concepts). Within concrete concepts, ii) we intended to explore whether the heart beating condition would create more interference with the concepts of animals, because of their animacy.

Method

Material selection.

The words were selected from both the database by Della Rosa et al. (2010) and our database (Villani et al., 2019). More specifically, the selection of concrete words was completely based on the database of Della Rosa et al. (2010). Concrete words included 10 natural objects (animals, e.g., lion, camel), 10 manipulable artifacts (tools, e.g., hammer, broom) and 10 food items (e.g., carrot, eggplant) Concrete stimuli are shown in Table 3. We selected these three categories because these can be considered almost exhaustive of the categorical space and are used in the majority of studies on concrete concepts. Since the seminal work by Warrington and Shallice (1984), many studies on concrete concepts have focused on the distinction between artifacts and natural objects (for a review on the living/nonliving double dissociation see Forde & Humphreys, 2002). Recent studies are targeted at investigating the specificity of food concepts, which possess a special status since they are neither natural nor artifact objects (Rumiati & Foroni, 2016). Within artifacts, we focused on tools, more likely to activate the hand motor system (see Martin, 2007, for a review).

Abstract words were selected taking into consideration the two databases. Abstract words included words present in Della Rosa et al. (2010) but were selected by means of the clusters that emerged in the study by Villani et al. (2019): 10 words were selected from the cluster Philosophical and Spiritual concepts (PS, e.g., destiny, morality), 10 from the cluster Physical Space Time and Quantity (PSTQ, e.g., number, acceleration). Because the differentiation between Emotional and Mental State concepts (EMS, e.g., shame) and Social and Self concepts (SS, e.g., calm) was not clear cut, we decided to collapse the two clusters and selected 10 words from them (5 for each cluster). Abstract stimuli are shown in Table 4. Importantly, the different sub-groups of concrete and abstract words did not differ across main psycholinguistic dimensions, including the number of syllables, familiarity, absolute and relative frequency. Further characteristics of the selected concrete and abstract words in terms of dimensions and psycholinguistic variables are available in an online repository as Supplementary Materials (https://osf.io/ypx7s/).

Table 3. Selected concrete words from Della Rosa et al. (2010) database. Frequency values for each word were determined by CoLFIS, a lexical database of written Italian (Bertinetto et al., 2005).

Italian word	English word	Frequency value	Numbers of letters	Frequency absolute mean	N Letters mean
Banana	Banana	24	6		
Carota	Carrot	41	6		
Uva	Grapes	26	3		
Fragola	Strawberry	30	7		
Fungo	Mushroom	38	5		
Melanzana	Eggplant	13	9		
Peperone	Pepper	27	8		
Pomodoro	Tomato	88	8		
Torta	Cake	67	5		
Zucca	Pumpkin	33	5	*Concrete Food* = 38.7	6.2
Lampada	Lamp	76	7		
Martello	Hammer	26	8		
Scopa	Broom	12	5		
Bottiglia	Bottle	122	9		
Coltello	Knife	117	8		
Trapano	Drill	9	7		
Ombrello	Umbrella	31	8		
Forchetta	Fork	25	9		
Matita	Pencil	45	6		
Pennello	Brush	29	8	*Concrete Tool* = 49.2	7.5
Cane	Dog	328	4		
Leone	Lion	78	5		
Maiale	Pig	40	6		
Cammello	Camel	15	8		
Pecora	Sheep	56	6		
Mucca	Cow	12	5		
Piccione	Pigeon	19	8		
Gallina	Chicken	32	7		
Pappagallo	Parrott	12	10		
Insetto	Insect	76	7	*Concrete Animal* = 66.8	6.6

Table 4. Selected abstract words from Della Rosa et al. (2010) and Villani et al. (2019) database. Frequency values for each word were determined by CoLFIS, a lexical database of written Italian (Bertinetto et al., 2005).

Italian word	English word	Frequency value	Numbers of letters	Frequency absolute mean	N Letters mean
Accelerazione	Acceleration	29	13		
Inizio	Beginning	453	6		
Schema	Scheme	116	6		
Area	Area	483	4		
Numero	Number	1196	6		
Risultato	Results	902	9		
Punizione	Punishment	76	9		
Rimedio	Remedy	71	7		
Sforzo	Attempt	258	6		
Denaro	Money	337	6	*Abstract PSTQ* = 392.1	7.2
Morale	Moral	85	6		
Descrizione	Description	66	11		
Motivo	Motive	602	6		
Salvezza	Salvation	85	8		
Destino	Fate	266	7		
Paradiso	Paradise	92	8		
Enigma	Enigma	20	6		
Peccato	Pity	178	7		
Giudizio	Judgement	371	8		
Logica	Logic	117	6	*Abstract PS* = 188.2	7.3
Calma	Calm	110	5		
Gioia	Joy	235	5		
Amicizia	Friendship	212	8		
Conflitto	Conflict	186	9		
Gentilezza	Kindness	25	10		
Vendetta	Revenge	112	8		
Ansia	Anxiety	137	5		
Vergogna	Shame	101	8		
Simpatia	Liking	132	8		
Paura	Fear	698	5	*Abstract EMSS* = 94.8	7.1

Sample size rationale

We conducted a power analysis through the pwr package in R (Champley, 2018). In order to achieve a power of 80% with a critical alpha of .05 divided by the number of unpaired t-tests (.05/9 = .0055) that would allow us to test our pre-registered hypotheses, and assuming a medium effect size (Cohen's D = 0.5) (Cohen, 1988), and having a directional hypothesis we would need 93 participants per group (total N = 372). Since it would have been unfeasible to achieve that number due to objective constraints (N = 120 students enrolled in the class, and a time limited to one month), we decided to determine an effect size as the minimum amount of observations needed to have a relatively stable estimate. Based on Green (1991)'s rule of thumb for determining the smallest sample size, we would need 104 + k (where k is the number of predictors, i.e., number of groups -1 = 3). Therefore, any sample size greater than 107 would be enough to avoid overfitting. However, since inferences based on the Null Hypothesis Significance Testing are problematic without adequately controlling for the Type I and Type II error at the same time (Dienes, 2008), we used a Bayesian approach, instead. The sample size consisted of around 100-120 participants (25-30 per condition).

Participants

130 students participated (108 female, 14 left-handed; M_{age} = 24 SD_{age} = 2.5). Participants were volunteers recruited among the students of a Psycholinguistic course; they were students of the first or second year of the Master's degree in Semiotics, Philosophy, Italian Studies, Language and Communication. Each participant was randomly assigned to one of the five groups (gum chewing, articulatory suppression, heart beating, ball squeezing, control), resulting in 26

participants for each group. All participants were tested together in a room equipped with computers, except for participants in control condition who were tested online.

Procedure

Participants were asked to evaluate the difficulty of the stimuli using a 5-point Likert scale where 1 corresponded to "very easy" and 5 to "very difficult". During the evaluation they have to perform a concurrent task depending on the condition to which they were assigned: they were asked to chew gum following the rhythm of a metronome (gum chewing), to rhythmically pronounce the syllable "ba ba ba"(articulatory suppression), to estimate their heart beat pace and in the end of the task report if they have noticed any change (heart beating), to manipulate a softball following the rhythm of a metronome (ball squeezing). In the control condition no concurrent task was introduced. In all conditions, the full list of stimuli was presented twice resulting in a total of 120 words. The order to the trials was fully randomized, with the exception to not repeat the same word twice in succession.

Data analysis

A detailed pre-registered analytic plan can be found on the Open Science Framework repository at the following link: https://osf.io/3qu7t Notice that some of the data were collected prior to pre-registration, even if we have not performed any kind of analysis on them.

We measured the evaluations provided on a 5-point scale; we also measured the response times required to respond and consider them as a covariate. Predictors: Modality of Acquisition (MoA, Wauters, 2003), abstractness and concreteness.

Given the clustered nature of our design (word categories were manipulated within participants) and to minimize any loss of information, we decided to analyze our data through a multilevel model (also known as mixed models, Pinheiro & Bates, 2000). In this way, we took into account participants and words as sources of variation. To this purpose, we modeled participants' and words' intercepts as random effects (i.e. (1|participant) and (1|word) in Wilkinson notation). Although it is recommended to keep the random structure maximal (Barr *et al*., 2013), adding the random slopes led to convergence issues, thus we decided to model only the random intercepts. Furthermore, Liddle and Kruschke (2018) have recently demonstrated that treating a response measured at an ordinal level of measurement (e.g., Likert response format) like a variable measured at an interval level can lead to false alarms, misses, and even inversions. For this reason, we followed the recommendations from Buerkner and Vuorre (2019), and modeled our responses within an ordinal model, using a cumulative model with a probit or a logit link function. To decide which link function had better predictive accuracy, we fitted them both and selected the best fitting model in terms of the Watanabe-Akaike information criterion (WAIC; Watanabe, 2010).

In the first model we tested whether the difficulty ratings were affected by the interaction between the sub-kinds of concepts and the experimental conditions. We set participant-level and word-level random intercepts in order to account for non-independence among our observations. Furthermore, we conducted our analyses within a Bayesian framework, as it provides more flexibility for parameter estimation, and allows us to make claims on the relative evidence in favor of a hypothesis (e.g., H1) compared to another (e.g., H0, Wagenmakers, 2007).

The analysis was conducted in the Bayesian framework provided by the brms (Bayesian regression models using 'Stan') library (Bürkner, 2017, 2018) in R. All the models were fit using three different priors on the coefficients, to assess the sensitivity of the analysis: uninformative (flat prior, default in brms), weakly informative (normal distribution centered on zero and with a standard deviation of 5), or a narrower prior (normal distribution centered on zero and with a standard deviation of 1). Our hypotheses were tested through the "hypothesis" function on brms, which assesses the relative strength of evidence in favor of competitive hypotheses using the Savage-Dickey density ratio method, which compares the plausibility of a hypothesis (e.g., the null hypothesis "abstracts = concrete" under the prior *vs*. under the posterior probability distribution). Bayes factors were reported following the convention of reporting the hypothesis tested as a subscript: BF_{10} stands for relative evidence for the alternative (H_1) vs. the null (H_0), whereas BF01 stands for relative evidence for the alternative (H_0) vs. null (H_1). We also sampled from the posterior distribution for computing the posterior probability (PP) of the alternative, directional, hypothesis. We chose the best fitting link function using the WAIC (the least the best).

We interpreted the relative strength of evidence using the labels provided by Jeffreys (1961, revised by Lee and Wagenmakers,2013). Furthermore, checking the inclusion of zero within the 95% posterior credible intervals were used as additional information about the plausibility of the null hypothesis (and/or estimates of practical irrelevance) given the data. Since Bayesian Multilevel models are relatively robust to outliers (Nezlek, 2011), especially with a relatively narrow priors as the ones used in our analysis, we did not exclude outliers. We excluded data that was incorrectly entered (e.g., age > 99, Likert scale response > 5, etc.). Missing data were dealt with using a pairwise deletion.

Results

We fit two models containing only the intercepts (fixed and random), changing only the link function for the ordinal cumulative model (logit vs. probit). We found that the ordinal cumulative model with the logit (WAIC = 29266.7) link function outperformed the ordinal cumulative model with the probit link function (WAIC = 29266.7, ΔWAIC = 7.9). We therefore used an ordinal cumulative model with the logit link function for all the following analyses (Table 5). In the first model we modeled the variables just in terms of abstract vs. concrete words and of experimental conditions (Figure 1). The estimates for the model with uninformative and flat priors appeared to lead to similar results, but the narrow priors lead to somewhat more conservative estimates – unsurprisingly. Therefore, we reported the results when placing a narrow prior on the parameters.

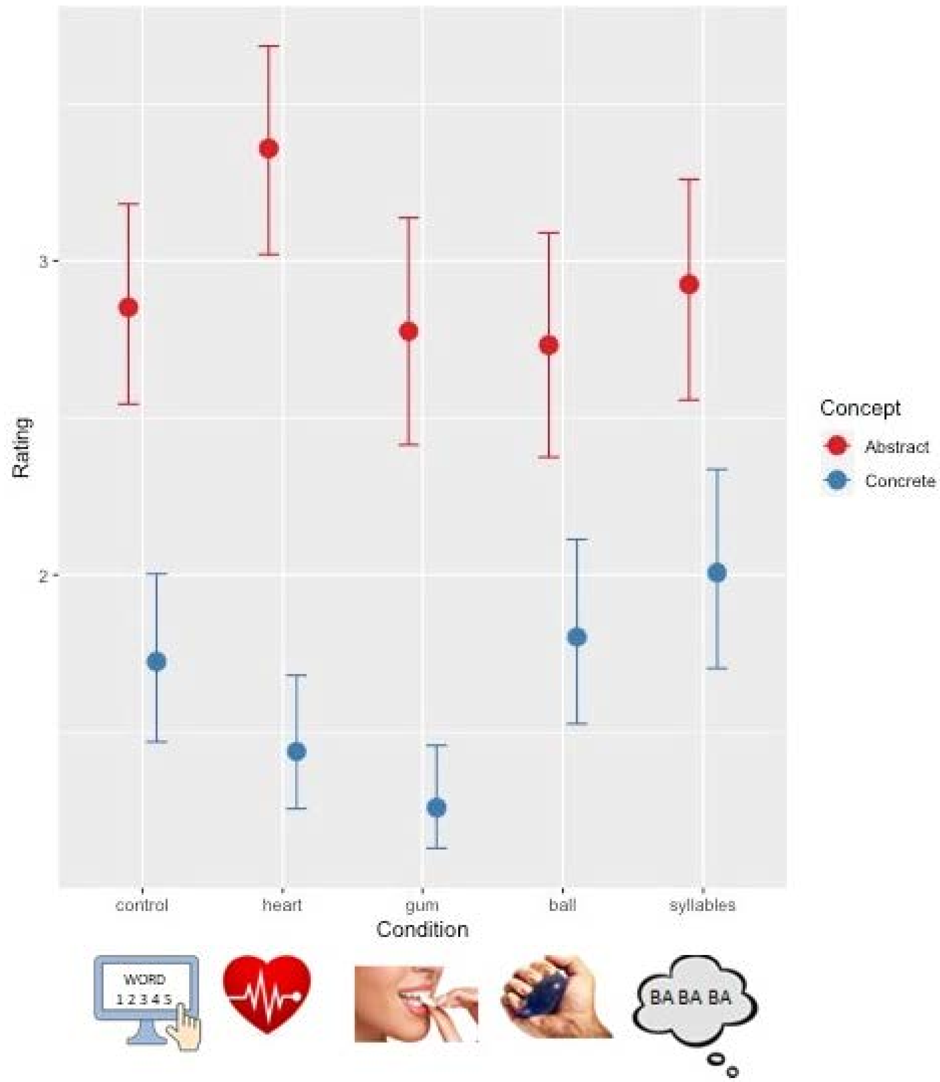

Figure.1. Interaction plot of ratings means versus conditions (control, heart, gum, ball, syllables) for abstract and concrete concepts. Error bars indicate the 95% credible intervals.

	Estimate	Est.Error	l-95% CI	u-95% CI
Intercept[1]	**-2.72**	**0.33**	**-3.38**	**-2.09**
Intercept[2]	-0.62	0.33	-1.27	0.01
Intercept[3]	**1.2**	**0.33**	**0.54**	**1.82**
Intercept[4]	**3.3**	**0.33**	**2.65**	**3.93**
Condition Heart	**1.01**	**0.38**	**0.29**	**1.76**
Condition Gum	-0.16	0.39	-0.91	0.6
Condition Ball	-0.25	0.4	-1.03	0.52
Condition Syllables	0.14	0.38	-0.62	0.89
Concept Concrete	**-2.48**	**0.31**	**-3.07**	**-1.85**
Condition Heart: Concept Concrete	**-1.83**	**0.11**	**-2.04**	**-1.61**
Condition Gum: Concept Concrete	**-1.35**	**0.12**	**-1.58**	**-1.12**
Condition Ball: Concept Concrete	**0.44**	**0.11**	**0.23**	**0.65**
Condition Syllables: Concept Concrete	**0.55**	**0.1**	**0.35**	**0.75**

Table 5. Estimates and 95% posterior credibility intervals (PCIs) for the estimates for the model in which we tested for the effect of concreteness (abstract vs. concrete) and experimental condition (control, heart, gum, ball, syllables) using a narrow prior (normal distribution with mean = 0 and SD = 1). Abstract concepts and heart beating conditions are set as reference variables for the concreteness and the experimental conditions, respectively. Boldfaced: the estimates whose 95% PCIs do not include the effect of zero.

Hypothesis 1. i) We predicted that the ball squeezing condition would have increased the perception of the difficulty of concrete concepts (vs. abstract ones). To test this hypothesis, we tested whether the difference between abstract and concrete concepts in the ball condition was different as compared to other conditions. We found extreme evidence that this difference was smaller in the ball condition, as compared to the control, the gum and the heart beating conditions (BF_{10}s > 100, posterior probability (PP) = 100%). However, there was moderate evidence that there was no difference between the difference between abstract and concrete concepts in the ball condition as compared to the articulatory suppression condition (BF_{01} = 8.88, PP = 16%). We also tested whether the difficulty ratings for concrete concepts in the ball condition were higher than in other conditions. We found extreme evidence in favor of the hypothesis that difficulty ratings for concrete concepts in the ball condition were higher than in the gum conditions (BF_{10} > 100, PPs = 100%), and moderate evidence that difficulty ratings for concrete concepts in the ball condition were higher than in the heart beating condition (BF_{10} = 3.4, PP = 99%). However, there was anecdotal evidence that difficulty ratings for concrete concepts in the ball condition did not differ from the articulatory suppression condition (BF_{01} = 2.25, PP = 13%). Finally, there was moderate evidence that difficulty ratings for concrete concepts in the ball condition did not differ from the control condition (BF_{01} = 3.01, PP = 68%). ii) Next, we verified whether the interference effect was particularly strong for tools, and then for food items. We found strong evidence that the interference effect is stronger for tools (vs. the more abstract concepts, i.e. PS) in the ball condition as compared to the control condition (BF10 = 19.9, , PPs = 99 %), and extreme evidence that the interference effect is stronger for tools (vs. PS) in the ball condition as compared to the heart beating condition and to the gum condition (BFs_{10} > 100, PPs = 100%). However, there was moderate evidence that there was no difference with the articulatory suppression condition (BF_{01}= 7.80, PP = 63%). Concerning the food, we found inconclusive evidence (BF01= 1.23, PP = 96%). We also found extreme evidence that the interference effect was stronger for food items (vs. PS) in the ball condition as compared to the heart beating condition and to the gum condition as compared to the control condition (BFs_{10} > 1000, PPs = 100%). However, there was moderate evidence that there was no difference with the articulatory suppression condition (BF_{01}= 4.12, PP = 12%).

iii) We verified whether within abstract concepts the interference effect was particularly strong for PSTQ (vs. the more abstract concepts, i.e. PS). Within abstract concepts, we found moderate evidence that there was no difference with the control condition (BF01= 5.9, PP = 52%). We found extreme evidence that the interference effect was stronger for PSTQ (vs PS) in the ball condition as compared to the heart beating condition and to the gum condition (BFs_{10} > 100, PPs = 100%). However, there was anecdotal evidence that there was no difference with the articulatory suppression condition (BF_{01}= 2.23), although in terms of posterior probabilities it is plausible to assume that the effect was stronger for PSTQ in the ball condition as compared to the articulatory suppression condition (PP = 95%).

Hypothesis 2. i) We predicted that the gum chewing condition would interfere more with abstract concepts than with concrete concepts of animals and tools, determining an increase in difficulty at the increase of the abstractness level. To test this hypothesis, we tested whether the difference between abstract and concrete concepts of animals and tools in the gum condition was different, as compared to the other conditions. When tested against the heart beating condition, we found inconclusive evidence in support of this hypothesis (BF_{10} = 2.9), and actually it was more plausible that the difference was in the opposite direction as compared to the predicted one (PP = 0.33%). However, when compared with the control, ball and articulatory suppression conditions, we found extreme evidence in support of our hypothesis (BF_{10}s > 100, PPs = 100%). ii) We also predicted that the gum condition would modulate more the food items, either determining a facilitation or an interference. Thus, we compared the difference between the food items and the rest of sub-categories in the gum condition against the same difference in all the other conditions. We found inconclusive evidence for a difference that food items were affected as compared with the control condition (BF10= 1.1, PP = 2%).

However, we found strong evidence for this hypothesis, when comparing the interference effect on food with the heart condition (BF10 = 84 because the interference was greater (PP = 100%).When compared to the ball condition, however, we found moderate evidence for this hypothesis (BF_{10} = 3.89), but in the opposite direction (PP = .03%), as the interference on food was greater in the ball condition. The same was true in the comparison with the articulatory suppression condition (PP = 0.03%), although in this case the evidence for an effect was extreme (BF10 > 100).

Hypothesis 3. We predicted i) that the articulatory suppression condition would interfere more with abstract concepts than with concrete concepts, and in particular ii) for the more abstract concepts, i.e. PS). It is clear from a simple visual inspection of the results that hypothesis 3 was not supported by our data (Figure 1), indeed the articulatory suppression condition seems to produce less interference with the abstract concepts, and it was indeed quite similar to the ball condition, as emerged in our analyses related to Hypothesis 2. Ii) The same applies to our second sub-hypothesis concerning the more abstract concepts (PS) that did not appear to be judged as more difficult in this condition, as compared to the other experimental conditions (Figure 2).

Hypothesis 4. i) We predicted that the heart beating condition would interfere more with abstract concepts than with concrete ones. To test this hypothesis, we tested whether the difference between abstract and concrete concepts was bigger in heart beating condition, as compared to other conditions. We found extreme evidence that the difference in the heart condition was bigger than in all the other conditions, including the control condition (BF_{10}s > 100, PPs = 100%). ii) Furthermore, we tested in particular if the effect was bigger for the abstract concepts that involve more the emotional and social dimension. We found extreme evidence for a greater difference between EMSS and PSTQ concepts (PS is the reference level) in the heart beating condition as compared with the ball, the articulatory suppression and the control conditions (BF_{10}s > 100, PPs = 100%), moderate evidence for a greater difference between EMSS and PSTQ concepts in the heart condition as compared with the gum condition (BF_{10} = 7.85, PP = 99%). ii) Finally, we explored whether the heart beating condition could create more interference with the concepts of animals, because of their animacy. However, even from a simple visual inspection of the results this does not seem to be the case (Figure 2).

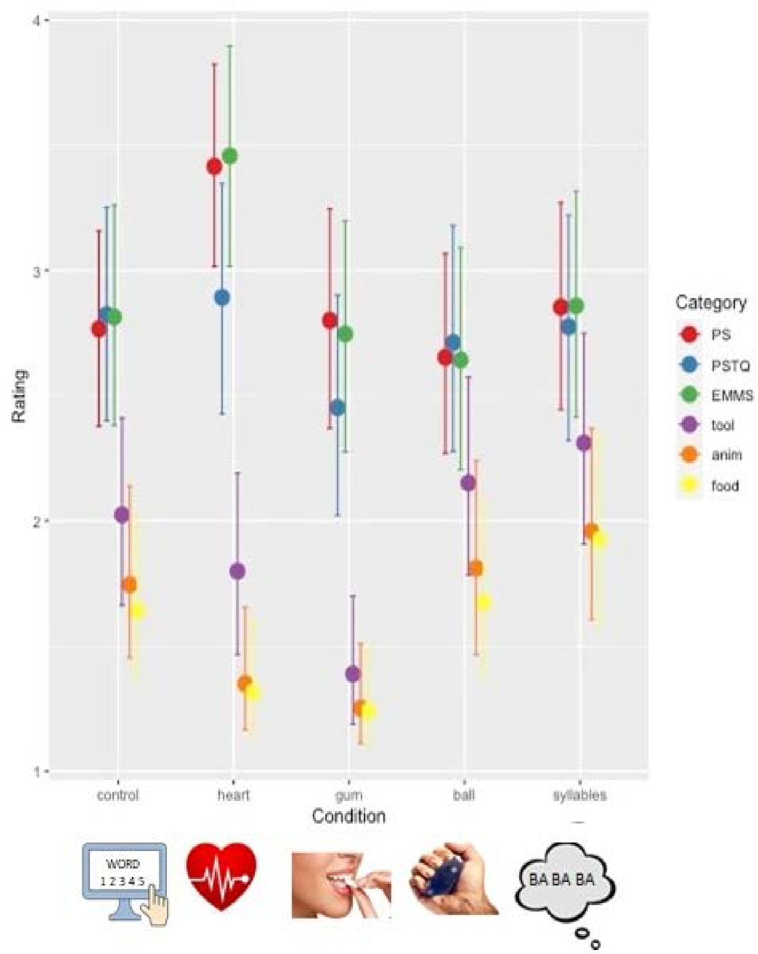

Figure.2. Interaction plot of ratings mean versus conditions (control, heart, gum, ball, syllables) for the sub-kinds of abstract (Philosophical and Spiritual concepts, PS; Physical Space Time and Quantity concepts PSTQ; Emotional, Mental State and Social concepts, EMSS) and concrete concepts (Tools, Animals, Food). Error bars indicate the 95% credible intervals.

Exploratory analyses

To better interpret how dual-tasks modulated the differences in ratings between the two kinds of concepts and their sub-kinds, we decided to run further exploratory analyses on our data.

Specifically, we tested whether the difficulty rating for abstract concepts in each condition differed from the rating for abstract concepts in the control condition. The same analysis was conducted for the concrete concepts. We also tested whether, when compared to the control condition, the difficulty rating in the gum and heart condition was higher for the more abstract concepts, PS and EMSS, than for the most concrete among the abstract concepts, PSTQ. Finally, we tested whether the perceived difficulty of tools compared to other concrete concepts decreased more in the gum condition than in the control condition.

Exploratory analyses results.

Concrete concepts. We found very strong evidence (BF_{10}= 61.48) that concrete concepts were judged as less difficult in the gum condition, as compared to the control (PP = 100%). We found only inconclusive evidence ($0.33 < BFs_{10} < 3$) in favor of a difference in the difficulty ratings provided to the concrete concepts between the control condition and the other conditions (4% < PPs < 98%).

Abstract concepts. We found strong evidence (BF_{10}= 15) that abstract concepts were judged as more difficult in the heart condition, as compared to the control condition (PP = 100%). We found only inconclusive evidence ($0.42 < BFs_{10} < 0.47$) in favor of a difference in the difficulty ratings provided to the abstract concepts between the control condition and the other conditions (4% < PPs < 34%).

Differences within abstract concepts. We found extreme evidence ($BFs_{10} > 100$) that PSTQ concepts were considered as less difficult, compared to other abstract concepts, in the heart condition and in the gum conditions as compared to the control condition (PPs = 100%). We found moderate evidence ($BF_{01} = 6.9$) that PSTQ concepts were not rated differently from other abstract concepts, in the ball condition as compared to the control condition (PPs = 32%). We found only inconclusive evidence ($BFs_{01} = 1.93$) in favor of the absence of a difference in the difficulty ratings provided to the PSTQ concepts compared to other abstract concepts between the control condition and the other conditions (PPs = 96%).

Differences within concrete concepts. We found strong and extreme evidence ($BF_{10} = 94.6$ and $BF_{10} > 100$) that tools concepts were considered as more difficult, compared to other concrete concepts, in the heart condition as compared to the control condition (PP = 99%). We found moderate evidence ($BFs_{01} > 4$) that tool concepts were not rated differently from other concrete concepts, in the gum (PP = 13%), in the ball (PP = 86%), and in the syllables condition (PPs = 59%) as compared to the control condition.

Discussion

The results clearly show that the different conditions modulate the ratings of abstract and concrete concepts, and of sub-kinds of abstract and concrete concepts. In many cases they supported the hypotheses we had advanced, with some exceptions that we will discuss later. We will summarize and discuss the implications of our results below.

We assume that the increase of difficulty ratings in one condition with respect to the others signal the presence of an interference. We will focus first on abstract and concrete concepts as a whole, and then on the sub-kinds of abstract and concrete concepts. Notice that the conditions might differ in terms of executive demands, but the introduction of a control condition allowed us to have a useful baseline. While we cannot completely exclude that the comparison between the different conditions might be impacted by the differences in difficulty between the secondary tasks, we do not think it is the case. The various conditions differently influenced the ratings on concrete and abstract concepts, hence we believe that their effect is due to the different dimensions they tackle, and not to the different level of task difficulty.

Abstract and concrete concepts as a whole.

In line with hypotheses 1, 2, and 4, when compared to concrete concepts abstract concepts elicited more interference with the gum chewing and the heart beating condition than with the ball squeezing condition. Results indeed showed that the difference between difficulty ratings in concrete and abstract concepts is larger in the heart beating than in all the other conditions, followed by the gum chewing condition which is larger than in all other conditions with the exception of the heart beating one. This supports the hypothesis that interoceptive experience is crucial for the representation of abstract concepts, and also suggests that processing of more abstract concepts involves the mouth motor system. Exploratory analyses allowed us to determine that the heart beating condition rendered abstract concepts more difficult with respect to all other conditions. The gum chewing condition, instead, rendered concrete concepts easier compared to all the other conditions.

As to a possible role of inner speech, our hypothesis that the articulatory suppression interfered more with abstract concepts than with concrete ones was instead not supported.

If we focus on concrete concepts, we found that the ball squeezing condition rendered the difference between concrete and abstract concepts smaller compared to the differences in the control, gum, and heartbeat conditions, but not to the articulatory suppression condition.

Specifically, the ball squeezing condition rendered concepts more difficult with respect to the gum chewing and to the heart beating conditions, in keeping with our hypothesis that manual activity would interfere more with more concrete concepts. However, there is absence of significant evidence that ball condition renders concrete concepts more difficult than the control and articulatory suppression condition. The difference in difficulty with the control condition is however present when we consider tool concepts, for which manual experience is clearly crucial.

In sum, most results confirm our predictions, testifying that abstract concepts are grounded in interoceptive experience and that they evoke the mouth motor system, and that concrete concepts and particularly tools are more grounded in sensorimotor experience and activate the hand motor system. However, with respect to our predictions one result strikes us as novel, and another as unexpected. The novel result is the pivotal role of interoceptive experience, that strikes us as more crucial than other dimensions for the representation of abstract concepts.

The unexpected result is the scarce modulation of articulatory suppression depending on the abstractness of stimuli. It is mainly unclear from the results whether articulatory suppression elicited a selective interference in processing of abstract concepts or instead on both abstract and concrete ones. In the articulatory suppression condition the disadvantage of abstract over concrete concepts is slightly larger than in the ball condition, in line with our predictions, but the evidence is inconclusive. It is therefore possible that the effect of suppression increases the difficulty of all linguistic stimuli, irrespective of their abstractness level. The result contrasts with recent evidence (Zannino, Fini, Benassi, Carlesimo, Borghi, under review) in which we found a selective interference of articulatory suppression on abstract concepts processing, in a task in which we asked participants to judge whether words were concrete or abstract and we measured response times. It is therefore possible that the absence of a selective interference due to articulatory suppression is owing to the specific task we selected, that required participants to explicitly evaluate conceptual difficulty and did not consider their online performance. Further studies are necessary, to investigate more in depth the role of articulatory suppression in abstract concepts processing across different tasks.

Sub-kinds of abstract and concrete concepts

PSTQ abstract concepts. As predicted (exploratory hypothesis), we found that the ball squeezing condition increased difficulty judgments of PSTQ concepts to a larger extent than the heart and gum conditions, but not than the control condition. Furthermore, as predicted EMSS (together with PS) differed from PSTQ concepts more in the heart condition compared to all the other conditions. This result confirms that PSTQ are the most concrete among the abstract concepts, and tap on sensorimotor (exteroceptive) rather than on interoceptive experience.

EMSS abstract concepts. As predicted (directional hypothesis), the heart beating condition interfered in particular with abstract concepts that involve more the emotional and social dimension, i.e., with EMSS, compared with the more concrete PSTQ concepts (but not with PS concepts).

Tools concrete concepts. Within concrete concepts, as predicted (directional hypothesis) the ball condition interfered more with judgments on tools when compared with all other conditions except the articulatory suppression one.

Food and animals concrete concepts. As predicted (directional hypothesis), compared with the ball squeezing and the suppression condition the gum chewing condition interfered more with abstract concepts than with animal and tool concepts (mouth activation), but also with food ones. Surprisingly, we did not find a clear effect of mouth chewing on food stimuli; instead, concrete concepts were differentiated into the two classical categories of living (food and animals) and nonliving (tools) entities. Interestingly, compared to PS abstract concepts food concepts were considered more difficult in the ball than in the gum and heartbeat condition (but not than in the control and articulatory suppression one), likely because of their graspability. Hence, it appears that food was represented more as graspable, hence more in relation to the hand than to the mouth effector.

PS abstract concepts. Our prediction that, because of their higher abstractness level, PS concepts would be mostly interfered in the articulatory suppression condition was not confirmed. This however depended on the fact that, overall, articulatory suppression did not seem to interfere more with abstract concepts than with concrete ones, if not for a slight tendency that requires further studies to be investigated. Interestingly, PS abstract concepts differed from PSTQ ones in interoception, likely because of their higher abstractness level.

General Discussion

The study was aimed to test a general claim and more specific claims deriving from the WAT proposal (Borghi et al., 2018b, 2019a) and from other proposals on abstract concepts representation. According to the general claim of the WAT proposal abstract concepts are more characterized than concrete ones by linguistic experience (see also Dove, 2019, LENS proposal), hence mouth activation, and by inner grounding and interoceptive experience (see also Connell et al., 2018), and less characterized than concrete ones by sensorimotor experience related to hand experiences. This general claim was supported by our results: perceived difficulty of abstract concepts selectively increased when participants were required to perform a task requiring interoceptive awareness (heart beating condition). Furthermore, when their mouth active movement was not allowed the processing of concrete concepts and of the more concrete within abstract concepts, PSTQ, was facilitated, suggesting the presence of a higher difficulty at the increase of the abstractness level of concepts (gum chewing condition). Finally, perceived difficulty of concrete concepts, and particularly of tools, increased when participants had to manipulate an object (ball squeezing condition). Notice that, even if the instructions we gave did not specify what we intended with "difficulty" of the word, our results suggest that this was interpreted as difficulty of processing: the words perceived as easier were "dog" (cane), "grapes" (uva), and "banana" (banana), while the words perceived as more difficult across conditions were "acceleration" (accelerazione), "enigma" (enigma) and "salvation" (salvezza) (see supplementary materials).

This study was also aimed to test more specific claims concerning the way in which different kinds of abstract and concrete concepts were represented. Our results demonstrated that abstract concepts cannot be considered as a whole (Villani et al., 2019), and that different mechanisms underline their representation. Within abstract concepts, EMSS and PS concepts are more characterized by interoceptive experience than PSTQ, the more concrete among abstract concepts. Within concrete concepts, the major differences concerned tools, more grounded in sensorimotor experience (ball experience) than animals and foods: our results thus confirmed the classic distinction between living and nonliving entities. Surprisingly, this distinction did not emerge only in the ball squeezing condition, in the direction we expected, but also in the heart beating and articulatory suppression condition.

What diverged from our initial predictions was the pattern elicited by the articulatory suppression condition, which we expected to provoke selective interference with abstract concepts processing. Can we conclude that articulatory suppression, typically used to access inner speech (Alderson-Day & Fernyhough, 2015), has not a selective influence on abstract concepts? Given the discrepant results found elsewhere with response times (Zannino et al., under review), we are inclined to think that this condition did not lead to the expected results because of the task, which required an explicit evaluation and did not have any specific time constraints. Another possibility we can speculate on concerns the mechanisms underlying the mouth motor system activation. We hypothesized that three mechanisms are at play: a re-enactment of the linguistically mediated acquisition experience, an inner re-explanation of the word meaning, occurring through inner speech, and a social metacognitive mechanism, aimed at asking others information to fill our knowledge gaps. The mechanism for which inner speech is more required is likely the internal re-explanation of the word meaning. It is possible that this mechanism is less powerful than the others, at least in the present task. Further studies are needed to investigate this issue.

Overall, our study reveals that abstract concepts, compared to concrete ones, are more grounded in interoceptive and linguistic (mouth motor system) experience, and that abstract concepts are not a unitary block but that the experiences they rely on widely differ.

CHAPTER 6

EXPERTISE MATTER: THE CASE OF INSTITUTIONAL CONCEPTS

STUDY III

Is *justice* grounded? How expertise shapes conceptual representation of institutional concepts [14]

Introduction

Defining the meaning of words like "democracy" or "justice" might be much harder than defining that of more concrete words like "hat" or "cat." And yet, well over 70 % of the words we produce and understand are abstract in content (Lupyan & Winter, 2018). Abstract thought represents a sophisticated and important ability of our species: Providing an explanation of abstract concepts is, therefore, one of the key challenges for any theory of cognition.

Contemporary approaches widely agree on rejecting a marked dichotomy between abstract and concrete concepts (Wiemer-Hastings et al., 2001; Wiemer-Hastings & Xu, 2005; Barsalou, Dutriaux & Scheepers, 2018). Such a dichotomy posed important limitations: Concrete and abstract concepts were defined exclusively on their perceptual basis, respectively as denoting something that can either be directly experienced or not through our senses (i.e., Paivio, 1986; Brysbaert et al., 2014). As a consequence, defining abstract concepts negatively in terms of their lacking a physical and perceptible referent did not offer much insight into what they are.

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[14] This paper was published on *Psychological Research*, and can be accessed through this link: doi.org/10.1007/s00426-021-01492-8

According to embodied and grounded approaches, all concepts are intended as flexible entities, re-enacting and integrating relevant information of a given category in a situated context to support goal-oriented actions (Barsalou, 1999; Kiefer & Barsalou, 2013; Barsalou, et al., 2018). Importantly, it is increasingly evident that the set of information retrieved by a concept might dynamically vary across contexts, ongoing tasks, and individual differences (for a review see Yee & Thompson-Schill, 2016). Despite the fact that all concepts are variable, conceptual flexibility might be more pronounced with abstract than with concrete concepts. Category members of abstract concepts are highly heterogeneous and refer to a broad range of situations compared to concrete concepts (e.g., “ethics” vs. “chair”). Abstract concepts also show a great intra-class diversity (e.g., Kiefer & Harpaintner 2020), thereby their semantic content varies depending on the individual concepts (e.g., “logic" vs. “desire”).

One of the most fruitful lines of recent research consists in drawing fine-grained distinctions among concepts, beyond the two broad groups of abstract and concrete concepts.

Within concrete concepts, the distinction into sub-categories is widely supported by neuropsychological and neuroimaging evidence. Brain damage studies have reported category-specific semantic impairments (e.g., fruits, animals, tools) and focused particularly on the double dissociations between living and nonliving entities (Warrington & Shallice, 1984, for review see Capitani et al., 2003) or the corresponding distinction between natural kinds and artefacts (Keil, 1989). Recently, a lot of attention has been dedicated to the investigation of food, which can be considered as belonging both to natural objects and artifacts (e.g., Rumiati & Foroni, 2016). Moreover, there is compelling evidence that concrete concepts and action-related words are based on perceptual and motor information, leading to modality-specific activation of sensorimotor systems (Hauk, Johnsrude, Pulvermüller, 2004; Glenberg & Gallese, 2012).

On the other hand, abstract concepts have often been considered as a unitary class, and their diversity has been almost completely overlooked in research on conceptual knowledge. This is likely due to the difficulty in identifying clear-cut categories within the abstract concepts' domain, which includes very dissimilar kinds, each of which might evoke different types of experience. While concrete concepts mainly activate perceptual properties of the words' referents, abstract concepts, like "freedom" or "justice", elicit higher proportions of complex and rich experiences, involving episodes and situational relations (Wiemer-Hastings & Xu, 2005), emotions (Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2011; Vigliocco et al., 2013), introspection (Barsalou & Wiemer-Hastings, 2005) and interoceptive states (Connell, Lynott & Banks, 2018). Because of the higher complexity of abstract concepts when compared to concrete ones, their representation could be more affected by linguistic, cultural, and individual variability (Borghi & Binkofski, 2014; Borghi, 2019; Barsalou, 1987). In recent years, interest in abstract concepts representation has yielded a lively debate (for special topics see Borghi et al., 2018; Bolognesi & Steen, 2018), driven mainly by the observation that they do not seem to be suitable for grounding in perception and action systems. However, in order to gain a comprehensive and insightful understanding of this topic it is now becoming pivotal to focus more narrowly on specific domains of abstract concepts, and not treat them as an undifferentiated whole.

Recently, behavioral and neuroscientific studies are starting to explore the differences within abstract concepts. Several studies revealed peculiar kinds of abstract concepts grouped on the basis of their dominant features, such as emotional ones (i.e., characterized to engage bodily information; see Altarriba, Bauer, & Benvenuto, 1999; Altarriba & Bauer, 2004; Barca, Mazzuca, & Borghi, 2017; 2020; Mazzuca, Lugli, Benassi, Nicoletti, & Borghi, 2018; Ponari, Norbury, & Vigliocco, 2018; Lund, Sidhu, & Pexman, 2019), numbers and math-related concepts (i.e., strictly linked to hand effector and fingers counting habits; Fischer & Shaki, 2018; Fischer & Brugger, 2011; see also Ghio, Vaghi, & Tettamanti, 2013; Ghio, Haegert, Vaghi, & Tettamanti, 2018; and influences by congruent motion see Lugli et al., 2013; 2018; Anelli et al., 2014;), social ones (Mellem, Jasmin, Peng, & Martin, 2016), moral/aesthetics concepts (Fingerhut & Prinz, 2018), theory of mind concepts (Desai, Reilly, and van Dam, 2018).

Overall, these studies suggest that the concrete-abstract dichotomy is an overly simplistic distinction, that their relations can be better represented in multidimensional spaces where some of their features overlap (Harpaintner, Trumpp, & Kiefer, 2018; Crutch, Troche, Reilly, & Ridgway, 2013, Villani et al., 2019), and that different kinds of abstract concepts exist. Some of them have received a great deal of attention, such as emotions and numbers, while others have not been considered yet.

Within this theoretical framework, in this study we will explore a specific kind of concept for which both concrete and abstract components are relevant. Specifically, we will focus on institutional concepts, namely, concepts that connote either an institution or an institutional element, like “norm”, “parliament”, “contract”. We purposely use the term “institution” in a broad way, to include both basic concepts like “norm” and more formalized ones like “contract”, for a reason that will become apparent in what follows. In general, however, these concepts describe entities constituted by more or less formalized rules in a social framework, and they are typically and primarily used in the legal context. As in the case of other abstract concepts, institutional concepts are symbolic in nature: Their content is typically defined linguistically by a set of definitions and formal rules. At the same time, institutional objects and facts are also an outcome of intentional human activity and fulfill a specific social function. According to some theories (Searle, 1995; 2010), institutional concepts can be considered as referring to a particular kind of human-made objects that perform their function not in virtue of their physical features, as in the case of standard concrete artefacts, but via collective acceptance of the relevant rules by a given community.

The cognitive structure of institutional concepts, and their relations with artefacts, has been the object of a recent study which compared concrete and abstract standard artefacts (e.g., screwdriver vs. poetry), concrete and abstract institutional entities (e.g., signature vs. ownership), and concrete and abstract social entities (e.g., choir vs. friendship) in a property-generation task (Roversi et al., 2013). Results showed that institutional concepts are more similar to physical artefacts than to social entities (see also Noyes et al., 2018, where it is argued that the similarity between institutional and standard artefacts is close to identity in young children). Specifically, social entities such as “choir” elicited a higher proportion of contextual situations or events associated with target concepts (e.g., choir-concert), while institutional concepts such as “ownership” mainly evoked normative relations and paradigmatic examples (e.g., ownership-testament), and standard artefacts such as “screwdriver” more frequently evoke partonomic relations (e.g., screwdriver-handle).

The findings also indicate that the abstract–concrete distinction is more marked within the social domain than in that of institutions and standard artefacts. The authors found that the relevance of exemplification and normative relations for institutional artefacts and the role of partonomic relations for standard artefacts do not change substantially for abstract or concrete cases, whereas the relevance of situational relations for social concepts in opposition to institutional artefacts is more specifically connected to abstract than to concrete social concepts. Even if all institutional concepts are characterized by abstract content, some of them – especially legal institutions – can be ordinary objects or states of events that acquire a new status (e.g., contract, marriage), and in this case they could be understood as artefacts in a proper sense (Burazin et al, 2018).

An important point, however, is that undoubtedly the institutional domain is rooted in some general social concepts. Concepts like “justice”, “responsibility”, “sanction”, “duty”, “rights” not only find their background in the social community but also define the general framework in which other, more technical institutional concepts like “contract”, “president”, or “marriage” are framed: While the latter are “pure institutional” concepts in the sense that they depend on formalized institutions and rules, the former could rather be qualified as “meta-institutional” concepts, because they are necessary to define the content of institutions but are not defined by those institutions. Just as there cannot be competitive games without the concept of victory, no legal system could be defined without a conception of “justice” or the concept of “duty”, “rights”, “sanctions”, and the meaning of these concepts do not depend on a specific legal system but on the general social framework (see Roversi, 2016, Lorini, 2014). In this work, while analyzing institutional concepts in opposition to other kinds of concepts, we have also added this new layer of specification: technical, “pure-institutional concepts” *vs.* more social, “meta-institutional concepts.”

We build our study about the conceptual representation of institutional concepts on three methodological assumptions.

First, to serve as a contrast for institutional concepts we have introduced both abstract and concrete categories of concepts, which are both human-related but to a different extent. We chose Theoretical concepts of mathematics and physics (e.g., sum, energy) which possess a specific object as referent, but their referent change (e.g., nuclear energy, kinetic energy) and can be ascribed to a specific area of knowledge, as in the case of Institutional ones (Villani et al., 2019). With regard to concrete concepts, we included simple and complex Artefacts (e.g., hammer and computer, respectively) that have a specific function (for a review see Martin 2007), and Food concepts (e.g., banana, pepper), that are neither artifact nor natural but that can be both depending on the circumstances (Rumiati & Foroni, 2016). We intend to verify whether only a marked distinction between concrete *vs.* abstract categories emerges or more subtle differences are present.

We also aim at verifying whether and to what extent the above mentioned sub-groups of Pure-institutional (e.g., marriage, contract) and Meta-institutional (e.g., rights, duty) differ across the rated dimensions.

Second, in order to observe the difference among categories and to assess the role of different grounding sources, we collected ratings on 16 dimensions (see below) already used in a previous norming study (Villani et al., 2019). This aim was driven by the fact that recent proposals have indeed suggested that multiple systems – not only sensorimotor ones – are engaged in shaping conceptual representation. According to multiple representation views, abstract concepts are grounded in situational and perceptual information just like concrete concepts (Cuccio & Gallese, 2018; Pulvermüller, 2018), but they also involve to a large extent linguistic, inner (interoceptive and emotions) and social experience (Borghi et al., 2018a; Dove, 2016; 2018; Vigliocco et al., 2013; Newcombe, Campbell, Siakaluk, & Pexman, 2012; Connell & Lynott, 2018). In this vein, we will focus on Words As social Tools proposal (WAT, Borghi & Binkofski, 2014; Borghi et al., 2018a, 2018b; 2019), according to which words can be considered as social tools useful to operate in external environment, and as inner tools, useful to support our categorization and thought process. Since instances of abstract concepts are more heterogeneous and different from those of concrete concepts (they do not have a single referent and activate a wider variety of situations, e.g., “cause” vs. “table”), WAT proposes that linguistic mediation and social input by others are fundamental for their acquisition and that this experience influences their representation and use. In our view, linguistic and social dimensions are particularly relevant in considering Institutional concepts since they are both language-based concepts and social constructs defined collectively.

Third, we have argued that conceptual knowledge is flexibly modulated in function of context and personal experiences (Casasanto & Lupyan, 2015). Hence, we are interested in exploring whether the conceptual representation of Institutional concepts might vary depending on the degree of the participants’ expertise in the legal framework. To this end, we contrast the ratings of each dimension obtained from experts in the legal domain, i.e., law graduates and law professionals (Law-group), with those obtained with laypeople, i.e., students and professionals of other fields (Control-group). The effect of expertise on conceptual knowledge is well-documented in the concrete domain, for example Medin et al. (1997) have shown that taxonomists, landscape workers, and park maintenance personnel categorize concrete items such as trees differently (see also Johnson & Mervis 1998; Tanaka & Taylor 1991). To the best of our knowledge, only a few studies attempted to observe the impact of expertise in the abstract domain. Borghi, Caramelli and Setti (2016) obtained different definitions of three abstract concepts belonging to the “safety and security at workplace” domain from four different categories of workers. Interestingly, Roversi et al. (2013) showed that students, law graduates and law professionals listed different features of institutional concepts: To ground the meaning of institutional concepts law professionals tended to appeal more to exemplification relations (e.g., ownership-house) than graduates in law. This testifies that graduates need to instantiate concepts in a context in order to represent them, while this need is not present with law professionals for whom such concepts have become familiar. Even if relevant to our aims, the results of this previous study were preliminary, and pertained only to a small number of participants in each group.

Given these assumptions, we have formulated the following predictions:

(1) *Institutional concepts vs. other categories.* In line with the idea that concepts are multidimensional constructs, where embodied, inner, linguistic, and social dimensions interact to different extent (Borghi et al., 2018), we expected that the ratings obtained for Institutional concepts would differ from those observed for other categories. Specifically, we hypothesize that Institutional concepts would be similar to other abstract concepts in some respects; hence they should score higher in abstractness and less in imageability than concrete ones, and they should be acquired later and more through the linguistic modality than through perception. However, because Institutional concepts serve to regulate social practices through shared sets of values, we expect them to be more linked to social dimensions when compared to Theoretical concepts. In addition, we expected that they would be at least in part grounded in physical interaction, similarly to standard Artefacts.

(2) *Institutional concepts vary across expertise.* In keeping with research on conceptual flexibility, we predict that conceptual representation of Institutional concepts is not fixed but may be sensitive to the level of participant expertise. Specifically, we assumed

that semantic representation is influenced by a complex set of experiences connected with concepts referent, including the modality of acquisition and the use of concept in a given context. Jurists do not only have a wider and deeper knowledge of institutional concepts than laypeople, but they also acquired their meaning through formal language and by the support of competent others. Further, differently from non-experts, law-experts master the use of institutional concepts and their consequent effects (e.g., a set of acts associated with a process). Thus, we hypothesize that these acquisition experiences and the real use of institutional concepts by expertise has an influence on their representations. We predict that the representation of institutional concepts in the Law and Control groups differ in function of qualitative factors, namely the kind of experiences associated with their semantic content. Given the exploratory character of the expertise variable, we only formulate a general prediction. Since experts in law (Law-group) develop a higher level of formalism in legal framework (e.g., a precise reference to legislative institutions, doctrines) than non-experts (Control group), they might evaluate Institutional concepts as more linked to linguistic dimensions and less to sensorimotor ones. At the same time, law experts (Law-group) are typically more accustomed to the legal field than non-experts, leading to the hypothesis that they represent Institutional concepts as contextually situated, and linked to their own personal life experience, while non-experts (Control-group) might have a more abstract representation.

(3) *Insight into the Institutional domain.* Given the compound structure of Institutional concepts, some differences should emerge within this category. Since Meta-institutional concepts form the conceptual background for the more specific

institutional frameworks, we hypothesize that these concepts have more generic abstract features (high scores in linguistic, social, and inner dimensions), while the Pure-institutional ones bear greater similarity with “technical” and concrete concepts of artifacts (high scores in sensorimotor dimensions).

Method

Participants

567 participants (409 female, $M_{age} = 24.02$; $SD_{age} = 5.97$) volunteered for the study. All participants were recruited among students and researchers of the University of Bologna, and people who work in the Bologna area. Participants were divided in two groups: 289 law graduates or law professionals (Law-group: 204 female, $M_{age} = 22.47$; $SD_{age} = 5.25$; $M_{years\ of\ university\ education} = 2.79$; $SD_{years\ of\ university\ education} = 1.8$) and 278 graduates or professionals in fields different from law, such as philosophy, art, communication science (Control-group: 205 female, $M_{age} = 25.\ 64$; $SD_{age} = 6.24$; $M_{years\ of\ university\ education} = 3.71$; $SD_{years\ of\ university\ education} = 1.5$). The following experiment fulfilled the ethical standard procedure recommended by the Italian Association of Psychology (AIP). All procedures were approved by the Bioethics committee of the University of Bologna. All participants gave their written informed consent to participate in the study.

Materials

Materials consisted of 56 words. Half of them were abstract and the other half were concrete ones. For each group we considered two sub-categories of concepts: Theoretical and Institutional categories for abstract and Food and Artefacts categories for concrete concepts. A set of 14 Theoretical abstract concepts (i.e., *mass, acceleration, subtraction, temperature, sum, energy, liter, meter, gravitation, calculation, equation, molecule, electron, multiplication*) were taken from the Villani et al. database (2019) where a cluster of Physical, Spatial-Temporal and Quantitative concepts was individuated. We included 14 Institutional concepts already used in the previous studies on Institutional concepts (Roversi et al., 2013; 2017). In selecting institutional concepts, we took care to insert half Pure-institutional (i.e., *contract*, *state*, *president*, *marriage*, *parliament*, *trial*, *property*) and half Meta-institutional concepts (i.e., *norm*, *rights*, *duty*, *sanction*, *responsibility*, *validity*, *justice*). For what concern concrete concepts, we included 14 natural Food concepts (i.e., *banana, carrot, grape, strawberry, mushroom, eggplant, pepper*, *tomato, pumpkin, basil*, *apple*, *orange, chestnut, potato*) and 14 Artefacts concepts (i.e., *hammer, wheel, knife, pot, spoon, tower, umbrella, bed; screwdriver, painting; chair, sculpture, book, computer*), selected from Della Rosa et al. (2014) and Barca et al. (2002) databases.

Procedure

Based on the Villani et al. (2019) procedure, we asked participants to evaluate each word on 7-point Likert scale, choosing randomly only one of the following dimensions: Abstractness-Concreteness (ABS-CNR); Imageability (IMG, Paivio, 1990); Contextual Availability (CA, Schwanenflugel et al., 1992); Familiarity (FAM); Age of Acquisition (AoA) (e.g., Gilhooly & Logie, 1980); Modality of Acquisition (MoA, Wauters et al., 2003); Social Valence (SOC, Barsalou & Wiemer-Hastings, 2005); Social Metacognition (MESO, Borghi et al., 2019); Arousal (ARO); Valence (VAL) (e.g., Bradley & Lang, 1999; Warriner, Kuperman, & Brysbaert, 2013); Interoception (INT, Connell & Lynott, 2018); Metacognition (META); perceptual strength in the Vision, Hearing, Touch, Taste and Smell modalities (VIS; HEA; TOU; TAS; SME, Connel & Lynott, 2013); Body-Object Interaction (BOI; Bennett, Burnett, Siakaluk, & Pexman, 2011; Pexman, Muraki, Sidhu, Siakaluk & Yap, 2019); Mouth involvement (MOUTH); Hand involvement (HAND) (e.g., Borghi & Zarcone, 2016). See for the rating instructions given to participants, and supplementary materials for theoretical discussion on each dimension.

Table 1 Rating Instruction for each dimension.

Dimension	Instruction
Abstractness-Concreteness (ABS)	rate how much each word is abstract or concrete 1 = very abstract; 7 = very concrete
Imageability (IMG)	rate how much the word arouses mental images, visual representation, a sound or some other sensory experience 1 = hardly imageable; 7 = highly imageable
Contextual availability (CA)	rate on the ease with which you can think of a context for each word 1 = very hard; 7 = very easy
Familiarity (FAM)	rate how familiar you are with the word, namely how much do you know its meaning. 1 = unfamiliar; 7 = very familiar
Age of Acquisition (AoA)	indicate the age at which you think you learned each word 1 = 0-2 years; 2 = 3-4 years; 3 = 5-6 years; 4 = 7-8 years; 5 = 9-10 years; 6 = 11-12 years; 7 = 13+
Modality of Acquisition (MoA)	rate how you think you have learned the meaning of word: through experience, through language or a combination of the two 1 = experience; 7 = language
Social valence (SOC)	rate how much the word evokes social circumstance 1 = not at all, 7 = very
Social metacognition (MESO)	rate how much you think you have or needed others to understand the meaning of each word 1 = never; 7 = almost always
Arousal (ARO)	rate how much each word evokes emotions 1 = not at all; 7 = very
Valence (VAL)	rate how much each word evokes positive or negative emotions 1 = negative emotions; 7 = positive emotions
Interoception (INT)	rate how much the word evokes an internal body state 1 = not at all; 7 = very
Metacognition (META)	rate how much the word evokes mental and cognitive processes, or more generally as it seems to you concerning processes that occur in the brain 1 = not at all; 7 = very
Perceptual strength in the vision, hearing, touch, taste, and smell modalities (VIS/HEA/TOU/TAS/SME)	rate to what extent do you experience of word through each of the five senses (i.e., “by vision”, “by touch”, “by hearing”, “by smelling” and “by tasting”) 1 = not at all; 7 = very
Body-Object Interaction(BOI) [15]	rate each word on the ease with which human body physically interacts with the object/entity to which the word refers 1 = easy; 7 = difficult
Mouth involvement (MOUTH)	rate how much the mouth is involved in a possible action with the named entity 1 = not at all; 7 = very
Hand involvement (HAND)	rate how much the hand is involved in a possible action with the named entity 1 = not at all; 7 = very

[15] Notice that the scale used for the body-object-interaction (BOI) is the opposite than that used in the previous literature (e.g., Siakaluk et al., 2008). Here, the low BOI score refers to things that the human body can easily interact with, (“high BOI”) and the high BOI score refers to things that are not easy for the human body to interact with (“low BOI”). The BOI results reported in Table 2 and Table 3 should be interpreted according to this value.

Data collection

For each dimension, a survey was created and administered through Google Form. Following the consent form and instruction page, participants were presented the full list of stimuli in randomized order. Notice that each rating was administered in order to obtain an equal sample of participants into the Law and Control groups, resulting in at least 15 participants per group in each dimension (ABS-CNR = 20, 22; IMG =18, 15 ; CA = 19,16; FAM = 15, 15; AoA =21, 21 ; MoA = 16, 16; SOC = 16,15; MESO = 18,18; ARO = 17, 17; VAL = 18,18; INT =15,15 ; META = 23, 17 ; VIS, HEA, TOU, TAS, SME = 16, 16; BOI = 23, 23; MOUTH = 15, 18; HAND = 19, 16; Law and Control participants, respectively for each dimension).

Statistical Analysis

The analysis was conducted on the rating values obtained in each dimension. Generalized Estimated Equations (GEE) with Gamma function [16] was used instead of standard analysis of variance since rating values were discrete rather than continuous variables (Dixon, 2008).

For each dimension, the factors taken into consideration were *Category* (Institutional, Theoretical, Food and Artefact) as within-subject factor and *Group* (Law-group and Control-group) as between-subject factor. Since we were particularly interested to verify whether Institutional concepts differed from other categories of concepts, in each dimension we performed a planned single contrast between the rating values obtained for Institutional concepts *vs.* Food, Artefacts and Theoretical concepts.

[16] GEE model with Linear function was also conducted. Results did not differ from those obtained using Gamma function

To explore the subtle differences within Institutional concepts, we performed an additional Generalized Linear Models (GLM) with Gamma function [17], considering *Type of Institutional* (Pure-institutional and Met-institutional) as within-subject factor and *Group* (Law-group and Control-group) as between-subject factor.

Results

Results of the GEE models are reported in detail in Table 2 for each dimension. They showed a significant main effect *Category* in all rated dimensions, demonstrating that the categories (i.e., Institutional, Theoretical, Food and Artefact) are widely different from each other (see planned contrast in Table 2 for a comparison across categories). In all dimensions, the main effect *Group* was not significant, revealing that, overall, no difference emerged between the Law-group and the Control-group. Interestingly, however, the interaction between *Category* and *Group* was significant in some dimensions (i.e., CA, FAM, AoA, VAL, TOU see Figure 1). Means, for each dimension, in function of the interaction *Group* x *Category* are reported in the supplementary materials.

Table 2. Results of Generalized Estimated Equations (GEE) with *Category* (Institutional, Theoretical, Food, Artefact) as within-subject factor and *Group* (Law-group and Control-group) as between-subject factor. Planned single contrast for the *Category*, between the scores obtained for Institutional concepts vs. Food, Artefacts and Theoretical concepts, are reported. In bold are reported significant results.

[17] GLM model with Linear function was also conducted. Results did not differ from those obtained using Gamma function

		Category				Group			Group x Category		
		Wald	*Df*	*p*		*Wald*	*Df*	*p*	*Wald*	*Df*	*p*
ABS-CNR		196.417	3	**.001**		.341	1	.599	2.088	3	.554
	Institutional (M = 4.1)				Law (M = 5.2)						
	vs. Theoretical (M = 4)	170	1	1							
	vs. Food (M = 6.8)	211.107	1	**.001**	Control (M = 5.1)						
	vs. Artefact (M = 6.7)	207.222	1	**.001**							
IMG		221.223	3	**.001**		1.386	1	.239	6.536	3	.088
	Institutional (M = 3.9)				Law (M = 5.2)						
	vs. Theoretical (M =3.9)	.012	1	1							
	vs. Food (M = 6.7)	334.223	1	**.001**	Control (M = 4.9)						
	vs. Artefact (M = 6.6)	374.983	1	**.001**							
CA		66.544	3	**.001**		2.079	1	.149	28.854	3	**.001**
	Institutional (M = 4.9)				Law (M = 5.0)						
	vs. Theoretical (M =4.3)	15.181	1	**.001**							
	vs. Food (M = 5.8)	8.793	1	**.009**	Control (M = 5.4)						
	vs. Artefact (M = 5.7)	16.222	1	**.001**							
FAM		40.988	3	**.001**		2.452	1	.117	40.513	3	**.001**
	Institutional (M = 5.9)										
	vs. Theoretical (M= 5.0)	31.405	1	**.001**	Law (M = 5.6)						
	vs. Food (M = 6.3)	3.315	1	.206							
	vs. Artefact (M = 6.1)	1.413	1	.704	Control (M = 6.1)						
AoA		352.688	3	**.001**		1.462	1	.227	16.806	3	**.001**
	Institutional (M = 4.6)				Law (M = 3.0)						
	vs. Theoretical (M =4.3)	10.654	1	**.03**							
	vs. Food (M = 2.1)	353.02	1	**.001**	Control (M =3.3)						
	vs. Artefact (M = 2.4)	397.889	1	**.001**							
MoA		93.817	3	**.001**		.269	1	.604	1.085	3	.781
	Institutional (M = 4.5)				Law (M = 3.2)						
	vs. Theoretical (M =5)	2.033	1	.462							
	vs. Food (M = 1.9)	209.358	1	**.001**	Control (M = 3.3)						
	vs. Artefact (M = 2.3)	209.422	1	**.001**							
SOC		81.594	3	**.001**		.685	1	.408	3.911	3	.271
	Institutional (M = 5.7)				Law (M = 3.0)						
	vs. Theoretical (M =2.8)	132.286	1	**.001**							
	vs. Food (M = 2.2)	125.665	1	**.001**	Control (M = 3.4)						
	vs. Artefact (M = 3)	114.944	1	**.001**							
MESO		284.447	3	**.001**		.433	1	.511	6.564	3	.087
	Institutional (M = 3.2)				Law (M = 2.1)						
	vs. Theoretical (M =3.2)	.246	1	1							
	vs. Food (M = 1.2)	75.445	1	**.001**	Control (M = 1.9)						
	vs. Artefact (M = 1.4)	79.852	1	**.001**							
ARO		68.102	3	**.001**		.709	1	.400	6.428	3	.093
	Institutional (M = 4)				Law (M = 2.8)						
	vs. Theoretical (M =2.7)	77.634	1	**.001**							
	vs. Food (M = 2.7)	31.511	1	**.001**	Control (M = 3.1)						
	vs. Artefact (M = 2.9)	49.081	1	**.001**							
VAL		28.779	3	**.001****		3.045	1	.081	12.337	3	**.006**
	Institutional (M = 4.6)				Law (M = 4.7)						
	vs. Theoretical (M =4.1)	6.336	1	**.035***							
	vs. Food (M = 5)	7.142	1	**.023***	Control (M = 4.3)						
	vs. Artefact (M = 4.5)	.188	1	1							

INT		24.954	3	**.001**		.036	1	.849	.431	3	.934
	Institutional (M = 4)				Law (M = 3.4)						
	vs. Theoretical (M =3.1)	14.664	1	**.001**							
	vs. Food (M = 3.2)	7.195	1	**.022**	Control (M = 3.3)						
	vs. Artefact (M = 3.1)	19.773	1	**.001**							
META		64.688	3	**.001**		3.002	1	.083	6.088	3	.107
	Institutional (M = 4.7)				Law (M = 3.3)						
	vs. Theoretical (M =3.6)	33.221	1	**.001**							
	vs. Food (M = 2.7)	51.286	1	**.022**	Control (M = 3.8)						
	vs. Artefact (M = 3.3)	43.077	1	**.001**							
VIS		56.441	3	**.001**		1.329	1	.249	7.583	3	.055
	Institutional (M = 4.4)				Law (M = 5.3)						
	vs. Theoretical (M =4.5)	.165	1	1							
	vs. Food (M = 5.9)	36.533	1	**.001**	Control (M = 4.9)						
	vs. Artefact (M = 6.0)	51.110	1	**.001**							
HEA		94.733	3	**.001**		.702	1	.402	6.096	3	.107
	Institutional (M = 3.5)				Law (M = 2.7)						
	vs. Theoretical (M =2.5)	39.864	1	**.001**							
	vs. Food (M = 1.7)	76.163	1	**.001**	Control (M = 2.4)						
	vs. Artefact (M = 3)	6.930	1	**.025**							
TOU		269.925	3	**.001**		3.654	1	.056	26.073	3	**.001**
	Institutional (M = 2)				Law (M = 3.6)						
	vs. Theoretical (M =2.6)	30.625	1	**.001**							
	vs. Food (M = 4.9)	136.141	1	**.001**	Control (M = 3.0)						
	vs. Artefact (M = 4.8)	336.637	1	**.001**							
TAS		1099.220	3	**.001**		.587	1	.443	1.642	3	.650
	Institutional (M = 1.3)				Law (M = 2.0)						
	vs. Theoretical (M =1.4)	.991	1	.959							
	vs. Food (M = 6)	661.493	1	**.001**	Control (M = 1.9)						
	vs. Artefact (M = 1.6)	18.369	1	**.001**							
SME		251.863	3	**.001**		2.249	1	.134	2.040	3	.564
	Institutional (M = 1.5)				Law (M = 2.4)						
	vs. Theoretical (M =1.6)	1.088	1	.891							
	vs. Food (M = 4.8)	201.666	1	**.001**	Control (M = 2.0)						
	vs. Artefact (M = 2.2)	76.979	1	**.001**							
BOI		42.130	3	**.001**		.968	1	.325	.639	3	.887
	Institutional (M = 4.1)				Law (M = 2.5)						
	vs. Theoretical (M =3.6)	6.441	1	**.031**							
	vs. Food (M = 1.7)	52.684	1	**.001**	Control (M = 2.8)						
	vs. Artefact (M = 2)	50.701	1	**.001**							
MOUTH		43.359	3	**.001**		2.344	1	.126	1.021	3	.796
	Institutional (M = 3.9)				Law (M =3.7)						
	vs. Theoretical (M =2.8)	21.312	1	**.001**							
	vs. Food (M = 5.1)	7.802	1	**.016**	Control (M = 3.3)						
	vs. Artefact (M = 2.8)	14.301	1	**.001**							
HAND		66.526	3	**.001**		.456	1	.500	5.393	3	.145
	Institutional (M = 2.9)				Law (M = 3.6)						
	vs. Theoretical (M =2.9)	.025	1	1							
	vs. Food (M = 4.5)	18.172	1	**.001**	Control (M = 3.8)						
	vs. Artefact (M = 4.8)	45.339	1	**.001**							

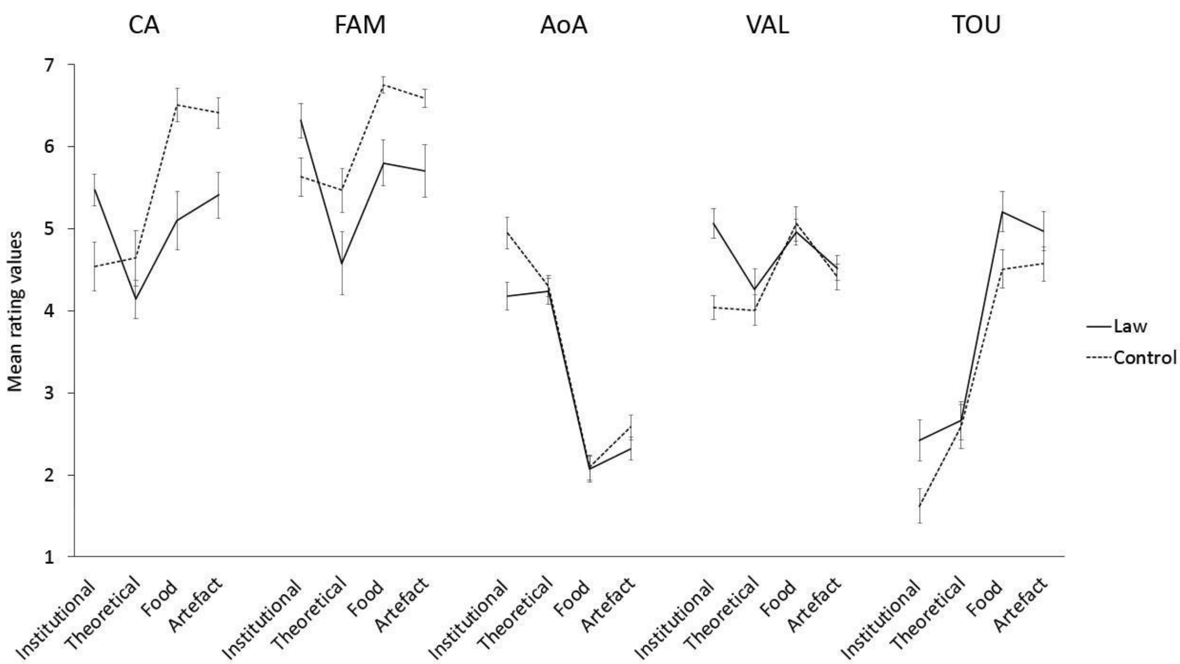


Figure 1. Mean rating values for *Group* (Law-group and Control-group) as a function of *Category* (Institutional, Theoretical, Food, Artefact) in the following dimension: Contextual Availability (CA), Familiarity (FAM), Age of Acquisition (AoA), Valence (VAL), Perceptual strength in touch (TOU). Error bars indicate standard errors of the mean.

Results of the GLM are reported in detail in Table 3. They revealed that the main effect *Type of Institutional* was significant in some dimensions (i.e., ABS-CNR, IMG, CA, MESO, ARO, VAL, INT, META, VIS, MOUTH), thus the two type of institutional concepts (i.e., Pure and Meta) significantly differ across specific dimensions. The main effect *Group* was significant in few dimensions (i.e., CA, FAM, AoA, MoA, VAL, VIS, HEA, TAS), revealing that, overall, a difference emerged between the Law-group and the Control-group. Crucially, the interaction *Group* x *Type of Institutional* was significant in some dimensions (i.e., ABS-CNR, CA, MoA, VAL; see Figure 2) Means, for each dimension, in function of the interaction *Group* x *Type of Institutional* are reported in the supplementary materials.

Table 3. Results of Generalized Linear Models (GLM) applied for each dimension with *Type of Institutional* (Pure-institutional and Meta-Institutional) as within-subject factor and *Group* (Law-group and Control-group) as between-subject factor. In bold are reported significant results.

	Group			Type of Institutional			Group x Type		
	Wald	Df	p	Wald	Df	p	Wald	Df	p
ABS-CNR	.612 Law (M = 4.1) Control (M = 3.7)	1	.434	29.960 Pure (M = 4.6) Meta (M = 3.3)	1	**.001**	3.888	1	**.049**
IMG	3.073 Law (M = 4.1) Control (M = 3.4)	1	.080	45.000 Pure (M = 4.9) Meta (M = 2.8)	1	**.001**	3.683	1	.055
CA	4.789 Law (M = 5.6) Control (M = 4.6)	1	**.029**	24.696 Pure (M = 5.6) Meta (M = 4.6)	1	**.001**	7.607	1	**.006**
FAM	4.648 Law (M = 6.3) Control (M = 5.6)	1	**.031**	5.791 Pure (M =5.8) Meta (M =6.0)	1	**.016**	.376	1	.540
AoA	12.269 Law (M =4.0) Control (M =5.0)	1	**.001**	2.041 Pure (M = 4.4) Meta (M = 4.6)	1	.153	.555	1	.456
MoA	9.924 Law (M =5.0) Control (M = 5.7)	1	**.002**	.001 Pure (M =5.3) Meta (M =5.3)	1	.973	5.643	1	**.018**
SOC	1.837 Law (M = 6.1) Control (M = 5.5)	1	.175	.084 Pure (M = 5.8) Meta (M = 5.8)	1	.772	.084	1	.772
MESO	.024 Law (M = 3.2) Control (M =3.1)	1	.878	10.057 Pure (M = 2.9) Meta (M = 3.4)	1	**.002**	.052	1	.819
ARO	1.222 Law (M = 4.3) Control (M = 3.8)	1	.269	18.606 Pure (M = 3.5) Meta (M = 4.7)	1	**.001**	.073	1	.786
VAL	14.994 Law (M = 5.2) Control (M = 4.1)	1	**.001**	9.006 Pure (M = 4.4) Meta (M = 5.0)	1	**.003**	5.894	1	**.015**
INT	.008 Law (M = 3.8) Control (M =3.8)	1	.929	21.134 Pure (M = 3.4) Meta (M = 4.2)	1	**.001**	.454	1	.500
META	.226 Law (M = 4.8) Control (M =4.6)	1	.635	10.515 Pure (M = 4.3) Meta (M = 5.1)	1	**.001**	.769	1	.381
VIS	4.129 Law (M = 5.0) Control (M =3.9)	1	**.042**	26.986 Pure (M = 5.2) Meta (M = 3.7)	1	**.001**	.000	1	.996
HEA	5.589 Law (M =4.1) Control (M =2.7)	1	**.018**	.000 Pure (M = 3.3) Meta (M = 3.3)	1	1.000	.000	1	1.000
TOU	3.439 Law (M = 2.1) Control (M =1.4)	1	.064	.436 Pure (M = 1.8) Meta (M =1.7)	1	.509	.011	1	.916
TAS	3.874 Law (M =1.1) Control (M =1.0)	1	**.049**	1.103 Pure (M =1.0) Meta (M =1.0)	1	.294	1.103	1	.294
SME	1.611	1	.204	.057	1	.812	.057	1	.812

	Law (M = 1.5) Control (M =1.1)			Pure (M =1.3) Meta (M = 1.3)					
BOI	3.584 Law (M = 3.5) Control (M = 4.5)	1	.058	1.670 Pure (M = 3.8) Meta (M = 4.1)	1	.196	1.123	1	.289
MOUTH	2.072 Law (M = 4.3) Control (M =3.5)	1	.150	6.995 Pure (M = 4.0) Meta (M = 3.7)	1	**.008**	1.508	1	.219
HAND	.793 Law (M = 2.4) Control (M = 2.9)	1	.373	3.544 Pure (M = 2.8) Meta (M = 2.5)	1	.060	1.690	1	.194

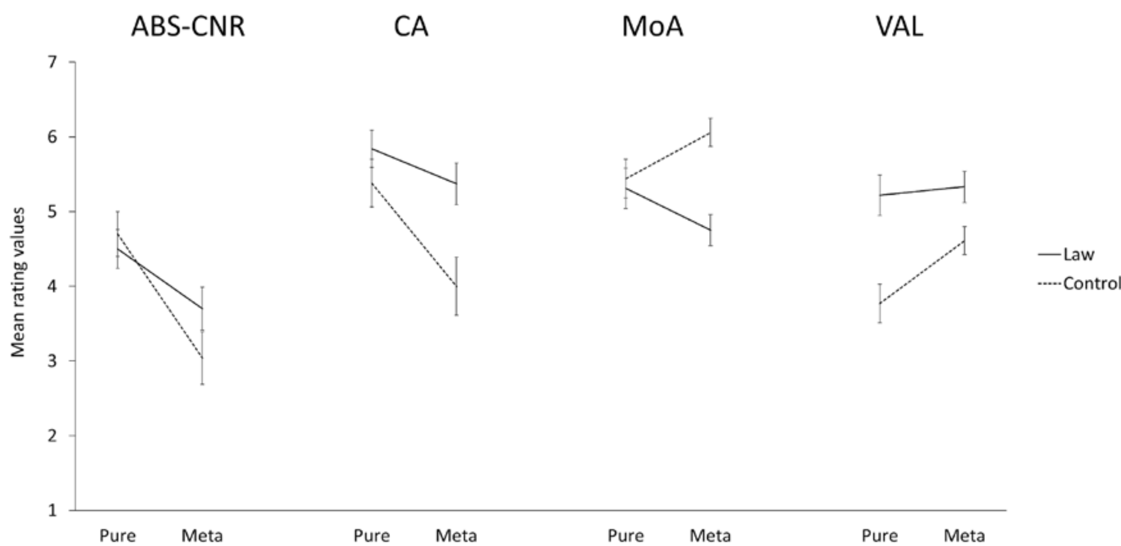


Figure 2. Mean rating values for *Group* (Law-group and Control-group) as a function of *Type of Institutional* (Pure, Meta) in the following dimension: Abstractness-Concreteness (ABS-CNR), Contextual Availability (CA), Modality of Acquisition (MoA), Valence (VAL). Error bars indicate standard errors of the mean.

Discussion

Overall, our findings confirm that the categories we investigated (Institutional, Theoretical, Food and Artefact) are widely different from each other and shed light on the more subtle differences among a specific domain of abstract concepts and other categories of concepts. Crucially, some of the obtained differences were affected by individual experience. Here, we will summarize and discuss firstly the results on Institutional concepts comparing them with concrete concepts and all other categories, secondly Institutional concepts related to group differences and thirdly, subtypes of Institutional concepts.

Institutional concepts vs. other categories

From our results, we could make a distinction between (1) the dimensions in which Institutional concepts differ only from concrete concepts, (2) the dimensions in which they differ from all categories, including Theoretical concepts, and (3) the dimension in which Institutional concepts differ only from Theoretical concepts but not from all other categories.

(1) The first case regards the dimensions of Abstractness-Concreteness (ABS-CNR), Imageability (IMG), Modality of Acquisition (MoA), Social Metacognition (MESO), Vision, Taste and Smell modalities (VIS; TAS and SME) and Hand involvement (HAND). Since in these dimensions Institutional concepts differ only from both kinds of concrete concepts (i.e., Food and Artifact), this means that Institutional and Theoretical concepts do not differ, but they share some properties that make them dissimilar to concrete concepts. In fact, compared to concrete concepts they are both evaluated as highly abstract and less imageable; they are mainly linguistically acquired (high MoA) and they involve a stronger need to rely on others, in order to understand their meaning (high MESO). In addition, abstract concepts are less experienced through perceptual modalities compared to concrete ones (i.e., vision, taste, and smell), and the hand effector is less involved in a possible action with them.

Overall, results confirm that abstract concepts are more detached from perceptual modalities (Barsalou, 2003). Crucially, they also show other components which contribute to the grounding of abstract concepts, in line with multiple representation views. The high values of Modality of Acquisition and Social Metacognition for abstract concepts fully confirms the prediction of the WAT proposal (Borghi et al., 2018a; 2019), and testifies that the higher the abstractness of words, the more we need others' support, and that linguistic and social experiences play a crucial role in representing abstract concepts.

(2) The second case concerns dimensions of Context Availability (CA), Age of Acquisition (AoA), Social Valence (SOCIAL), Arousal (ARO), Valence dimension (VAL), Interoception (INT), Metacognition (META), Hearing (HEA), Touch modalities (TOU), Body-Object Interaction (BOI) and Mouth involvement (MOUTH). These results suggest that Institutional concepts possess specific features that distinguish them from other concepts, including abstract ones. Compared to Theoretical, Food and Artefact concepts, Institutional concepts are more linked to a specific context (high CA); they are acquired later (high AoA); they evoke more social experience (high SOC); they are characterized by evoking inner emotional and cognitive states (i.e., high ARO, INT, META); they denote entities with which is not easy to physically interact (high BOI, that correspond to low BOI score according to the scale used in previous studies, e.g., Siakaluk et al., 2008); they require an higher mouth and hearing activation (high HEA and MOUTH) but less tactile interaction (low TOU). Institutional concepts were perceived as more positive than Theoretical concepts, and more negative than Food concepts (higher and lower values in the VAL, respectively), however, they did not differ from Artefacts.

From an embodied perspective, it is interesting to note that Institutional concepts were characterized by both mouth and hearing dimensions, suggesting a clear link to the use of language in a social context. This pattern is in keeping with the specific claim of WAT that abstract conceptual representation not only lead to the activation of linguistic and social experiences, but also engage the mouth motor systems to a larger extent than concrete concepts. Three different mechanisms, that are not necessarily exclusive, might underlie such a mouth activation (for details see Borghi et al., 2019): (A) Re-enactment of the past experience of acquiring abstract concepts, which typically occurred through the verbal linguistic mediation (Granito et al., 2015; Barca et al., 2017, 2020; Mazzuca et al., 2018). (B) Re-explanation to ourselves of the word meaning, through the use of inner speech (Zannino et al., submitted; Villani et al., 2021; Dove et al., 2020; Borghi, 2020). (C) A motor preparation to ask additional explanations of word meaning to others, derived from the feeling of uncertainty and the metacognitive awareness that the owned knowledge of that concept is scarce and not adequate (i.e., Social Metacognition, Borghi et al., 2019; Fini & Borghi, 2019; see Borghi, Fini & Tummolini, in press; Borghi, 2020; Dove et al., 2020; see also Prinz, 2012; Shea, 2018). The case of Institutional concepts, which can be considered as highly complex words, may include either the mediation of inner and overt speech or simulation of listening to someone else speaking. Collecting new evidence will be pivotal to disentangle between these mechanisms with respect to specific sub-kind of concepts.

3) The third case concerns familiarity dimensions (FAM). Planned contrasts showed that Institutional concepts were rated as more familiar than Theoretical concepts, while no difference emerged with Food and Artefact concepts. This means that the participants are more familiar with meanings conveyed by institutional concepts compared to other concepts with the same abstractness level, namely physical and mathematical terms.

Generally, our main prediction was confirmed by results: Social/linguistic experiences contribute to the shaping of Institutional concepts. However, the social context and hence the inter-subjective dimension resonates with a distinctively intra-subjective dimension in the conceptualization of institutions, which are perceived as being dependent on our mental states and involve a considerable state of emotional arousal. Apart from the *quantity* of arousal, which is significant, also the *quality* of the arousal behind institutional concepts is particular interesting: When compared with abstract Theoretical concepts, Institutions require some degree of positive emotional support, but on the whole the weak positive valence that seems also typical of tools and other artifacts, not the strong positive valence that is elicited by basic needs. This emotional element will be further specified below in the light of the distinction between Pure-institutional and Meta-institutional concepts.

Institutional concepts vary across Expertise.

In line with our prediction, we found that the conceptualization of Institutional concepts is modulated by different kinds of personal experience. Results (see Figure 1) showed that participants who have more experience in the legal framework (i.e., Law group), compared to those that haven't (i.e., Control group), rated Institutional concepts as more contextually situated (high CA), slightly more familiar (FAM), as acquired earlier (low AoA), and as associated to a more positive valence (high VAL). Furthermore, compared to participants in the Control-group, those in the Law-group engage in more tactile experience during Institutional concepts processing (high TOU). The present dimensions are often used as indexes of concreteness/abstractness of a word. Typically, abstract words are less associate to a single context (Schwanenflugel et al., 1992), are acquired later than concrete ones (Gilhooly & Logie, 1980; Carroll & White, 1979), even if, according to some authors, affective experience may provide a bootstrapping mechanism for acquisition of abstract words

(Vigliocco et al., 2013). Finally, recent studies, which obtained norms on 400 words on perceptual strength of each of the five senses, have shown that not only sight but also touch plays a critical role in considering a word as concrete (Connell & Lynott, 2012; Lynott & Connell, 2013). It is noteworthy that Law-group results present an opposite pattern to those commonly observed in literature. This suggests that people who have greater experience in the legal field tend to perceive Institutional concepts as more embodied and concrete even if they developed complex knowledge of these categories. Our results partially support the idea of an artifactual nature of institutional concepts. Only law experts, who are aware of all nuances of the meaning of institutional concepts, considered them as concrete objects that possess useful functions, as testified by the higher scores in tactile modality and positive valence. Finally, it does not surprise that Institutional concepts were evaluated as slightly more familiar by Law-group (M= 6.3) than Control-group (M = 5.6), since jurists have more knowledge of the concepts about which they are experts. Importantly, results observed in the other dimensions suggest that the law experts and non-experts do not differ only for the *quantity* of knowledge associated with institutional concepts, but rather bear a *qualitative* difference in the content of semantic representations.

Insight into the Institutional domain: Pure vs. Meta-institutional concepts

Crucially, our findings also support a fine distinction between Pure and Meta-institutional concepts. Pure-institutional concepts obtained high scores in Concreteness (ABS-CNR), Imageability (IMG), Context Availability (CA), Visual modality dimensions (VIS) and high Mouth effector activation (MOUTH). Meta-institutional, compared to Pure-institutional concepts, are characterized by their being more familiar (FAM), by their relying to a larger extent on the competence of others (high MESO), and by their activating emotions (high ARO), mainly positively connoted emotions (high VAL), inner states and process (high INT; high META). Overall, while the Pure-institutional elicited a higher proportion of exteroceptive experiences, the Meta-institutional mainly rely on inner and metacognitive experiences.

At first glance, the absence of the association between the mouth and social metacognition dimensions conflicts with WAT's proposal regarding an increase of mouth activation for processing of most abstract concepts. However, the mouth motor system can be also activated by the semantic content of the words. A good example is provided by food concepts and face-related action words (e.g., talk), the content of which directly refers to mouth actions (for neuroimaging evidence see Dreyer & Pulvermüller, 2018). Likewise, although Pure-institutional concepts were linked to concrete components, a mouth involvement emerged. Specifically, Pure-Institutional concepts included words like "parliament", "president" or "process" that refer to entities and social practices that are inevitably based on the use of language, hence the mouth motor system. Meta-Institutional concepts, instead, include words like "duty", "responsibility" or "justice" whose content varies dynamically depending on context. One could speculate that mouth engagement is of paramount importance for Institutional concepts, and especially for Pure ones, since they are acquired through other words (both verbal or written modality), most often by explanations by others in a formal context (e.g., at the university), and because their content refers to situations in which language/dialogue is used. Furthermore, our results showed that Meta-institutional concepts are vaguer and more difficult to interpret than Pure, technical Institutional concepts, but also that they are more familiar and generally bear the weight of the emotional adhesion behind our institutional framework. This seems to strongly support the intuition, mentioned at the beginning, of a distinction between Institutional concepts perceived as technical tools to achieve normative effects and Meta-institutional concepts forming the socially supported background (a broad and vague background, in need of constant reinterpretation) within which those tools are inscribed.

Regardless of the type, we found that expertise has an influence on the representation of Institutional concepts. Overall, the Law-group was more familiar with both Pure and Meta Institutional concepts than the Control group (FAM). Compared to Control-group, the Law-group also rated both types of Institutional concepts as acquired earlier in their childhood (AoA) and considered those concepts as more related to hearing (HEA), vision (VIS), and taste modality (TAS). These differences confirm that the law experts are more acquainted with legal concepts than non-experts, but also suggest that their higher sensitivity to Institutional concepts is reflected in a higher involvement of sensorimotor experiences.

Importantly, results (see Figure 2) also showed that the two types of Institutional concepts were differently evaluated by the two groups. In the ABS-CNR dimensions, Pure-institutional concepts were rated as more concrete than Meta-institutional concepts by both groups. However, Meta-institutional were rated more concrete by the Law group than the Control-group, indicating that for law experts Meta-institutional concepts also possess concrete aspects. Likewise, in CA dimensions the Law-group considered both concepts as highly contextually situated compared to the Control-group. Interestingly, the difference between the groups emerged to great extent for Meta-institutional concepts: Law-group evaluated them as easier to associate to a context compared to the Control-group. In the MoA dimension, for the Pure-institutional concepts, the modality of acquisition was the same for the two groups, while for the Meta-institutional concepts, in the Law group, compared to Control-group, linguistic acquisition was less involved. Finally, the effect of expertise clearly emerged in the valence dimension (i.e., VAL): Overall, the Law-group has associated more positive scores to both kinds of institutional concepts compared to the Control-group. This result is in line with evidence showing that higher processing fluency is associated with a feeling of pleasantness (e.g., Topolinsky & Strack, 2009). Specifically, an equally positive valence to Pure and Meta-institutional concepts were given by the Law-group, while the Control-group associated more negative emotions to Pure-institutional concepts than Meta Institutional ones. These results show that expertise modulates both the distinction between Pure-institutional and Meta-institutional concepts and the vagueness of the latter. In general, experts in law find it less difficult to contextualize general concepts like justice, duty, rights, than non-experts, and in this sense for them these concepts are already "embedded" in specific institutional frameworks. Moreover, experts in law show emotional support not only to general social ideas connected with institutions, but also to specific institutional frameworks.

Expertise and variability

We argued that all concepts have fuzzy boundaries, and a simple concrete-abstract dichotomy is not sufficient to account for the entire semantic variability within either domain, since many abstract concepts have concrete components and vice versa (Barsalou et al., 2018; Wiemer-Hastings & Xu, 2005).

Our findings contribute to the literature on conceptual representations, highlighting the importance of individual variability. We found interesting differences in conceptualizing institutional concepts depending on the level of expertise of participants, in line with research on conceptual flexibility (Barsalou, 1993; 1987). Importantly, the effect of expertise is not limited to how familiar the participants are with the word, but rather to different kinds of content tied by their experience with concept referent. The law experts tend to consider Institutional concepts as less abstract and more linked to sensorimotor experiences than non-experts; and represented both Pure and Meta institutional concepts as equally contextually situated and grounded them in emotional (positive) states. Our results suggest that the higher the level of competence possessed, the higher the degree of direct 'embodied' experience re-enacted by a given concept. Similar findings were shown in the concrete domains. For example, Hoening et al. (2011) using fMRI showed that only professional musicians activate the auditory association cortex when identifying pictures of musical instruments but not with pictures of another object. With regards to abstract domains, Mazzuca et. al. (2020) has recently shown with a property generation task that people who differ in gender identity, sexual orientation, and gender-normativity stressed different aspects of concepts of gender. Specifically, normative individuals mainly relied on a bigenderist conception (e.g., male/female), while non-normative individuals produced more properties related to social context (e.g., queer, fluidity, construction).

Further research should deeply explore whether the correlation between expertise and high grounding representation is more prominent for some concepts, for example the more difficult and technical like "entropy" or whether it is also extended to the social-emotional connotated ones, like "ethnicity", and whether the same effects emerge using language production tasks in which an easy and precise activation of appropriate word-associations might be observed at the increasing of expertise.

Implication for Conceptual Jurisprudence

These results could have a significant import for legal theory and the theory of social institutions more in general. The ultimate dependence of institutional structures on mental states is here taken as a premise, and it justifies the methodological assumption that an analysis of conceptual content can provide us with new insights to deal with questions about the nature of law and of social institutions. Even though we considered only a few representative stimuli for each subtype of institutional concepts, the concepts chosen for the institutional domain have not been selected arbitrarily: They capture several aspects of that domain, thus providing us with a picture that, though partial, nevertheless is quite comprehensive. Not only do Pure-institutional concepts denote paradigms of institutions both in private and public law, but they are also quite diverse, denoting legal roles (i.e., “President”), institutions (i.e., “State”), transactions (i.e., “contract”), procedures (i.e., “trial”). Also, the selection of Meta-institutional includes entities (i.e., “rules”), modalities (i.e., “duty”, “rights”), values (i.e., “justice”), statuses (i.e., “responsibility”, “validity”). The most important legal-theoretical consideration coming from these results is that the idea of institutions being supported by general acceptance must be significantly shaded. First of all, even though institutional concepts have a stronger dependence on linguistic and social factors than other kinds of abstract concepts, as one would expect (institutions are activated by way of declarations and taught by way of definitions and rules), they also elicit a high degree of emotional arousal: Hence, social acceptance is not simply a matter of cold “cognitive” states and beliefs—a picture that, for example, theories of collective intentionality (Searle, 2010; Tuomela, 2013; Gilbert, 2014) convey—but of personal emotional involvement. Second, the way in which institutional concepts are experienced varies on the basis of the kind of institutional concept and of the subject who is internalizing it. The distinction between Pure-institutional concepts, referring to actual institutional entities or practices that have normative effects in a social context (marriage, contract, president, etc.), and Meta-institutional concepts referring to the general ideas and values that provide the conceptual background for law and social regulation (justice, validity, responsibility, sanction), finds a strong support in this work, because these two sub-groups of Institutional concepts show significant distinctions in most dimensions. Previous work on the relation between institutions and artifacts (Burazin et al., 2018) is also confirmed but, interestingly, only in connection with expertise: While, in general, institutional concepts are perceived as abstract, linguistic and difficult to imagine, jurists in particular conceive institutions as more context-related, “physical”, technical tools that can be “touched”. Apart from this technical part of the institutional domain, Meta-institutional concepts bear the most part of the emotional weight of institutions: Here, too, expertise becomes relevant, because jurists tend to connect positive values to institutional frameworks—they are not simply emotionally aroused, they rather embrace the institutional context—and tend to blur the emotional dichotomy between general concepts and technical institutions, conceiving these two aspects as connected and therefore shaping general ideas in the form of specific regulations of behavior. All of this can be interpreted as an indirect support to the legal-theoretical tenet that, though legal institutions require general conformity in a community, legal officials play a peculiar role in supporting them and in building the overall institutional structure (Hart, 1994).

Conclusions

In the current literature, while sub-categories of concrete concepts have been identified, less is known about the distinctions within the abstract domain. In this study, we provide a fine-grained characterization of Institutional concepts, investigating their similarity and difference with respect to other kinds of concepts on several psycholinguistic and semantic dimensions. Overall, this study shows the peculiarity of Institutional concepts that, within the abstract domain, can be considered as a particular kind in which emotional, social, and physical aspects coexist. These components might vary dynamically as a function of personal life experiences and expertise. Importantly, we found that the higher the expertise level, the stronger are the concrete determinants. Future research on different kinds of abstract concepts should shed light on whether such a link between concrete and embodied determinants of abstract concepts and higher level of expertise holds across domains.

STUDY IV

Expertise in grounding abstract concepts: the case of institutional concepts in situated contexts [18]

Introduction

Conceptual knowledge is not stable and rigid, but it is dynamically sensitive to contextual factors and personal life experience. Concepts vary depending on the current goal, task condition (e.g., Connell & Lynott, 2014; Lebois et al., 2015), situation (van Dam et al., 2012), and they can change between people and within individuals over the lifespan (Barsalou, 1982) (for a review see Yee & Thompson-Schill, 2016). In general, our understanding of concepts benefits from information derived from the environment. Traditionally, it has been assumed that it is more difficult to process and retrieve semantic knowledge associated with abstract concepts than with concrete concepts (concreteness effect, Paivio, 1986) since they have a weak link with a wide range of contexts (i.e., contextual availability, Schwanenflugel,1992; see also Hoffman et al., 2013; Davis, Altman & Yee, 2020).

Nevertheless, abstract concepts are not completely devoid of situational elements, rather their representation relies on more complex configurations of events compared to concrete ones. Appealing to the notion of situated conceptualizations, Barsalou and colleagues (Barsalou et al., 2018; see also Barsalou, 2016; 2020) proposed to conceive abstract and concrete concepts as patterns of situational memories that capture different kinds of information. Thus, concrete conceptualizations might emerge from the processing of external situational elements, such as objects, actions, and settings; instead, abstract conceptualizations

[18] This paper is currently in preparation.

may be derived either from the internal situational elements, such as emotions, motivations, mental states, and from the relational structure establishing the integrations among situational elements, such as agents and events. Supporting evidence of this view mostly comes from feature listing studies, showing that concrete and abstract concepts evoke different aspects of situations (e.g., Barsalou & Wiemer-Hasting, 2005; Wiemer-Hasting & Xu, 2005).

A novel approach to investigate the interplay between abstract concepts and context is to present them against the background of real-world situations. In a word-picture/picture-word priming study, McRae and colleagues (2018) found that semantically related pairs of abstract content (e.g., the word *share* preceded by a picture of two girls *sharing* a cob of corn, or vice versa) mutually facilitated the performance on lexical and congruence decision tasks. In a similar paradigm, Lakhzoum, Izaute, and Ferrand (2021) recently showed that when tangible features of settings are available, participants rely on them to represent abstract concepts. These findings suggest that situations and events experienced in real life are important components of representing abstract concepts.

Until now, the role of situational contexts in abstract concept representations has been examined either considering abstract concepts as a whole (Lakhzoum, Izaute, and Ferrand, 2021) or as a single word presented against related semantic situations (e.g., reading the word “discipline” after seeing the images of kids line-up, McRae et al. 2018). In the present study, we adopted a similar approach using a priming paradigm to address the hypothesis that integrated situational elements differ depending on the concept kinds and personal experiences. Specifically, in line with the WAT proposal (Borghi et al., 2018a, 2018b; 2019), we intend to investigate whether linguistic inputs and communicative exchanges represent the major source of information through which abstract concepts are represented and whether differences emerge in how linguistic and communicative experience impacts the representation of diverse kinds of abstract concepts in individuals with different level of expertise.

The effect of expertise has already been documented in the concrete domain. For example, Medin et al. (1997) have shown that concrete items such as trees are differently categorized by groups of professionals (see also Johnson & Mervis, 1998; Tanaka & Taylor, 1991). With regards to the abstract domain, only a few studies have examined the influence of expertise. Bechtold et al. (2019) explored the conceptual processing of abstract mathematical concepts in math and non-math experts. They found experience-dependent effects during a lexical decision task with a reduction of N400 and a higher LPC amplitude in math experts with mathematical words, indicating less effort and a large amount of experiential information compared to non-math experts. Recently, Mazzuca and colleagues (2020) provided evidence that features produced in association to the word "gender" are modulated by gender identity and sexual orientation: While transgender, plurisexual individuals provided definitions based on complex/abstract information and social-based attributes of gender (e.g., queer, fluidity, identity); the bigender, heteronormative individuals mentioned more likely biological and less sociocultural contents (e.g., male/female).

Therefore, it is reasonable to assume that different life experiences and habits impact categorization. Large individual differences might occur for abstract concepts, since linguistic and social practices play a major role both during their acquisition and use.

The present study: the case of institutional concepts

In the present study, we examined the differences between kinds of concepts, focusing on a specific domain of abstract knowledge, namely institutional legal concepts like “norm”, “parliament”, or “marriage”, taking into account their intrinsic link with individual life experiences and situated contexts. This choice is motivated by a twofold reason. The first reason is that they are associated with a well-defined community of expert speakers: lawyers. They can be ascribed to a specific area of knowledge with which people may have more or less competence based on their own experience and knowledge. This aspect allows us to assess the role of expertise in conceptualizing institutional terms. Secondly, institutional concepts seem to be a particular kind of abstract concept in which multiple elements coexist. Like other abstract words, institutional words are, for the most part, defined through language. In addition, their meaning is established in a collective way by a community of speakers - often authoritative ones - that share common principles and rules. Contemporary studies in conceptual jurisprudence (Leiter 2018; Schauer 2018; Marmor 2018; Roversi, 2018) have stressed that legal concepts constitute a sub-category of artifact concepts, and thus, unlike natural kind concepts, they necessarily supervene on the attitudes, the intentions, and the histories of the human communities which created them. This suggests that the elaboration of such concepts must depend essentially on linguistic and social factors. At the same time, institutional concepts can be considered as multifunctional cognitive tools: they are both means to represent the existing institutions such as “contract”, “parliament”, “marriage”, as well as means to actively engage in the normative practice. According to legal philosopher HLA Hart (2012), legal systems emerge by virtue of the conceptual capacity of a subclass of their members to take what he calls the "internal point of view" on institutions. Those with this capacity not only use legal concepts to refer to behaviors and states of affairs, but also use them as standards for expressing approval or disapproval of behaviors and states of affairs and consider them as sources of reasons for action. According to Hart, this mental attitude is typical of “legal officials”, i.e., people with special legal expertise to whom the law assigns the task of enforcing rules (judges, administrative officials, etc.)

This theoretical approach is supported by recent evidence on institutional concepts. In a rating study, Villani et al. (2021b) found that compared to other sub-kinds of abstract concepts (theoretical-scientific terms) and concrete concepts (foods, tools), legal institutional concepts have specific properties: They were easier to contextualize (context availability, Schwanenflugel, 1992), they rely more on linguistic and social dimensions; that is, late age of acquisition, high social valence, an higher engagement of mouth effector and hearing modality; and finally, they evoked a higher proportion of inner experiences (interoception, metacognition) and emotional arousal. Notably, an effect of expertise was present: the law experts conceived institutional concepts as more positively connoted than non-experts (high valence), and associated them to more concrete and sensorial experiences (less abstractness, high scores on touch) rather than encoded in linguistic expressions (perceptually Modality of Acquisition). The differences observed in this study provide relevant insights into the semantic content of institutional concepts and how it varies across individuals. However, the methodology used did not allow to explore to what extent expertise influences the processing of institutional concepts into a situated perspective.

In the present study, participants experts and non-experts in the law field (Law-group vs. Control-group, respectively) were presented with a list of target-words belonging to specific sub-categories of abstract concepts (i.e., institutional and theoretical) and concrete concepts (i.e., food and tools). The verbal stimuli were preceded by a picture-prime, that elicit the following situations: social-action (e.g., dance together), linguistic-social (e.g., chatting with a friend), linguistic-textual (e.g., reading a book) and control (a landscape). We intend to verify the following hypotheses:

1) *Abstract vs. Concrete.* In keeping with previous literature, we predicted to replicate the concreteness effect: Overall, the sub-categories of abstract concepts should be processed slower than the concrete ones. More crucially, if social and linguistic experiences are paramount for abstract concepts, then the social-action, linguistic-social, and linguistic-textual primes should affect more abstract concepts than concrete ones while no difference should appear with the control prime. The relevant primes should lead to a modulation of response time in terms of either facilitation or interference (bidirectional hypothesis).

2) *Kinds of Abstract Concepts*. Because sub-categories of abstract concepts are differently learned, represented, and used, we should find an interaction between the different primes and the different kinds of abstract concepts. We hypothesize that the situations elicited by picture-prime will interact with the processing of two types of abstract concepts to a different extent, leading to a facilitation or an interference (bidirectional hypothesis). Specifically, comparing the RTs obtained in control condition: i) the social-action prime should have a greater effect on institutional concepts than theoretical ones: indeed, the former are social constructs that serve to regulate social practices through a set of shared principles; ii) the linguistic-social prime should affect more institutional concepts than theoretical ones, due to the fact that institutional concepts are typically used in a social context, and are characterized by dialogical aspects and meaning negotiation practices; ii) the linguistic-textual prime might influence more the processing of theoretical concepts than institutional concepts, because the

linguistic mediation (e.g., formula and definitions) is crucial during the acquisition of these concepts. We consider the last hypothesis as an exploratory one.

3) *Expertise* (exploratory hypothesis). Because abstract concepts' meaning is more variable across individuals than of concrete concepts, experts (Law-group) should differentiate more institutional and theoretical concepts than no-experts (Control-group). Furthermore, the interaction between prime and institutional concepts might be modulated by expertise. We will explore whether: i) the linguistic-textual prime might have a greater effect on the Law-group than the Control-group, driven by the text-based acquisition and by the high level of formalism possessed by Law-group; ii) the linguistic-social prime might have a greater effect on the Control-group, because non-jurists could conceive institutional concepts as less objective and more subject to negotiation of meaning. It might be conjectured that jurists tend to consider institutions as more akin to technical, artifactual, and objective entities. Non-jurists, on the contrary, could interpret these notions as more relative, and more prone to processes of meaning negotiation.

Method

The hypotheses, experimental procedures, and data analysis have been specified in a pre-registration available osf.io/cj8sh. Data has not been collected prior to pre-registration. [19]

Materials Selection

Prime stimuli A total of 60 pictures were selected from Google Image. Of these, 10 depicted two people performing a joint action, such as dancing or carrying a sofa (social-action prime), 10 represented two people talking (linguistic-social prime), 10 showed a

[19] Because the stimuli were not fully balanced across prime conditions, we did not test the pre-registered hypotheses on *Type of Institutional concepts* (Meta vs Pure).

person reading a book (linguistic-textual prime), 10 were landscape (control), and finally 10 depicted a person interacting with a tool and 10 a person interacting with a food, included as filler. The selected pictures were adjusted for size (800 x 600), and balanced for gender, and age of characters (range = 25-35 years). In order to create a set of prime stimuli more representative for each prime condition, we asked 73 independent participants (63 female, M_{age} = 22.4; SD_{age} = 4.3), to rate each picture using a 7-point Likert scale for three different scales: social scale ("how much the image evokes a situation of social interaction"); linguistic scale ("how much the image evokes a situation of linguistic interaction") and physical scale ("how much the image evokes a situation of physical interaction").

For each scale, a multidimensional scaling analysis was conducted to evaluate the distances between the pictures across all scales. For each prime, two pictures that minimize the distance (highly similarity) on the critical scale and maximize the distance (highly dissimilarity) in the other scales were selected, according to the following criteria: (a) Social-action prime. Highly similarity in the social scale and highly dissimilarity in physical and linguistic scales; (b) Linguistic-social prime. Highly similarity in linguistic scale and highly dissimilarity in physical scale, but with a minimum distance in the social scale; (c) Linguistic-textual prime. Highly similarity in linguistic scale and highly dissimilarity in the physical and social scale; (d) Control. Two pictures obtained low scores on the social, linguistic, and physical scales. See Supplementary Materials for the final set of picture-prime stimuli.

Target stimuli Target stimuli consist of 80 words: Half of them were nogo-trials and the other half go-trials. The nogo-trials include 40 words that denote planets, atmospheric and astronomical phenomena (e.g., Jupiter, snow, eclipse). The go-trials were composed by four sub-groups of abstract and concrete concepts. Abstract concepts include 10 institutional (e.g., marriage, contract) and 10 theoretical concepts (e.g., energy, multiplication) already used in the previous norming study (Villani et al., 2021b). Concrete concepts include 10 food items (e.g., bread, carrot) and 10 tools concepts (e.g., lamp, knife) selected from Barca et al., (2002) database.

The selected go-trials were balanced across the main psycholinguistic variables that are word length, number of syllables, absolute frequency and level of concreteness. Specifically, a one-way ANOVA showed that the four-categories did not differ in word length (F (3) = 2.058; MSE = 9.358; p = .123), numbers of syllable (F (3) = 1.431; MSE = 0.867; p = .250) and absolute frequency on books (F (3) = 1.495; MSE = 569.767; p = .232), as determined by CoLFIS, a lexical database of written Italian (Bertinetto et al., 2005). Importantly, the sub-categories differ in the level of concreteness (F (3) = 26.080; MSE = 139520.892; p <.001). Post hoc analysis showed that the institutional and theoretical concepts differ significantly from food and tools concepts (p < .001), while no difference was found between the abstract concepts of institutional and theoretical (p = 1) and between the concrete concepts of food and tools (p = .871). See Supplementary Materials for the full set of the verbal stimuli.

Sample size rationale

To estimate the sample size we used G*Power. In the ANOVA for repeated measures we indicated power = 0.80, alpha error probability p = 0.05, and low-medium effect size f = 0.10 and we obtained a required sample size of 110. To estimate the effectiveness of these results and in order to take into account also the random effect (i.e., Target) we checked the sample size also by using the app Power Analysis with Random Targets and Participants by Judd, Westfall, and Kenny, (2016) (jakewestfall.org/two_factor_power). The analysis indicates that at least 124 participants were required. In this procedure we specified the following information: effect size d: 0.4; residual VPC: 0.35; participant intercept VPC: 0.1; stimulus intercept VPC 0.1; participant slope VPC: 0.15; stimulus slope VPC: 0.2.

Participants

150 participants (105 female, $M_{age} = 23.6$; $SD_{age} = 3.3$) were volunteers recruited among the students and researchers of the University of Bologna. Participants were divided in two groups: 75 law graduates or law professionals (Law-group: 46 female, $M_{age} = 24.3$; $SD_{age} = 3.9$; $M_{years\ of\ university\ education} = 4.6$; $SD_{years\ of\ university\ education} = 0.6$) and 75 graduates or professional in fields different from law, such as communication science, art, philosophy (Control-group: 59 female, $M_{age} = 22.9$; $SD_{age} = 2.4$; $M_{years\ of\ university\ education} = 2.9$; $SD_{years\ of\ university\ education} = 1.6$). Data were collected to obtain an equal sample of participants into the Law and the Control-groups. The study was conducted in accordance with the ethical standard procedure recommended by the Italian Association of Psychology (AIP), and procedures were approved by the local Bioethics Committee. All participants gave written informed consent before proceeding with the study.

Procedure

The experiment was set up and run through the online behavioral science platform Gorilla experiment-built software (www.gorilla.sc, Anwyl-Irvine, Massonnié, Flitton, Kirkham, & Evershed, 2020). In order to minimize possible distractions, participants were invited to carry out the experiment in a quiet place and avoid manipulating objects during the entire task. In addition, we asked participants to close other background apps/programs and all browser windows except for that of the experiment. The automated procedure ensured that participants were all using computers, since no other devices were allowed (tablets or smartphones), and automatically rejected participants that took longer than 2 hours to complete the task.

We used a go-nogo paradigm. Participants were presented with a controlled combination of a picture followed by a word in random order. Prime consisted of a picture for each prime type [20]: social-action, linguistic-textual, and linguistic-social were used as critical prime, while landscape as control. Target stimuli were composed of 40 words that constituted go trials (10 institutional, 10 theoretical, 10 foods, 10 tools) and 40 words that were nogo trials (i.e., planet or atmospheric and astronomical phenomena). For a total of 320 trials. Each trial began with a centered black fixation cross of 500ms, followed by the picture prime lasting for 1000ms. After a short interval of 500ms (SOA, stimulus-onset asynchrony), the target word appeared; it remained on the screen until the response, or for a maximum of 2000ms. The intertrial interval was 1000ms (Figure 1; for a paradigm with similar duration, see Kalenine et al., 2014; McRae et al., 2018). The task was preceded by 8 practice trials (4 go and 4 nogo); none of the stimuli used as practice were used in the experimental trials. A visual feedback appeared after each response and in the case of a wrong response the feedback briefly reminded the instruction of the task. Participants were asked to read the word and press the spacebar only if the word did not denote a planet or atmospheric and astronomical phenomena. They were invited to respond as quickly and accurately as possible as their response time and accuracy were measured.

[20] Please note that for each prime type 2 images were selected from the rating described above, however they were rotated among conditions.

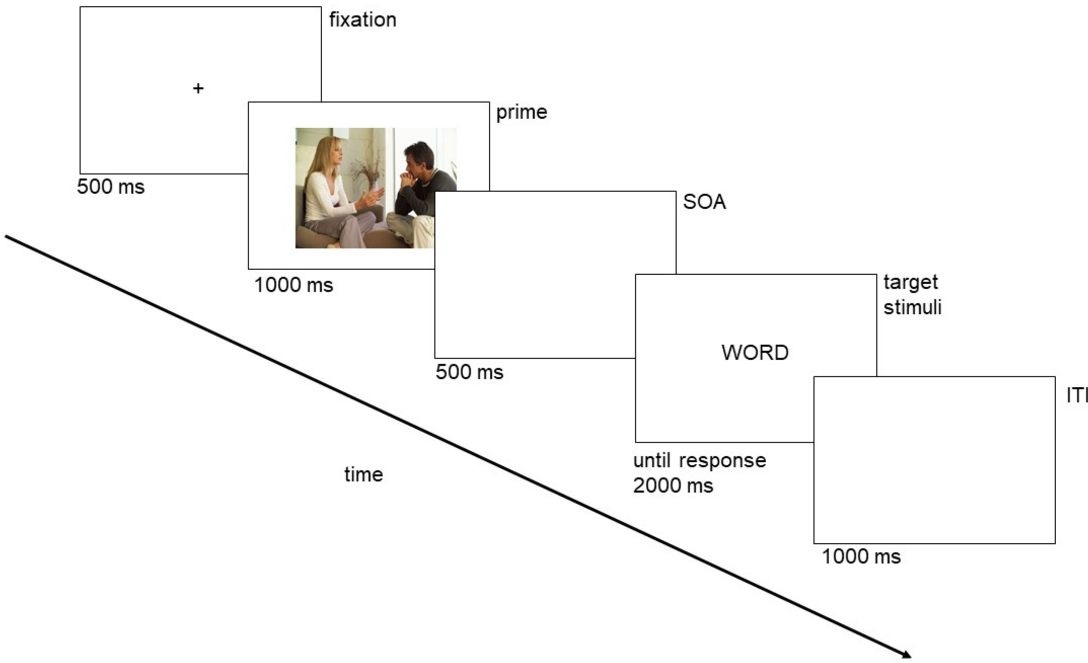


Figure. 1 Illustration of the priming task procedure depicting sequential events of an experimental trial in the linguistic-social prime condition (not drawn to scale).

Data Analysis

To provide a better summary of our findings, we combined the speed and accuracy in a single dependent variable called the inverse efficiency score (IES, Townsend and Ashby, 1978, 1983). IES was calculated by dividing response time by the proportion of accuracy in each condition, so that a lower IES corresponds to a better performance than a higher IES, in terms of both accuracy and response time (for the procedure, see Bruyer & Brysbaert, 2011). For each hypothesis, we run a Generalized Linear Mixed Model (GLMM) on the IES index as dependent variable. The fixed factors taken into consideration in the analysis were as follows: *Hypothesis 1. Type of Concept* (abstract, concrete) and *Prime* (social-action, linguistic-textual, linguistic-social, control) as within-participants factors.

Hypothesis 2. Type of Category (institutional, theoretical) and *Prime* (social-action, linguistic-textual, linguistic-social, control) as within-participants factors.

Hypothesis 3. Type of Category (institutional, theoretical) and *Prime* (4 levels: social-action, linguistic-textual, linguistic-social, control) as within-participants factors and *Group* (law-group, control-group) as between-participants factors.

For each model, target words and participants were included as random effects. We used p-values (standard $p < .05$ criteria for determining the effect and the planned contrast tests suggesting that the results are significantly different from those expected if the null hypothesis were true) as criteria to make inferences. Two-tailed tests were used. For exploratory analysis in order to account for multiple comparisons, additional correction was applied (i.e., Bonferroni correction).

Results

Practice trials (7.6 % of the total trials) were discarded. RTs faster or slower than 2 SD from the individual RT average were excluded from the analysis (5.6% of the go trials). 17 participants, with more than 50% of errors, were excluded. The analysis was performed on 133 participants (Law-group = 67; Control-group = 66) out of 150. Satistically significant results related to each hypothesis are reported below.

Hypothesis 1. Abstract vs. Concrete

Results showed significant main effects of *Type of Concept* [F (1, 5297) = 258.771; $p < .001$] and *Prime* [F (3, 2419) = 8.591; $p < .001$]. Particularly, abstract concepts showed a worse performance (M = 738 ms, SE = 2.886) compared to concrete concepts (M = 676 ms, SE = 2.511). The performance was worse for the linguistic-social prime (M = 717 ms, SE = 3.148), followed by linguistic-textual prime (M = 712 ms, SE = 3.257), social-action prime (M = 704, SE = 3.527) compared to control condition (M = 696 ms, SE =3.290). The interaction between *Type of Concept* and *Prime* was significant [F (3, 2419) = 5.164; p <.001]. Interestingly, the planned contrast revealed that the prime influenced the performance of abstract concepts [F (3, 1298) = 9.776; p < .001], but not those of concrete concepts [F (3, 1476) = 2.169; p = .090]. Specifically, the performance was worse for abstract concepts after social-action (M = 737 ms, SE = 5.342; p = .030), linguistic-textual (M = 740 ms, SE = 5.060; p = .005), and linguistic-social prime (M = 756 ms, SE = 4.956; p < .001) than after the control prime (M = 718 ms, SE = 5.063), and they showed a significant worse performance after linguistic-social prime than social-action (p = .024) and linguistic-textual prime (p = .030).

Hypothesis 2. Kinds of Abstract concepts.

Results showed significant main effects for *Type of Category* [F (1, 2678) = 183.021; p <. 001] and *Prime* [F (3,1039) = 9.456; p < .001]. The performance was worse for theoretical concepts (M = 781 ms, SE = 4.704) than institutional concepts (M = 701 ms, SE = 3.625). The performance was worse for linguistic-social prime (M = 757 ms, SE = 5.000), followed by linguistic-textual prime (M = 747 ms, SE = 5.398) and social-action prime (M = 739 ms, SD = 5.275) compared to control condition (M = 721 ms, SD = 5.192). The interaction between *Type of Category* and *Prime* was significant [F (3, 1039) = 5.903; p <.001]. Planned contrasts showed that theoretical concepts had a greater disadvantage after all critical prime than after control (M = 742 ms, SE = 8.221; p_s <.001), no difference emerged between linguistic-social (M = 802 ms, SE = 7.932), linguistic-textual (M = 791 ms, SE = 9.286), and social-action prime (M = 788 ms, SE = 8.637; p_s >.05). In contrast, the performance for institutional concepts was worse after linguistic-social prime (M = 712 ms, SE = 6.088) compared to social-action prime (M = 690 ms, SE = 6.060, *p* = .028), no statistically significant difference emerged considering control (M = 699 ms, SE = 6.345) and linguistic-textual prime (M = 702 ms, SE = 5.506). See Figure 2.

Further, we conducted paired t-test to verify our hypotheses on the difference between institutional and theoretical concepts across the critical prime, using the control condition as a baseline. When compared to the control, performance of institutional and theoretical concepts differ significantly in linguistic-textual (t (126) = 4.764; $p < .001$), in linguistic-social (t (132) = 3.533; $p < .001$) and in social-action prime (t (132) = 4.953; $p < .001$). Specifically, compared to the control condition i) the social-action prime lead to a great disadvantage in the processing of theoretical concepts (-45 ms) and a slight advantage for institutional concepts (0.5 ms); ii) the linguistic-social prime generate a relevant disadvantage for both theoretical (-63 ms) and institutional concepts (-28 ms); finally iii) the linguistic-textual prime lead to a great disadvantage in the processing of theoretical (-55 ms) and only a marginal disadvantage for institutional concepts (-3 ms).

Hypothesis 3. Expertise

With regard to the third hypothesis, we reported here only the results including the factor *Group* as the others were already presented in the above sections. Results showed a main effect *Group* [F (1, 2683) = 8.996; p = .003], indicating a better performance for law-group than control-group (M = 732 ms, SE = 3.846; M = 750 ms, SE = 4.429, respectively). The interaction between the *Group* and *Type of Category* was not significant [F (1, 2683) = .292;

p = .589). Interestingly, we found a significant interaction between *Group, Prime* and *Type of Category* [*F* (6, 633) = 2.763; *p* = .012]. With regard the processing of institutional concepts, planned contrasts on prime between the two groups showed that: i) the linguistic-textual prime did not affect group differently (the law-group, M = 702 ms, SE = 7.108; control-group, M = 703 ms, SE = 8.099; *p* = .967) ; ii) the linguistic-social prime caused a worse performance for the control-group (M = 735 ms, SE = 9.502) compared to the law-group (M = 690 ms, SE = 7.254) (*p* < .001). Similarly, the social-action prime led to a worse performance in the control-group than the law-group (M = 710 ms, SE = 9.820; M = 668 ms, SE = 6.926; respectively) (*p* < .001). Furthermore, by considering planned contrasts between prime for each group, we found a better performance for the law-group after social-action (M = 668 ms, SE = 6.926) than control (M = 701 ms, SE = 8.283; *p* = .009), linguistic-textual (M = 702 ms, SE = 7.107; *p* < .001) and linguistic-social prime (M = 690 ms; SE = 7.254; *p* < .028). On the contrary, the control-group showed a better performance after control (M = 697, SE = 9.368) and linguistic-textual prime (M = 703 ms, SE = 8.099) compared to linguistic-social ones (M = 735 ms, SE = 9.502) (p_s = .022). No other contrasts reached the significance. See Figure 3.

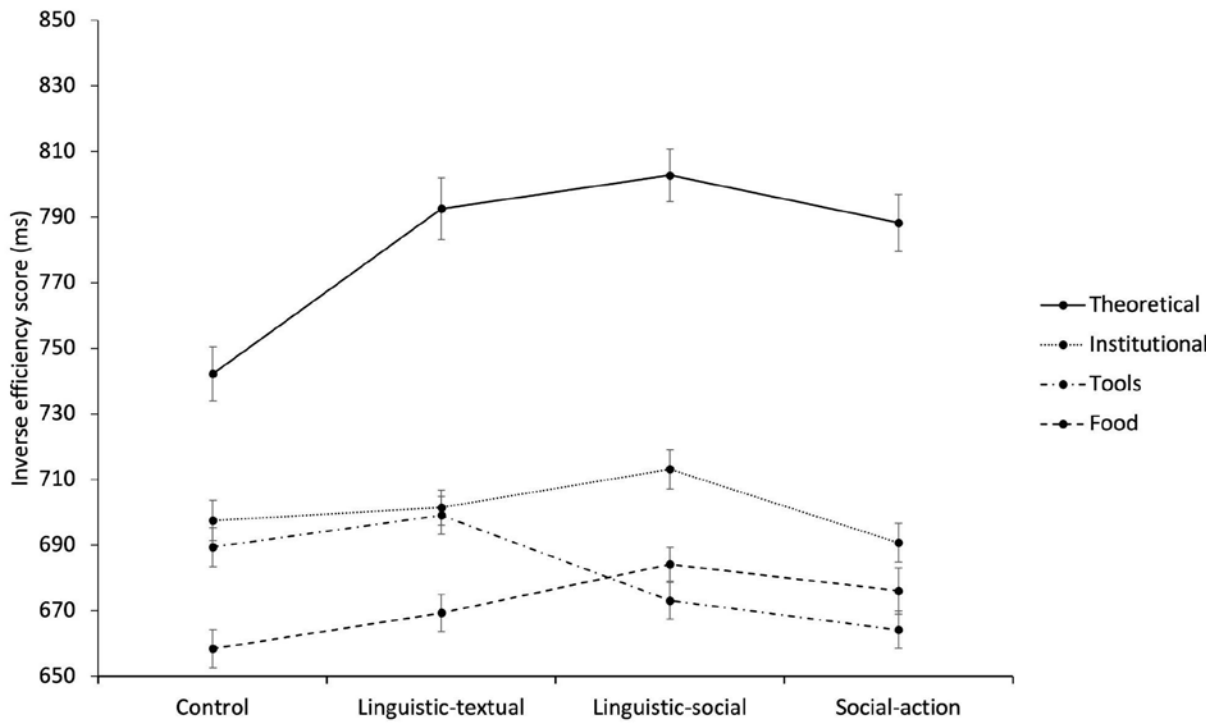


Figure 2. Mean Inverse efficiency score (IES) for Type of Category (Theoretical, Institutional, Tools and Food concepts) as a function of Prime (Control, Linguistic-textual, Linguistic-social, Social-action). Error bars indicate standard errors of the mean.

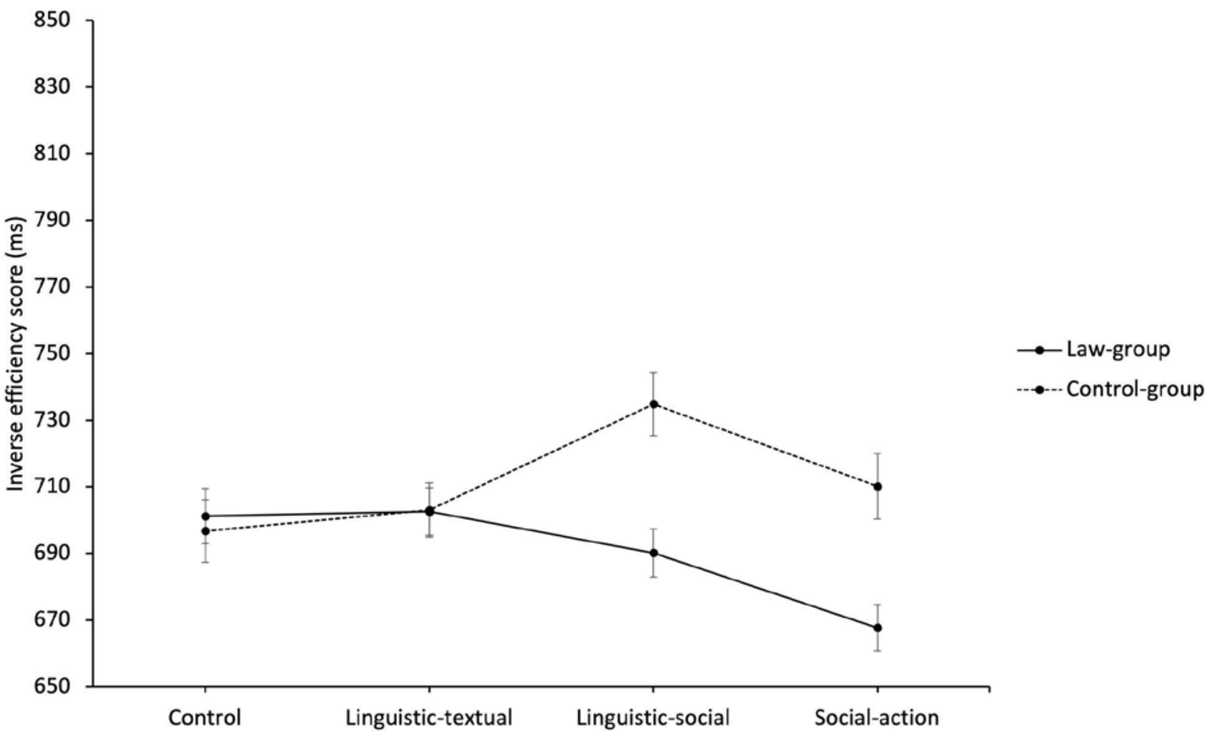


Figure 3. Mean Inverse efficiency score (IES) for Group (Law-group and Control-group) as a function of Prime (Control, Linguistic-textual, Linguistic-social, Social-action) for institutional concepts. Error bars indicate standard errors of the mean.

Exploratory analysis and results

To better interpret how pictures-prime modulated the processing of different sub-categories of abstract and concrete concepts, we conducted a further GLMM on the IES variable, including *Type of Category* (institutional, theoretical, food, tools) and *Prime* (social-action, linguistic-textual, linguistic, control) as within-participants factors.

Results showed significant main effects for *Type of Category* [F (3, 3614) = 134.309; $p < .001$] and *Prime* [F (3, 2058) = 9.791; $p < .001$]. We found a better performance for food items (M = 672 ms, SE = 3.474), followed by tools (M = 681 ms, SE = 3.379), institutional (M = 701 ms, SE = 3.435), and theoretical concepts (M = 781 ms, SE = 4.645). The performance was worse for linguistic-social prime (M = 718 ms, SE = 3.126), followed by linguistic-textual prime (M = 716 ms, SE = 3.371) and social-action prime (M = 705 ms, SD = 3.480) compared to control condition (M = 697 ms, SD = 3.311). In addition, planned contrasts showed a significant difference between all categories (p_s < .001), except for the comparison between concrete concepts of food and tools (*p* = .052). The interaction between *Type of Category* and *Prime* was significant [*F* (9, 1452) = 5.971; *p* < .001]. Planned contrasts on prime within each category showed, besides the results concerning institutional and theoretical concepts (hypothesis 2), that performance for tool concepts was worse after control (M = 689 ms, SE = 5.940) than social-action prime (M = 664 ms, SE = 5.702) (*p* = .009), and after linguistic-textual prime (M = 699 ms, SE = 5.723) compared to linguistic-social ones (M = 673 ms, SE = 5.568) (*p* < .001); whereas the performance for food items was worse after linguistic-social prime (M = 684 ms, SE = 5.104) compared to control condition (M = 658 ms, SE = 5.806) (*p* = .004). No other contrasts reached the significance. See Figure 2.

Planned contrast between sub-categories in each prime showed that performance for institutional and tool concepts did not differ significantly in control (M = 697 ms, SE = 6.174; M = 689 ms, SE = 5.940, respectively, *p* = .342) and linguistic-textual prime (M = 701 ms, SE = 5.349; M = 699 ms, SE = 5.723, respectively, *p* = .763), while all others comparison were significant (p_s < .001). With regard to linguistic-social prime, we found that all categories differ significantly (p_s < .001) except for the comparison between food and tool concepts (M = 673 ms, SE = 5.568; M = 684 ms, SE = 5.104; respectively; *p* = .141). With regard to social-action prime, results showed significant differences across all categories (p_s < .004) except for the comparison between food (M = 676 ms, SE = 7.111) and tool concepts (M = 664 ms, SE = 5.702) and between food and institutional concepts (M = 691 ms, SE = 5.950) (p_s = .228).

Discussion

The findings are in line with our predictions. Sociality and language provide relevant information for constructing abstract concepts representation, to a different extent for concept kinds and individual competence and this modulates the responses. Thus, the linguistic and social situational elements provided by the primes influence word processing, differently modulating concepts that re-enact the same experience(s). In the following sections, we will first summarize and discuss results on abstract and concrete concepts as a whole, then results on institutional concepts compared to other categories of abstract and concrete concepts, and finally, the difference between experts and non-experts in the processing of institutional concepts.

Abstract vs. concrete

Overall, participants' performances were worse with abstract than concrete concepts. This result is in line with previous literature on concreteness effect, viz. processing advantage of concrete over abstract concepts in response time and accuracy (Paivio, 1986). Interestingly, our findings clearly indicated that abstract concepts are more variable across contexts than concrete concepts: While concrete concepts processing showed a similar pattern regardless of the type of prime, abstract concepts processing varied in function of the contextual priming to which they were exposed. Specifically, critical (social-action, linguistic-textual, and linguistic-social prime) but not control prime (landscape) impaired the performance with abstract concepts, resulting in word processing difficulty. This effect was more pronounced with situations evoking interpersonal communication (linguistic-social) than purely social-cooperative and linguistic-textual situations. We interpreted these findings as a consequence of a conflict between the processing of pictures-prime content and the re-enactment of experiences evoked by a word during language processing. Thus, the mechanisms engaged in elaborating linguistic and social experiences evoked by the prime, and in particular dialogic exchanges, are less available for representing abstract words that rely mainly on the same experiences, leading to interference (for similar interpretation, see Kaschak et al., 2005). Our results fully support the WAT proposal that emphasized the role of the linguistic and social dimension in abstract word acquisition and use (Borghi and Binkofski, 2014; Borghi et al, 2018a; 2019). In detail, because abstract concepts encompass heterogeneous members, linguistic information and interactions with other speakers are thought to be fundamental to define and understand their meaning (social metacognition, Borghi et al., 2020; Borghi et al, 2019). However, other interpretations of these findings are possible. The intereference effect for abstract words could reflect greater ambiguity of meaning. As abstract words have more complex/ambiguous meanings, seeing the primes may introduce some uncertainty in participants processing of the word meaning, which in turn interferes with their performance and go-nogo decision.

Kinds of concepts: the case of Institutions

In line with our predictions, we found that the linguistic and social situational contexts have a different impact on the two types of abstract concepts. At a general level, results showed that all critical pictures-prime lead to an increase of difficulty in processing theoretical abstract concepts compared to the control condition; in contrast, the processing of institutional words was impaired more by linguistic-social than social-action prime. A similar pattern emerged from the analysis exploring the difference between institutional and theoretical concepts across prime, in which the control prime (i.e., landscapes) served as the baseline. Even though the critical pictures-prime interfered more with theoretical than institutional concepts, we found that the interference for institutional concepts was more marked after linguistic-social prime and only marginal or null after social-action and linguistic-textual prime.

In the first place, these findings proved that the two kinds of abstract concepts differ in the level of complexity and abstractness, with theoretical concepts having more abstract attributes than institutional concepts. It is reasonable to think that the interference effect with theoretical concepts is due to the activation of linguistic/social experiences elicited by pictures-primes that have hindered the simulation of concepts whose meaning is typically learned through linguistic mediation or definitions provided by others. Secondly, results confirm our prediction that dialogic and communicative interaction (linguistic-social prime) influence to a greater extent the representation of institutional than theoretical concepts, suggesting that their meaning and use are likely to remit disagreements and negotiations. Finally, social-cooperation situations (social-action prime) seem to reduce the interference with institutional concepts, in line with our hypothesis that institutional concepts elicit an idea of shared agreement over the rules that regulate social life. This aspect will be better clarified below in the light of differences between experts and non-experts.

Furthermore, results of exploratory analyses confirm that the domain of abstract concepts is more heterogeneous than that of concrete ones: Processing of abstract concepts not only varies from those of concrete ones but also within their subcategories of institutional and theoretical concepts. In contrast, we found less marked differences between the concrete concepts of food and tools. However, within the concrete domain, the linguistic-textual situations influenced to a large extent the processing of tool concepts, likely in virtue of their strong association with manipulative actions performed with objects (i.e., the book depicted in the image); whereas the linguistic-social context affected the processing of food concepts typically experienced in sociable circumstances.

It is noteworthy that institutional concepts were processed more similarly to concrete than other abstract concepts, especially when they were elaborated against social cooperation and linguistic-textual situations. Interestingly, the link between institutional and tool concepts resonates with contemporary theories in conceptual jurisprudence, according to which institutional concepts, much like ordinary artifact concepts, are essentially constituted by the linguistically and socially assigned function of their referents. The linguistic and the social elements seem to reflect however two peculiar aspects of the recognition of an institution as existent: the fact that an institution needs shared acceptance of its rules—hence an idea of cooperation—, but also the fact that institutional contexts involve processes of linguistic negotiation and conflicting interpretation, thus problematizing conceptual content in an ongoing social debate. Institutions are artifacts, but they are the product of a deliberative history which consists of a process of constant modification and re-interpretation. This dialectic between a cooperative and a competitive aspect seems to be well-captured by our results.

Expertise

The level of expertise of participants modulated the processing of institutional concepts in the priming task. Results in some cases confirmed our predictions, in others showed novel patterns. Our initial hypothesis that linguistic-textual prime should affect the performance of the law group more than the control group was not fully supported by our data. The two groups showed similar results patterns after priming by linguistic-textual situations.

However, the control group showed a greater disadvantage than the law group in processing institutional concepts when primed by linguistic-social situations. In addition, non-experts showed worse performance with institutional concepts after linguistic-social prime than after control and linguistic-textual ones. These results align with our hypothesis that non-jurists tend to represent institutional concepts in a communicative context in which linguistic negotiations are inevitable to master their meaning, particularly because differences in that meaning can have important practical consequences. Surprisingly, we also found that the two groups were differently influenced by social-action prime during the processing of institutional concepts, resulting in better performance for the law group than the control group in this condition. Consistently, we found that jurists performed better when primed by social-action prime compared to all others prime, including the control condition. These results suggest that the language and its use in a social context are crucial features of institutional concepts. We spaculate that these features could assume different values in function of proficiency: the role of linguistic/social experiences become prominent for non-experts, who associate institutional concepts to conceptual/linguistic entities regulated by a dialogic and negotiation practices; while this role is tempered for jurists, who tend to conceive institutional concepts as a broader form of social-cooperation between people.

In the dialectics between the competitive and cooperative aspects that characterizes legal institutions, non-experts seem to navigate the former less well than experts and to feel less compelled by the latter: They conceptualize institutions more as a domain of conflict than of shared cooperation. The idea that jurists connect institutional concepts first of all with cooperative support, rather than conflict negotiation, is coherent with Hart’s already-mentioned concept of “internal point of view”, which is typical of legal officials. According to

Hart, having an internal point of view towards an institutional normative framework means accepting and using it as a standard for justification and criticism, an attitude that is plausibly rooted in a general view of institutions as a cooperative endeavor.

Conclusions

The understanding of concepts depends on the individual experiences in situated contexts. In this study, we used a picture-priming paradigm to examine the conceptualization of different subtypes of abstract and concrete concepts by individuals with different levels of expertise exposed to real-world situations. Overall, we found that linguistic and social exchanges have a stronger influence on the processing of abstract concepts than concrete concepts. This confirms that verbal inputs and/or definitions provided by others are the preferential means to represent concepts whose meaning is more uncertain and less tied to systematic elements of situations. Our findings also provide insights into the nature of institutional concepts, suggesting that they are a special kind of *abstract artifact*, namely social constructs that are collectively defined to fulfill normative practices: as such, their conceptualization is closer to that of concrete concepts than of theoretical, scientific ones. Crucially, institutional concepts are grounded in dimensions that vary as a function of expertise: Non-legal experts rely mainly on linguistic negotiations to master their meaning, whereas legal experts rely on purely social situations. We interpreted this result as a difference in the perception of the competitive vs cooperative aspects of legal institutions: non experts connect legal concepts with an idea of debate, negotiation, and potential conflict, whereas experts are more aware of their social-coordinative function and cooperative background. To make our provisional conclusion stronger, further studies are needed to test more precise predictions on which situated contexts should either facilitate or interfere with the processing of specific kinds of abstract concepts depending on individual experience.

CHAPTER 7

EXPLORE THE USE OF CONCEPTS: A NOVEL, INTERACTIVE METHOD

STUDY V

Abstract and concrete concepts in conversation [21]

Introduction

Concepts allow categorizing objects and entities, making inferences based on previous experiences, and preparing to act (Murphy, 2002). Many have distinguished concepts into concrete and abstract concepts (from now, CCs and ACs) (e.g., "table" vs. "justice", but also "stop" and "maybe"; Lupyan & Winter, 2018). Recent views see CCs and ACs as neither dichotomously opposed nor as representing a continuum. Instead, different concepts would be points within a multidimensional space, defined by various dimensions (Crutch et al., 2013). Studies have identified some of these dimensions, none of which is exhaustive or necessary. Compared with more CCs, ACs generally include more heterogeneous members (density, Sloutsky & Deng, 2019); they are more detached from the five senses, less imageable (Paivio, 1990), and evoke more frequently inner experiences (interoception, emotions) (Connell, Lynott, & Banks, 2018; Vigliocco et al., 2014). Furthermore, they refer to relations rather than single objects (Gentner & Asmuth, 2019), are less iconic (Lupyan & Winter, 2018), and more variable across contexts (Schwanenflugel et al., 1992; Davis et al., 2020).. The words expressing them are typically acquired later and through language rather than through perception (Wauters et al., 2003). Language and social interaction are crucial for their acquisition and representation (Borghi et al., 2019; Dove, 2014; Dove et al., 2020). Because of

[21] This paper is currently under revision on *Scientific Reports.*

their complexity, ACs might lead to higher uncertainty, less confidence in their meaning, and stronger involvement of metacognition and inner speech (Borghi, Fini, & Tummolini, 2020).

Importantly, some have recently acknowledged that ACs come in different kinds (Borghi et al., 2018), for which different dimensions are relevant (Villani et al., 2021). Thus, emotional and aesthetic ACs evoke more interoception and emotions (Fingerhut & Prinz, 2018), numerical ACs more sensorimotor experiences linked to finger counting (Fischer & Shaki, 2018). All ACs, just as CCs, activate sensorimotor brain areas. A meta-analysis demonstrated that numerical, emotional, morality, and theory of mind ACs also engage specific brain areas (Desai et al., 2018). To date, converging evidence supports the existence of different types of ACs. They span in a multidimensional space that includes interoceptive, sensorimotor, affective, social, and linguistic features to a different extent (review: Conca et al., 2021).

Understanding how ACs are represented constitutes a challenge for both embodied theories, according to which the body influences and constrains cognition, and distributional theories, according to which we get meaning through word associations. Hybrid, multiple representation views represent a promising alternative (Borghi et al., 2017; Binder et al., 2016; Dove, 2019). They relate the differences between CCs and ACs and their kinds to the different weights sensorimotor, interoceptive, linguistic, and social experiences play.

Crucially, the emergent ways to conceive concepts impose the adoption of new methods (Barsalou, Dutriaux, & Scheepers, 2018; Barsalou, 2020; Borghi, 2020). Most studies so far have focused on single words or simple sentences. Typical methods are ratings of different dimensions (imageability, contextual availability, Age of Acquisition, Modality of Acquisition, Emotionality) (Villani et al., 2019; Troche et al., 2017), and feature listing and definitions (Barsalou & Wiemer-Hastings, 2015; Harpaintner et al., 2018). Among the implicit tasks, the most common are lexical decision, recall, recognition, and property verification tasks (e.g., Kousta et al., 2011; Siakaluk et al., 2016; Mazzuca et al., 2018). Brain imaging studies typically use words or simple sentences differing in imageability or abstractness (Dreyer et al., 2018; Binder et al., 2016; Rodríguez-Ferreiro et al., 2011). Conversely, studies on natural conversations (Sidnell & Stivers, 2012) rarely focus on ACs and CCs. In one of the few studies on interaction, participants had to explain the meaning of CCs and ACs, avoiding using the word themselves (taboo game) (Zdrazilova et al., 2018; see also Fini et al., 2021).

An effective approach for investigating conceptual representation is to infer it from the use of concepts in interaction. According to some recent theories, social interaction is crucial for abstract concepts. Because their referents are not objects and the members of abstract categories are very heterogeneous, other people are particularly crucial to help us acquire them. In addition, we have proposed elsewhere that other people might be particularly important also during abstract concepts processing. Through interaction, other people can facilitate our processing of abstract words, either helping us understand the meaning of the words or negotiating the word's meaning with us (Mazzuca & Santarelli, 2021; Borghi, 2022). Because of the crucial role of social interaction might play for abstract concepts, it becomes pivotal to investigate them through interactive tasks. In our study, participants engaged in exchanges starting from different kinds of concepts. We presented three kinds of CCs, the most common in the literature (tools, animals, and food), and three kinds of ACs, derived from a previous rating study, i.e., philosophical-spiritual, PS (e.g., value), physical-spatio-temporal-quantitative, PSTQ (e.g., mass,), emotional-mental states and social concepts, EMSS (e.g., anger) (Villani et al., 2019; 2021). The previous norming study (Villani et al., 2019) showed that PS concepts resulted as more abstract, EMSS characterized mostly by inner experiences, and PSTQ more based on sensorimotor experience than other ACs. In this study, we asked participants to simulate a conversation with another person, responding to a written sentence focused on a concrete/abstract concept (e.g., I made a cake/a judgment). We then used the Interpersonal Reactivity Index (IRI, Davis, 1980) questionnaire to explore whether individual differences in empathy influenced the responses, especially for those prompted by ACs that may rely heavily on emotions and affective states (Vigliocco et al., 2014; Kousta et al., 2011). Since we hypothesize that, with abstract concepts, people rely more on others (Borghi, 2022) we intended to explore whether there is a relationship between conceptual abstractness and the level of empathy demonstrated by participants.

We hypothesized that responses to sentences involving ACs would differ from those involving CCs and intended to explore the dimensions distinguishing concept kinds. Notably, some of these dimensions allow inferring how concepts are represented from the conversational pattern they evoke. We outline below the hypotheses we pre-registered and tested; for each of the six hypotheses, we also explored eventual differences between kinds of ACs and CCs.

1) Conversations: Uncertainty expressions, Number of questions, and Target word repetitions. We expected (directional hypothesis) more uncertainty expressions and signs of uncertainty, like questions and repetitions of the target word, with ACs than CCs (moderate to strong evidence).

2) Conversation: Turn-taking (directional hypothesis). With ACs participants should be more uncertain on the word meaning and need to rely on others more (Borghi et al., 2020; Borghi,

2022); hence, with ACs, participants should more often continue the discussion assigning a further turn to the other either by asking questions or by using expression signaling the willingness of knowing more details, thus eliciting a social interaction dynamic (moderate to strong evidence).

3) Conversation: Point of views and General Statements. We investigated whether the participants made a general statement or whether s/he considers the other's perspective. We referred to this with Points of View. Specifically, we distinguished between 1st, 2nd, and 3rd person Point of View and the coupling of 1st and 2nd person (i.e., interpersonal Point of view). We expected more general statements with ACs than CCs.

4) Number of evoked contexts. Because ACs meaning is more context-dependent [9], we expected that participants would refer to more contexts with ACs than CCs (moderate to strong evidence).

5) Produced features. We expected (directional hypothesis) that a) ACs are more focused on internal situational elements [25], [12], i.e., leading to the production of belief, evaluative (not perceptual), emotional, introspective, and metacognitive properties; b) CCs evoke more external sensorimotor and contextual properties, i.e., evaluative (perceptual) properties and thematic relations, particularly those related to action/agency (moderate to strong evidence). We also expected emotional concepts to activate more emotional and interoceptive features than other concepts.

6) Conversation: Kind of questions (how, why, where, what, when, who). We predicted more "why" questions with ACs, the meaning of which generates more uncertainty and more questions related to external situational elements ("what," "where," and "when" questions) with CCs (moderate to strong evidence).

Method

The hypotheses, experimental procedures, and data analysis have been specified in a pre-registration available at https://osf.io/6mkc7. Data has been collected after the pre-registration.

Materials

Stimuli consisted of sixty sentences composed of a verb and a concept noun. Concept nouns included 30 abstract concepts and 30 concrete concepts used in a previous study (Villani et al., 2021). The set of stimuli consisted of 3 sub-categories of concrete concepts, i.e., ten tools (e.g., hammer, umbrella, fork), ten animals (e.g., lion, dog, cow), and ten food items (e.g., banana, tomato, carrot), and three sub-categories of abstract concepts, i.e., ten philosophical-spiritual (PS, e.g., moral, destiny, salvation), ten physical-space-temporal-quantitative (PSTQ, e.g., area, number, acceleration), and ten emotional-social concepts (EMMS, e.g., shame, joy, conflict). We controlled the frequency of use of target nouns. Specifically, the subgroups of abstract and concrete words were balanced for classical psycholinguistic variables, including the absolute frequency (concrete food, tools, animals: $F(2,27) = 0.536$; $MSE = 3758.196$; $p = .591$; ηp2 = .038; abstract PS, EMSS, PSTQ: $F(2,27) = 1.855$; $MSE = 72376.078$; $p = .18$; ηp2 =.121) and relatively frequency (concrete food, tools, animals $F(2,27) = 0.694$; $MSE = 178.537$; $p = .508$; ηp2 = .049; abstract PS, EMSS, PSTQ: $F(2,27) = 1.817$; $MSE = 4541.619$; $p = .18$; ηp2 = .119) based on CoLFIS, a lexical database of written Italian (Bertinetto et al., 2005) (further details of psycholinguistic variables of target nouns are available at https://osf.io/rx85h/, and Villani *et al.* 2019, database).

For each of the selected concepts, we created a sentence in the Italian language. Each sentence was constructed by pairing a verb in present perfect tense with the concept noun (e.g., Ho fatto una torta/I made a cake; Ho pensato al destino/I thought about destiny). All sentences were declarative statements in the first person, balanced for definitive and indefinite articles and length (from min. 20 to max. 26 letters). See Supplementary Materials for the full list of sentences.

Participants

The choice of our sample size was guided by reference to a previous study in literature in which similar measurements and statistical analyses are used (N = 62, Zdrazilova et al., 2018). We recruited 92 native Italian speakers through Qualtrics survey software among students of the Cognitive Psychology course and researchers of the University of Bologna, who were asked to disseminate the survey to colleagues or acquaintances. Participants with incomplete data were excluded (n = 12). The final sample consisted of 80 participants (59 female, Mage = 26.3, SDage = 5.9). The study was approved by the Ethical Committee of the University of Bologna and fulfilled the ethical standard procedure recommended by the Italian Association of Psychology (AIP) and conformed to the Declaration of Helsinki. All participants were naïve as to the purpose of the experiment and gave their informed consent to participate in the study.

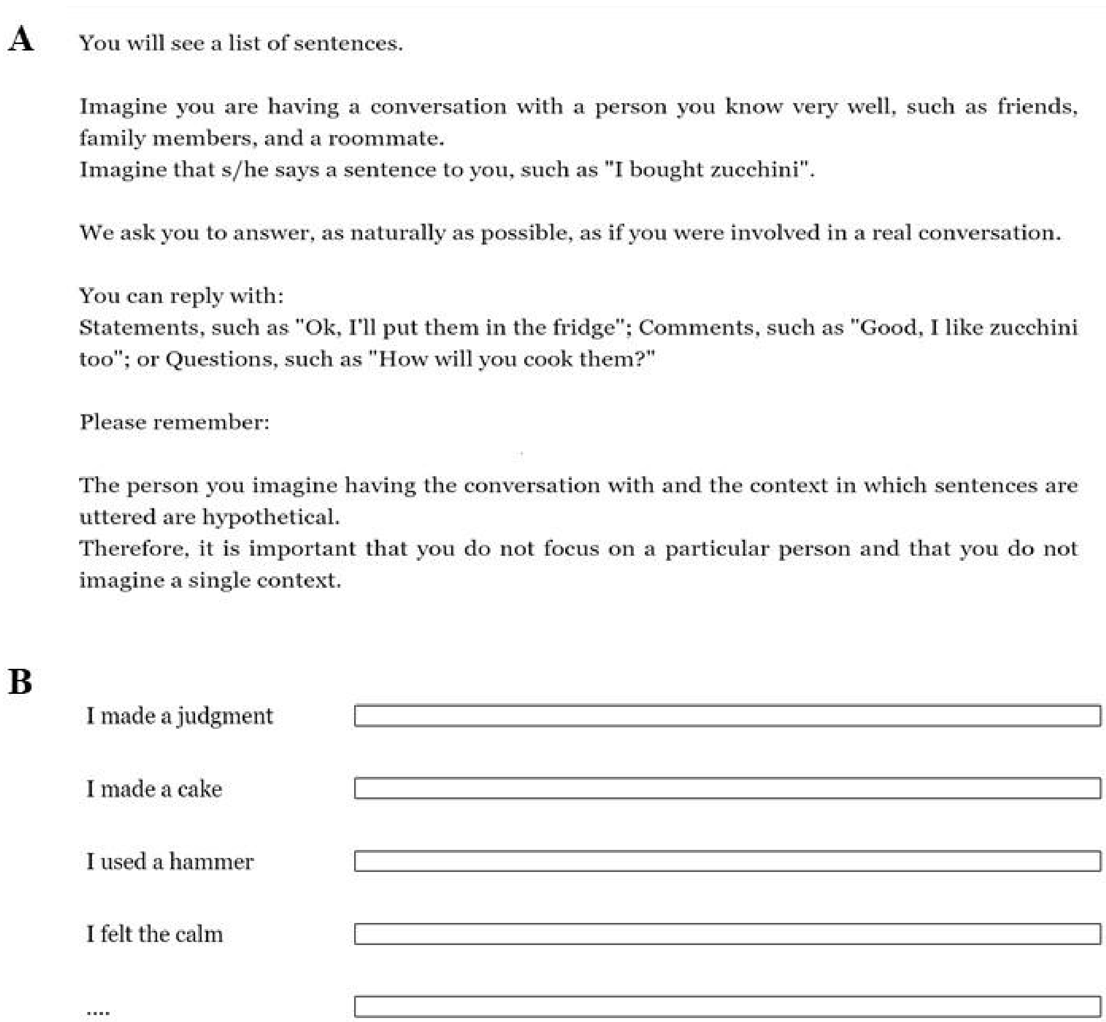
Procedure

The study was implemented as an online questionnaire in Qualtrics and consisted of three parts: (1) conversational task, (2) debriefing ratings, and (3) the Interpersonal Reactivity Index (IRI, Davis, 1980); Italian version, see Albiero et al., 2006).

In the conversational task, 60 written sentences were presented in random order. Participants were asked to respond through written language production, simulating interaction with another person. Specifically, participants saw a list of sentences; for each sentence they were asked to imagine a natural conversation with a familiar person who uttered the sentence and to write their own response as naturally as possible. Participants were invited to avoid focusing on a single person or situation during the task. No character limit was imposed. Figure 1. reports both the instructions provided to participants and the Qualtrics interface used in the experimental task.

In the debriefing ratings, participants were asked to rate their general comprehension of the task and how much they felt involved in a real conversation using 7-point scales ranging from 1 = "not at all" to 7 = "extremely". Finally, they indicated which sentences they had had more doubts about answering.

In the last part of the questionnaire, participants completed the IRI survey, a 28-item self-report measure of empathy. It consists of four subscales with seven items measured on a 5-point scale ranging from 0 = "does not describe me well" to 4 "describes me very well". Each subscale measured different dimensions of dispositional empathy: the Perspective Taking (PT) assess cognitive empathy, or the tendency to adopt the psychological point of view of others spontaneously; the Empathic Concern (EC) assess emotional empathy, or the other-oriented feelings of sympathy and concern for unfortunate others; the Fantasy (FS) taps the respondent's tendency to transpose oneself into feelings and actions of fictional situations imaginatively; and the Personal Distress (PD) measures the tendency to experience anxiety and unease in response to other's suffering (Davis, 1980).



A

You will see a list of sentences.

Imagine you are having a conversation with a person you know very well, such as friends, family members, and a roommate.
Imagine that s/he says a sentence to you, such as "I bought zucchini".

We ask you to answer, as naturally as possible, as if you were involved in a real conversation.

You can reply with:
Statements, such as "Ok, I'll put them in the fridge"; Comments, such as "Good, I like zucchini too"; or Questions, such as "How will you cook them?"

Please remember:

The person you imagine having the conversation with and the context in which sentences are uttered are hypothetical.
Therefore, it is important that you do not focus on a particular person and that you do not imagine a single context.

B

I made a judgment

I made a cake

I used a hammer

I felt the calm

....

Figure 1. Instructions provided to the participants (**A**) and the Qualtrics interface with examples of four sentences used in the study (**B**).

Sentences coding

37 category codes (see Supplementary Materials) were used to best capture the type of features the participants produced with each sentence. Coding categories were adapted from Barsalou and Wiemer-Hastings (2005) and Zdrazilova *et al.* (2018). Two independent

researchers, one of whom blind to the aims of the study, coded the produced text. Reliability among the coders was 96%. The cases of disagreement were solved through consensus after discussion together with a third judge.

Debriefing responses

On average, participants declared to have correctly understood the task (M= 3.5; SD = 1) and to have simulated a real conversation (M= 3.7; SD = 0.8). Most of the sample showed moderate (34%) and good comprehension of the sentences used in the task (31%), 17% extreme, and only 16% poor comprehension. Half of the sample (51%) reported being very involved in natural speech, 27% moderately involved, 12% extremely involved, and only 9% felt slightly involved. Finally, participants reported more uncertainty when responding to sentences related to abstract concepts (40%) and situations compared to concrete ones (20%). Within concrete concepts, they had major doubts about sentences related to animals (27.5%). The last percentages on uncertainty were calculated based on the responses to an open-ended question, in which participants were free to express doubts about one or more sentences used in the task.

Analysis

Bayesian Generalized linear mixed models were applied to estimate the probability of different models' hypotheses. The Bayesian approach determines the probability that a model’s parameters take on different values, given the observed data. According to Bayes’ theorem, this is the combination of our prior expectations and the likelihood that we would have observed our data given different parameter values. Thus, functions describing the prior and the likelihood are combined to create a posterior density function. This is then sampled, and the resulting sample can be used to establish the 95% credible intervals: the range of values with a 95% probability of containing the true value for a given parameter. When a given parameter's credible interval does not include zero, we consider it significantly different from zero and worth interpreting.

The Bayes factor (BF) is the ratio of the probabilities of the data in models 1 and 2 and indicates how much the prior odds change, given the data (Kruschke, 2015). Before proceeding with the inferential analyses, for each output variable, the model with the highest Bayes Factor has been chosen. One convention for converting the magnitude of the BF to a discrete decision about the models is that there is "substantial" evidence for model 1 when the BF exceeds 3.0 and, equivalently, "substantial" evidence for model 2 when the BF is less than ⅓ (Kruschke, 2015). Bayesian Generalized linear mixed models were applied separately on each outcome variable: Uncertainty expressions, number of questions, repetitions of the target words, turn-taking, point of view (1st, 2nd, 3rd,1st or 2nd, 1st & 2nd person perspective), number of evoked contexts, general statements, perceptual evaluations on vision, touch, hearing, smell, taste, materials/components, space, time, events, concrete actions, abstract actions, interoception, emotion, metacognition, belief/intentions, introspection, associations, subordinates, non-perceptual evaluations, why-questions, who-questions, where-questions, what-questions, when-questions, how-questions. A total of 37 analyses were developed.

In each model, the predictors were the Type of sentences (Abstract vs. Concrete) and the Kind of concepts. We had three kinds of ACs - Philosophical-Spiritual (PS), Physical-Spatio-Temporal-Quantitative (PSTQ), and Emotional-Mental State-Social (EMSS), three kinds of CCs - Tool, Food, Animals. We decided to use either the Kind of concepts or the Type of sentences as a predictor because these two factors are strongly correlated: it was therefore not possible to include both in the same model. In detail, when the Kind of concepts had zero or very few elements, the Type of sentences was preferred as a predictor. See table 2. Further details of the model's convergence and suitability of effective sample size are available as Supplementary Materials.

The Type of sentences and the Kind of concepts were the within-subject factors. Models included random subject intercepts. Random effects help generalize results beyond a particular set of subjects; accounting for subject-level variation (see, Zdrazilova *et al.* (2018). Bayes factor and credible interval were used to make inferences. Regarding the variables number of questions and number of evoked contexts that had a count response outcome, models with Poisson distribution with logistic link function were developed, whereas for all other variables models with Binomial distribution with logit link function were carried out.
For models with Type of sentences and Kind of concepts factors, analyses were run computing four sampling chains, each with 10000 iterations. For each chain, the first 4000 iterations are treated as warmups, resulting in 24000 posterior samples. In addition, for a better sampler's behavior, adapt_delta and max_treedepth parameters were set to 0.99 and 15, respectively. For the Null Hypothesis model or only intercept model, analyses were run computing four sampling chains, each with 5000 iterations. For each chain, the first 2000 iterations are treated as warmups resulting in 12000 posterior samples. In addition, for a better sampler's behavior, adapt_delta and max_treedepth parameters were set to 0.99 and 10, respectively.

Due to the lack of previous literature on the topic, models were fit using flat priors for fixed and random effects. All models were seen as reliable, reaching convergence with an R.hat that is the potential scale reduction factor on split chains equal to 1.00 and with suitable effective sample size measures evaluated with Bulk_ESS and Tail_ESS. Finally, we used a contrast method to explore the hypnotized differences between the ACs and CCs kinds. The analyses were carried out using R (version 4.0.3; (R Core Team, 2020); data processing was also carried out in part using ‘openxlsx’ (Schauberger & Walker, 2020), ‘dplyr’ (Wickham et al., 2021), ‘lattice’ (Deepayan & Lattice, 2008), ‘brms’ (Bürkner, 2017); this package allows fitting Bayesian mixed-effects models using the Stan programming language; ‘bayesplot’ (Gabry & Mahr, 2021); ‘gridExtra’ (Auguie, 2017) and ‘repmod’ (Marin, 2021). The bar charts on polar axis graphs were carried out by using Python language (version 3.8) and *Matplotlib* and *Numpy* libraries.

Results

Bayesian Generalized linear mixed models were applied to estimate the probability of different models' hypotheses, separately for each variable in ACs and CCs, and their subcategories (see “Analysis” below). The Bayes Factor (BF) for the Kind of concepts (i.e., emotional EMSS, philosophical PS, quantitative PSTQ, Animals, Food, Tool) and the Type of sentences (i.e., abstract, concrete) and Null Hypothesis models have been calculated for the model selection to each hypothesis (see Table 1). The subsequent analyses have been carried out according to the BF values. Table 2 shows a summary of the results. We report below the contrast analysis on hypothesized differences between the ACs and CCs kinds. For each kind of concept (i.e., emotional EMSS, philosophical PS, quantitative PSTQ, Animals, Food, Tool) the frequency of coding variables is displayed in polar plots grouped according to our hypotheses on: Conversation, Turn-taking (Figure 2), Sensorimotor grounding (Figure 3), Inner grounding (Figure 4). Polar plots showing the frequency of other variables are reported in Supplementary Materials.

Table 1. Bayes Factor (BF) values for model comparison between the model carried out using the Type of sentences as the factor with the Null Hypothesis model (only intercept) (first column); the model carried out using the Kind of concepts as the factor with the Null Hypothesis (only intercept) (second column); the Type of sentences and the Kind of concepts models (last column). The BFs values highlighting meaningful differences are in bold. ** Due to few elements in the variable only the comparison between Type of sentences and Null Hypothesis was carried out.

Variables	**BF (Type of sentences) vs BF (Null Hypothesis)**	**BF (Kind of concepts) vs BF (Null Hypothesis)**	**BF (Kind of concepts) vs BF (Type of sentences)**
Action Abstract	1,25E+43	**6,44E+46**	5,11E+03
Action Concrete	6,45E+136	**2,77E+147**	4,27E+10
Association	2.44E+00	**2,46E+03**	1,02E+03
Belief	2,04E+27	**1,51E+29**	7,42E+01
Emotion	7,28E+8	**1,39E+22**	1,92E+13
Events	2,56E+10	**6,08E+12**	2,48E+02
General Statement	1,22E+24	**9,30E+25**	7,47E+01
Hearing**	**3,12E+03**	//	//
How	0,33	3,64E+28	**1,10E+29**
Interoception	1,56E+03	**2,49E+10**	1,58E+07
Introspection	2,91E+02	**3,04E+03**	1,02E+01
Material**	**2,99E+31**	//	//
Metacognition	6,92E+04	**8,80E+12**	1,25E+8
Number of Questions	0.1	1,07E+07	**1,10E+08**
Non-Perceptual Evaluation	4,31	**9,68E+12**	2,25E+12
Number of Target Word repetition	1,51	**3,12E+14**	2,17E+14
Number of Contexts	**0.98**	0.07	0.07
Point of View	**0.28**	//	//
1st or 2nd Point of View	//	**6,37**	//
1st & 2nd Point of View	//	**7,60E+01**	//
2nd Point of View	**0.34**	//	//
1st Point of View	//	**8,23E+11**	//
3rd Point of View	1,48	**1,36E+03**	9,29E+02
Smell**	**9,89E+01**	//	//
Spatial	3,12E+27	**5,93E+44**	1,88E+17
Subordinates	6,51	**6,88E+11**	1,08E+11
Taste	**9,98E+74**	//	//
Temporal	1,26E+04	**1,59E+10**	1,26E+06
Touch	7,19E+04	**5,00E+10**	6,71E+05
Turn	0,24	5,54E+19	**2,36E+20**
Uncertainty	5,87E+02	**1,33E+12**	2,20E+09
Vision	1,89E+33	**1,19E+34**	6,33
What	9,94E+14	**3,05E+51**	3,02E+36
When	1,57E+03	**8,02E+06**	5,23E+03
Where	3,25E+57	**2,54E+97**	7,92E+39
Who	6,65E+22	**1,73E+47**	2,62E+24
Why	0,35	1,67E+32	**4,80E+32**

Table 2. Results of Bayesian linear mixed effect models. We showed the main probability of conditional effects according to the type of sentence (abstract, concrete) or kind of concepts (i.e., emotional EMSS, philosophical PS, quantitative PSTQ, Animals, Food, Tool) in each variables. We report the percentage of all variables for each kind of sentence, with the exception of the variables “number of questions” and “numbers of contexts” where the count frequency is reported. This discrepancy is due to the fact that for the variables “number of questions” and “number of evoked contexts” we did not have a total numerical reference value, while for the others we had it, consequently we reported the percentages. For each variable, we report the comparative analysis between Abstract and Concrete sentences (ACs vs. CCs) and the 95% Credible Intervals (CI) and the probability of posterior observations major to zero (PP > 0) according to our hypothesis. The PPs values highlighting meaningful differences are in bold.

Variables	Type of Sentences		Kinds of Concepts								
	Abstract	**Concrete**	**EMSS**	**PS**	**PSTQ**	**Animal**	**Food**	**Tool**	**ACs vs. CCs**	**95 % CI**	**PP**
Uncertainty Expression			0.24	1.81	0.76	0.69	0	0.3	0.6	[0.2, 1.1]	**ACs > CCs, 99**
Number of Questions			0.38	0.55	0.50	0.57	0.45	0.41	0.0	[-0.04, 0.04]	ACs > CCs, 50
Target Word			2.5	5.1	2.5	6.2	5.4	1	- 0.8	[-1.9, 0.1]	ACs > CCs, 3.6
Turn-Taking			39.1	58.2	51.8	58.4	44.8	41.5	1.5	[-1.4, 4.3]	**ACs > CCs, 83.8**
1^{st} or 2^{nd} Point of View			40.1	35.3	32.8						
1^{st} & 2^{nd} Point of View			10. 2	5.8	7.5						
1^{st} Point of View						9	18.7	7.4			
3^{rd} Point of View			0.72	0.13	0.48	0.6	0.25	0.13	0.11	[-0.2, 0.5]	**ACs > CCs, 756**
General Statements			8.5	10.6	6.9	3.3.	1.7	2.3	6.2	[4.7, 7.9]	**ACs > CCs, 100**
Number of Contexts			5.5	5	5	4	4.5	4.4	0.87	[-0.22, 1.95]	**ACs > CCs, 93**
Vision			0.5	0.5	1.1	7.8	5.9	7. 1	6.2	[5, 7.4]	**CCs > ACs, 100**
Touch			0	0	0.1	0.8	0.1	0. 72	0.5	[0.2, 1.0]	**CCs > ACs, 100**
Hearing			0.1	0	0	0.5	0	0.6	0.3	[0.08, 0.7]	**CCs > ACs, 99.9**
Taste	0	9.9							9.9	[8.7, 11.2]	**CCs> ACs, 100**
Smell	0	0.12							0.1	[4.5e-5, 3.04e-3]	**CCs > ACs, 99.6**
Materials			0	0	0	0.7	6.3	3.5	3.47	[2.5, 4.5]	**CCs > ACs, 100**
Space			1	0.2	0.6	7.6	0.9	7	4.6	[3.4, 5.9]	**CCs > ACs, 100**
Time			2.1	3.4	4	2.9	8.9	5.9	- 2.6	[-3.8, -1.5]	ACs > CCs, 0
Events			1.0	0.3	0.6	2.6	1.8	3.5	- 2	[-2.9, -1.2]	ACs > CCs, 0
Concrete Actions			2.3	3.3	8.2	27.8	27.6	36.6	26	[23.4, 28.9]	**CCs > ACs, 100**
Abstract Actions			6.3	11.1	6.6	0.5	1	1.2	7.14	[5.6, 8.8]	**ACs > CCs, 100**
Interoception			0.2	0	0.1	0.1	1.9	0.4	- 0.6	[-1, -0.3]	ACs > CCs, 0
Emotions			11. 7	3.6	3.8	4	1.5	2.3	3.8	[2.6, 5]	**ACs > CCs, 100**
Metacognition	0.63	0.04							0.6	[0.2, 1.1]	**ACs > CCs, 100**
Beliefs			13.6	14.8	10.8	4.4	3.1	5.9	8.6	[6.9, 10.6]	**ACs > CCs, 100**
Introspection			1.4	2	1.1	1	0.3	07	0.8	[0.3, 1.4]	**ACs > CCs, 99.9**
Associations			1.4	1.4	2.2	0.7	2.1	0.8	0.5	[0, 1.1]	**ACs > CCs, 95.8**
Subordinates	1.7	2.6							-0.8	[-1.6, 0.1]	**ACs > CCs, 1**
No Perceptual evaluations	9.1	7.3							1.8	[0.3, 3.4]	**ACs > CCs, 99**
Why-Questions			4.9	1.9	9.7	3.5	1	11	0.2	[-0.9, 1.4]	**ACs > CCs, 68**
Who-Questions			12.2	1.32	0.88	0.99	0.55	0.88	4.7	[3.5, 5.8]	**ACs > CCs, 100**
What-Questions	14.13	6.89							7.2	[5.4, 9]	**ACs > CCs, 100**
Where-Questions			0.8	0.2	0	20.4	3	4.6	8.9	[7.6, 10.2]	**CCs > ACs, 100**
When-Questions			0.4	0.2	0	1	1.4	0.5	0.7	[0.3, 1.2]	**CCs > ACs, 100**
How-Questions			8.3	11.2	7.5	5	17.7	2.8	-0.5	[-2, 1]	CCs> ACS, 25.9

Hypothesis 1. Conversation: Uncertainty, Number of questions, and Target word repetitions.

ACs elicited more *Uncertainty Expressions* than CCs. In particular, we found moderate evidence that PS sentences elicited more Uncertainty expression than other ACs (1.4%; 95% CI [0.6, 2.5]. However, by inspecting the mean number of posterior observations major to zero (PP, Posterior Probability) we are 100% confident that the Uncertainty Expressions in PS sentences are more frequent compared to all other sentences. We found inconclusive evidence in support of the hypothesis that ACs evoke a higher *Number of Questions* than CCs. However, contrast methods showed strong evidence that PS sentences elicited more questions than EMSS and PSTQ sentences (0.11; 95% CI [0.05, 0.17]; PP = 99.9%). We found inconclusive evidence for the hypothesis that *Target Word Repetitions* were more frequent with ACs than CCs. However, contrast methods showed strong evidence that Target Word Repetitions were more frequent with the most abstract PS sentences compared to the other ACs (i.e., EMSS, PSTQ) (2.5%; 95% CI [1.1, 4.3]; PP = 99.9%).

Hypothesis 2. Conversation: Turn-Taking.

We found moderate/strong evidence that ACs generate more *Turn-Taking* (i.e., further interactions, turn of words) than CCs. Within ACs, we found strong evidence that turn-taking was more frequent with the most abstract PS sentences than EMSS and PSTQ sentences (12.7%; 95% CI [8.4, 17.1]; PP = 100 %).

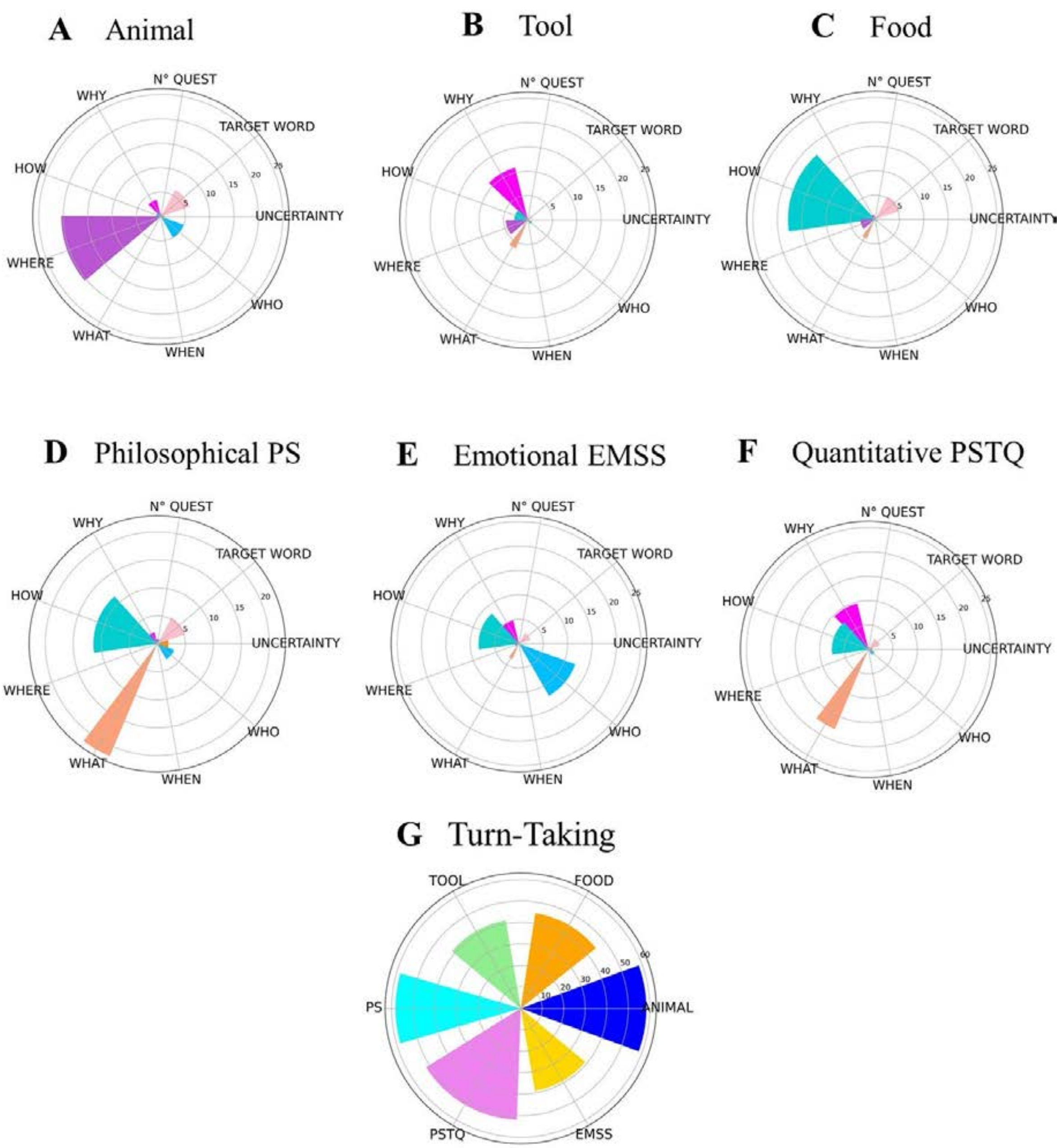


Figure 2. Polar plots for each kind of sentence, showing the row frequency count of the variable number of questions, the percentage of the other coded variables concerning conversation (i.e., uncertainty expressions, repetition of the target word, why, how, where, who, when, and what questions) and the percentage of the turn-taking variables.

Hypothesis 3. Point of views and General Statements.

We found strong evidence for the hypothesis that ACs elicit more *General Statements* than CCs. In addition, contrast methods showed strong evidence that General Statements were more frequent with PS sentences compared to PSTQ and EMSS sentences (2.9%; 95%CI [0.7, 5.5]; PP = 99.5%). Concerning the Points of view of participants, we found strong evidence that *1^{st} or 2^{nd} person Points of View* are more frequent with EMSS and PS sentences than PSTQ sentences (4.9%; 95% CI [0.9, 8.9]; PP = 99.1%), and moderate evidence that *1^{st} & 2^{nd} person Points of Views* were more frequent with EMSS and PS sentences than PSTQ sentences (0.6%; 95% CI [-1.6, 2.6]; PP = 69.3%). We found strong evidence that 1^{st} Point of Views was more frequent with food and animal sentences than tool sentences (6.5%; 95% CI [4.0, 9.1]; PP = 100 %) and moderate evidence that the *3^{rd} Point of Views* was more frequent with ACs than CCs. According to the Bayes Factor (BF, see Table 1), it was not possible to demonstrate the effect of sentences on overall Point of View and on 2^{nd} Point of View.

Hypothesis 4. Number of evoked contexts

We found strong evidence that the *Number of Evoked Contexts* was higher with ACs than CCs. In addition, contrast methods showed inconclusive evidence for the hypothesis that PS and PSTQ sentences evoked a higher number of contexts than EMSS sentences (-0.48, 95% CI [-2.29, 1.18]; PP = 29 %); and actually, it was more plausible that the effect was in the opposite direction as compared to the predicted one.

Hypothesis 5. Produced Features

Sensorimotor grounding

We found strong evidence that CCs elicited more *Sensory* (i.e., vision, touch, hearing, taste, smell) and *Material features* than ACs (see Figure 3).

Within CCs, contrast methods showed inconclusive evidence that *Visual features* were more frequent with animal and food sentences than tool sentences (-0.02; 95% CI [-2.4, 1.8]; PP = 41.7 %); moderate evidence that *Tactile features* were more frequent with tool sentences than other CCs (i.e., animal, food) (0.2%; 95%CI [-0.2, 1]; PP = 85 %), inconclusive evidence that *Tactile features* were more frequent with tool and food sentences compared to animals sentences (-0.3%; 95%CI [-1.2, 0.1]; PP = 6.2 %); strong evidence that *Auditory features* were more frequent with animal and tool sentences than food sentences (0.5%; 95%CI [0.1, 1.2]; PP = 100 %), and strong evidence for the hypothesis that, within CCs, *Material features* were more frequent with food and tools sentences compared to food sentences (4.2%; 95%CI [2.8, 5.7]; PP = 100 %).

Within ACs, contrast methods showed strong evidence for the hypothesis that the more concrete PSTQ sentences elicited more Visual features than other ACs (i.e., EMSS, PS) (0.6%; 95% CI [-0.1, 1.4]; PP = 95.4 %).

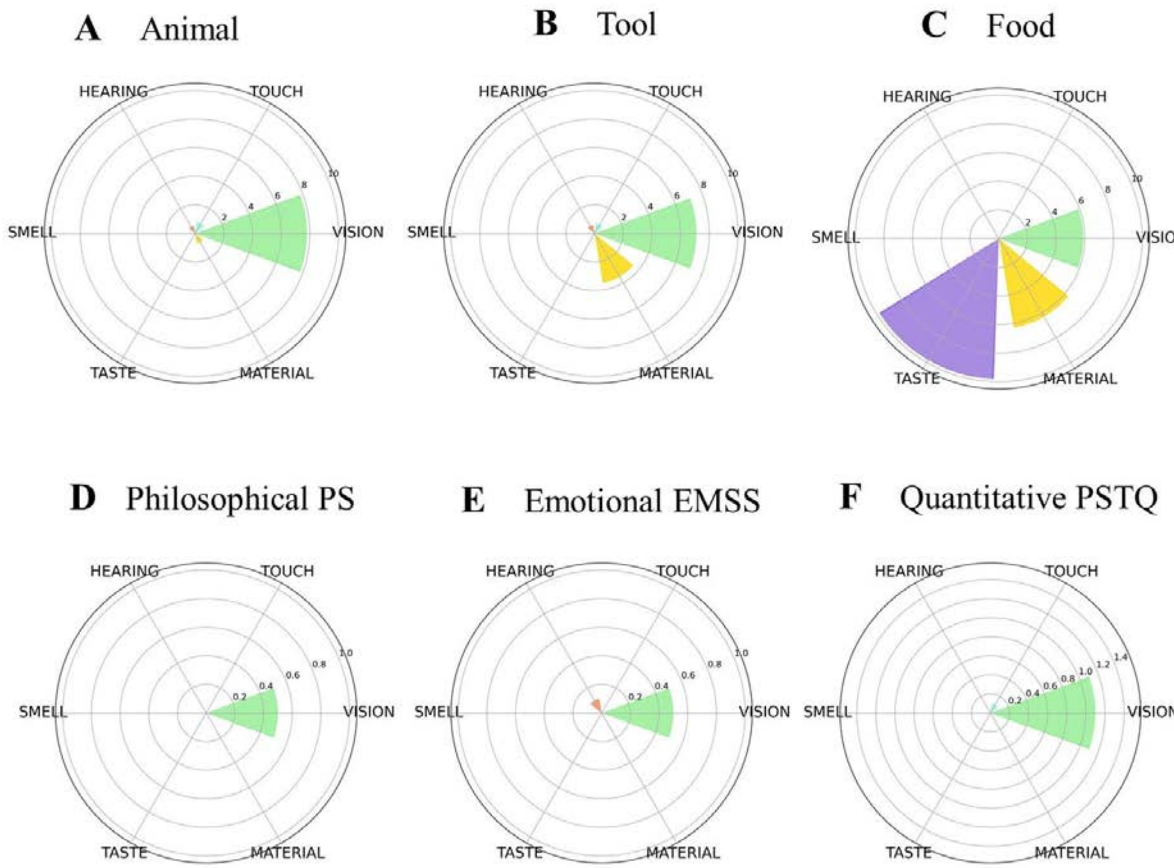


Figure 3. Polar plots for each kind of sentence, showing the percentage of sensorimotor grounding dimensions.

Thematic relations: Space, Time, Events, and Actions.

Spatial features were more frequent with CCs than ACs. In addition, contrast methods showed strong evidence for the hypothesis that Spatial features were more frequent with tool sentences than other CCs (4.9%; 95%CI [3.1, 7]; PP = 100 %). Within ACs, we found inconclusive evidence that Spatial features were more frequent with the most concrete PSTQ sentences compared to the other ACs (i.e., EMSS, PS) (-0.02%; 95%CI [-0.5, 0.6]; PP = 47.3 %).

We found inconclusive evidence for the hypothesis that ACs elicit more *Temporal features* than CCs. However, contrast methods showed strong evidence for the hypothesis that, within ACs, the most concrete PSTQ sentences evoke more Temporal features than other ACs (1.3%; 95%CI [-0.2, 2.9]; PP = 95.9 %). Within CCs, we found inconclusive evidence for the hypothesis that animal sentences evoke more Temporal features compared to other CCs (-4.3%; 95%CI [-6.1, -2.6]; PP = 0 %), and actually, it was more plausible that the effect was in the opposite direction as compared to the predicted one. We found inconclusive evidence in support of the hypothesis that *Events* were more frequent with ACs than CCs.

Concrete Actions were more frequent with CCs than ACs. Within CCs, contrast methods showed strong evidence that Concrete Actions were more frequent with food and tools sentences than animal sentences (4.3%; 95%CI [0.3, 8.1]; PP = 98.3 %). Within ACs, contrast methods showed strong evidence for the hypothesis that PSTQ sentences elicit more Concrete Actions than other ACs (i.e., EMSS, PS) (5.3%; 95%CI [3.4, 7.6]; PP = 100 %).

Abstract Actions were more frequent with ACs than CCs. In addition, contrast methods showed inconclusive evidence in support of the hypothesis that Abstract Actions were more frequent with PSTQ sentences than PS and EMSS sentences (-2.1%; 95%CI [-4.21, 0]; PP = 2.4 %), and actually, it was more plausible that the effect was in the opposite direction. Consistently, we found strong evidence that Abstract Actions were more frequent with PS and EMSS sentences than PSTQ sentences (2.1%; 95%CI [0, 4.21]; PP = 97.6 %).

Inner grounding: Interoception, Emotions, Metacognition, Beliefs, and Introspections.

We found inconclusive evidence in support of the hypothesis that *Interoceptive features* were more frequent with ACs than CCs. However, contrast methods showed moderate/strong evidence that, within ACs, Interoceptive features were more frequent with EMSS sentences than PS and PSTQ sentences (0.14%; 95%CI [0, 0.6]; PP = 88.3 %). Within CCs, we found strong evidence that Interoceptive features were more frequent with food sentences compared to tool and animal sentences (1.6%; 95% CI [0.7, 2.7]; PP = 100 %).

Overall, we found strong evidence that ACs evoke more *Emotions*, *Metacognition features*, *Beliefs*, and *Introspection* than CCs (see Figure 4).

Within ACs, contrast methods showed strong evidence for the hypothesis that *Emotions* were more frequent with EMSS sentences than other kinds of ACs (i.e., PS, PSTQ) (8%; 95%CI [5.6, 10.6]; PP = 100%)*;* inconclusive evidence for the hypothesis that the most abstract PS sentences evoke more *Metacognitive features* than other ACs (i.e., EMSS, PSTQ) (-0.05%; 95%CI [-1.13, 0]; PP = 2.3 %); strong evidence for the hypotheses that the most abstract PS sentences evoke more *Beliefs* than the EMSS and PSTQ sentences (2.6%; 95%CI [0.2, 5.6]; PP = 96.3 %), and that Beliefs were more frequent with PS and EMSS sentences compared to the less abstract PSTQ sentences (3.4%; 95%CI [0.7, 6.2]; PP = 99.3 %). Finally, we found strong evidence that PS sentences elicit more *Introspective* states than EMSS and PSTQ sentences (0.7%; 95%CI [-0.1, 1.8]; PP = 95.2 %). and that Introspection was more frequent with PS and EMSS sentences than the less abstract PSTQ sentences (0.6%; 95%CI [-0.2, 1.5]; PP = 94.1 %).

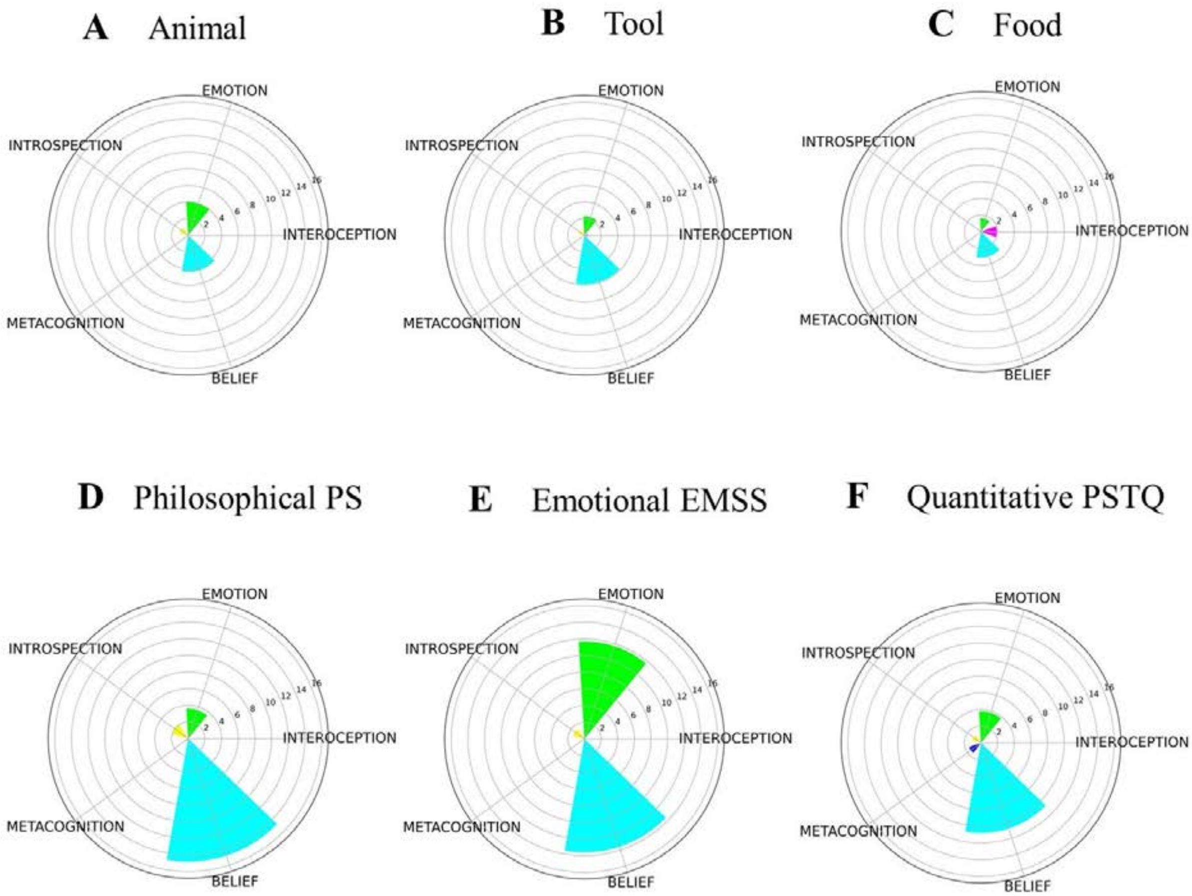


Figure 4. Polar plots for each kind of sentence, showing the percentage of inner grounding dimensions.

Other: Associations, Subordinates, Non-perceptual evaluations.

We found strong evidence that *Associations* were more frequent with ACs than CCs. However, contrast methods showed inconclusive evidence for the hypothesis that, within ACs, Associations were more frequent with PS sentences compared to PSTQ and EMSS sentences

(-0.4%; 95%CI [-1.3, 0.4]; PP = 15.6 %). We found inconclusive evidence in support of the hypothesis that *Subordinates* were more frequent with ACs than CCs (-0.8%; 95%CI [-1.6, 0.1]; PP = 1 %), and strong evidence that *Non-perceptual evaluations* were more frequent with ACs than CCs.

Hypothesis 6. Conversation: Kinds of questions.

Why questions were slightly more frequent with ACs than CCs. In addition, contrast methods showed inconclusive evidence for the hypothesis that, within ACs, PS and EMSS sentences evoke more Why Questions than PSTQ sentences (-6.2; 95%CI [-8.7, -4.1]; PP = 0 %), and actually it was more plausible that the effect was in the opposite direction as compared to the predicted one. Consistently, we found strong evidence that Why Questions were more frequent with PSTQ sentences compared to PS and EMSS sentences (6.2%; 95%CI [4.1, 8.7]; PP = 100 %).

Who questions were more frequent with ACs than CCs. In addition, contrast methods showed strong evidence for the hypothesis that, within ACs, EMSS sentences evoke more Who Questions than PS and PSTQ sentences (10%; 95%CI [7.5, 12.9]; PP = 100 %).

What questions were more frequent with ACs than CCs. Instead, W*here* and *When questions* were more frequent with CCs than ACs. Within CCs, contrast methods showed strong evidence that Where Questions were more frequent with animal and tools sentences than food sentences (9.4%; 95%CI [7.4, 11.5]; PP = 100 %).

How questions were not more frequent with CCs than ACs as we assumed. However, contrast methods showed strong evidence that, within CCs, How Questions were more frequent with food and tool sentences than animal sentences (5.2%; 95%CI [3.1, 7.3]; PP = 100 %).

Within ACs, contrast methods showed inconclusive evidence for the hypothesis that How Questions were more frequent with EMSS sentences compared to PS and PSTQ sentences (-1%; 95%CI [-3.3, 1.3]; PP = 19 %); and that PSTQ sentences evoke more How Questions than EMSS and PS sentences (-2.2%; 95%CI [-4.5, 0]; PP = 2.7 %). Consistently, we found strong evidence that PS sentences evoke more How Questions compared to the other kinds of ACs (3.3%; 95%CI [0.9, 5.9]; PP = 99.6 %).

Exploratory analyses on Empathy

We run correlation analyses to explore the relationship between the results of the conversational task and the dispositional empathy of participants, detected using the IRI scale (Davis, 1980). Among the four subscales included in the IRI survey, we focused on the perspective-taking (PT) and empathic concern (EC) subscales that tap separate facets of empathy particularly relevant for our purposes. The PT subscale measures the reported tendency to adopt the psychological point of view of others in everyday life (e.g., "I sometimes try to understand my friends better by imagining how things look from their perspective"). In contrast, the EC subscale assesses the tendency to experience feelings of sympathy and compassion for unfortunate others (e.g., "I often have tender, concerned feelings for people less fortunate than me").

Specifically, we tested whether the main PT and EC scores of each participant correlated with the following variables: Turn-Taking, Agreement, Emotions, Points of View (1^{st}, 2^{nd}, 3^{rd}, and 1^{st} & 2^{nd} person), Why and How questions. Finally, we tested whether the number of words produced by participants varied across different sentences. We intend to investigate whether such correlations are different in CCs and ACs, and their sub-categories.

Exploratory analyses results

Because of the frequency nature of our dependent variables, we conducted our analysis using Spearman's Rho correlation. Table 3 shows a summary of the results for each variable.

Table 3. Spearman Rank Correlation between the Empathic Concern (EC) and Perspective-taking (PT) subscale for the selected variables across abstract and concrete sentences and sub-type of concrete sentences (i.e., animals, foods, tools) and abstract sentences (i.e., Emotional EMSS; Philosophical PS; Quantitative PSTQ). In bold are reported significant correlation (p < .05).

		Abstract		**Concrete**		**Animals**		**Foods**		**Tools**		**Emotional EMSS**		**Philosophical PS**		**Quantitative PSTQ**	
Variable		*EC*	*PT*	*EC*	*PT*	*EC*	*PT*	*EC*	*PT*	*EC*	*PT*	*EC*	*PT*	*EC*	*PT*	*EC*	*PT*
Turn	*Rho*	- .021	- .028	.031	.052	.040	.078	.034	.043	.021	.037	-.013	-.041	-.039	-.001	-.013	-.042
	p	.305	.175	.127	**.010**	.254	**.028**	.333	.227	.553	.295	.716	.251	.269	.969	.719	.232
Agree	*Rho*	-.002	-.011	-.040	-.051	-.0133	-.062	-.065	-.089	-.043	-.012	-.018	.013	-.001	-.029	.014	-.020
	p	.915	.592	.052	**.012**	.710	.078	.067	**.012**	.224	.725	.606	.704	.969	.407	.686	.567
Emotions	*Rho*	.059	.025	.015	.016	.043	.078	-.045	-.005	.029	.028	.090	.027	.038	.024	.036	.026
	p	**.004**	.218	.466	.438	.224	.558	.203	.878	.418	.423	**.011**	.453	.283	.502	.306	.460
Why-Q	*Rho*	-.065	.002	- .027	-.044	.019	-.078	-.093	-.066	-.038	-.025	-.053	-.001	-.022	.007	-.101	.001
	p	**.001**	.904	.189	**.031**	.583	**.027**	**.008**	.063	.280	.489	.136	.980	.534	.837	**.004**	.969
How-Q	*Rho*	.050	-.016	.018	.033	.021	.078	.017	.034	.020	-.013	.119	-.011	.023	-42	.007	.009
	p	**.015**	.445	.384	.105	.549	**.028**	.627	.344	.575	.721	**.001**	.767	.507	.234	.840	.793
PoV	*Rho*	.044	.053	.050	.035	.022	-.010	.062	.032	.066	.081	.061	.079	.012	.021	.059	.055
	p	**.032**	**.010**	**.014**	.091	.530	**.777**	.082	.368	.064	**.022**	.085	**.026**	.727	.552	.098	.119
1st PoV	*Rho*	.035	.019	.041	-.077	.019	-.109	.030	-.040	.084	-.100	.045	.049	.050	.028	.008	-.022
	p	.087	.352	**.043**	**.001**	.585	**.002**	.399	.265	**.017**	**.005**	.208	.164	.161	.423	.812	.530
2nd PoV	*Rho*	-.005	.022	.023	.039	.033	.056	.020	.000	.018	.061	-.004	.022	-52	.019	.043	.024
	p	.794	.287	.259	.054	.347	.117	.568	.999	.614	.008	.910	.533	.143	.595	.222	.503
3rd PoV	*r*	-.008	.015	-.018	-.028	-.008	-.039	-.019	-.036	-.047	-.005	.007	.063	.004	-.026	-.035	-.021
	p	.697	.476	.375	.169	.829	.273	.598	.314	.186	.881	.852	.077	.900	.465	.326	.546
1st&2nd PoV	*Rho*	.044	.030	.026	.061	-.016	-.014	.046	.089	.037	.088	.061	.039	.043	-.008	.028	.054
	p	**.031**	.143	.202	**.003**	.645	.701	.195	**.012**	.302	**.013**	.086	.274	.230	.828	.423	.129

EC sub-scale, more emotionally connoted, correlated mostly with ACs and their kinds. In particular, the positive correlation between EC subscale and EMSS sentences for emotions, how-questions, and 1^{st} & 2^{nd} point of view suggests that more empathic individuals may be more sensitive to emotions and keener to adopt others' perspectives asking questions about how they feel. Within CCs, the EC sub-scale correlated with tools in first-person pronouns; hence, such a personal involvement concerns tools, likely because of their link with action.

PT sub-scale mainly correlated with CCs and their subkinds. The positive correlation of the PT scale with the further turn-taking for concrete sentences concerns mainly animals. Unsurprisingly, the level of agreement correlated negatively with the PT subscale for food sentences, for which participants frequently express their own tastes. In addition, the negative correlation between PT subscale and why-questions for animals and foods suggest that people who adopt the psychological point of view of others are less prone to inquire about common actions involving everyday objects/entities. Consistently, we found a negative correlation between the PT subscale in 1^{st} person and a positive correlation in 2^{nd} person and 1^{st} & 2^{nd} person combined, especially with tools and foods, possibly due to their link with interactive and joint actions. However, these findings do not allow drawing strong conclusions because the Spearman's correlation indicates only weak relationship.

Finally, we used the Wilcoxon Signed-Ranks test to explore the Number of Words produced by participants. We found no differences between the produced texts to ACs and CCs ($Z = 1.666$, $p = .067$). However, according to Friedman's test the sub-categories of ACS and CCs differ significantly in the produced numbers of words (χ^2_F (5) = 20.03, $p <. 001$). Participants tend to produce longer responses to sentences including food items (*Mdn* = 3.84) and EMSS concepts (*Mdn* = 3.86) than animals (*Mdn* = 2.81) ($Z = -1.056$, $p = .007$; $Z = -1.038$, $p = 005$, respectively). No other pairwise comparison reached the significance.

Discussion

The results are in line with the predictions. CCs and ACs differ along various dimensions. CCs evoke more sensorimotor properties, ACs elicit more inner properties (emotions, beliefs, etc.). Crucially, CCs and ACs also differ in the conversational dynamics they elicit. Furthermore, exploratory analyses confirmed the differences between the various concept kinds. We will first summarize the main differences between CCs and ACs, and then between concept kinds.

ACs. Compared to CCs, ACs generate more uncertainty expressions, a higher number of cases of 1^{st} & 2^{nd} person point of views, and evoke a higher number of contexts. Furthermore, they yield more associations, more inner processes (emotions, beliefs, introspections), more general statements. In addition, they evoke more why and who questions. Finally, the correlation between the Empathic Concern subscale and ACs, especially EMMS, for emotions and how-questions suggests a higher personal engagement with ACs, confirmed by the correlations with 1^{st} & 2^{nd} point of view. Some of these dimensions have been identified in previous norming, ratings, and feature production studies: for example, Villani et al. (2019; 2021) and Barsalou et al. (2018) stressed the role of inner grounding; Kousta et al. (2011) the importance of emotions; Barsalou and Wiemer-Hastings (2005) and Barca et al. (2017), the role of free associations, and introspections; Schwanenflugel et al. (1992), the association with various contexts. However, some dimensions are completely new since they characterize ACs in a simulated direct interaction. As predicted, ACs generate more uncertainty, as testified by the correspondent expressions, and, possibly as a consequence of this, lead to more interactive exchanges, assessed through the higher presence of 1st & 2nd person point of views and the higher numbers of turns. They elicit more generalizations and questions linked to possible underlying mechanisms (why) and agents (who).

CCs. Compared to ACs, CCs yield more sensory properties, materials, spatial expressions, and concrete actions. These dimensions confirm that CCs are firmly grounded in the sensorimotor system; unlike previous studies, we find these properties using a simulated interaction rather than isolated words. Crucially, we also find that CCs elicit more questions about the spatial and temporal context (what, where, and when). Finally, the finding that the CCs and the Perspective Taking subscale correlated positively for 1st & 2nd point of views and correlated negatively for why-questions and 1st person perspective is an index that CCs are rooted on common ground knowledge that requires fewer specifications.

Kinds of ACs. While some dimensions, like metacognition, do not differ across the kinds of ACs, a major opposition exists between the more abstract PS and the more concrete PSTQ concepts. Consistently, compared to the two other kinds of ACs, PS concepts elicit more uncertainty in conversation (uncertainty expressions, questions, and repetitions) and a more interactive dialogue (more turns). Inner grounding is stronger (more beliefs and introspections), and the tendency to produce general statements is more marked. PS concepts evoke more points of view and abstract actions than PSTQ ones. In contrast, PSTQ concepts evoke more visual properties and concrete actions than other abstract kinds. Curiously, they also elicit more temporal features and why-questions, but this is likely a matter of the content they convey, being often scientific concepts. EMSS concepts are in the middle in terms of abstractness. Consistently, they evoke fewer points of view than PS, and more abstract actions than PSTQ concepts. Crucially, they are characterized for interoception (e.g., Connell, Lynott, & Banks, 2018; Villani et al., 2021), and they yield more who-questions, testifying the interest for the person who experiences emotions.

Kinds of CCs. Our results allow us to frame the kinds of CCs in a novel way. The personal involvement, as testified by 1st person statement, is stronger with animals and food, while where-questions interest more animals and tools, likely because of the possible variety of their contexts. Notably, food evokes both perceptual (materials) and bodily experiences (interoception); animals and tools elicit auditive properties.

Conclusions

This study allows drawing three main conclusions.

The first is that the abstract/concrete distinction is an important one. CCs and ACs cannot be characterized as extremes of a continuum but as a collection of different points in a multidimensional space. Some of these dimensions have been intensively investigated. For example, classical theories emphasized the role of imageability for CCs and the higher number of contexts for ACs; recent views underlined the importance of emotions and inner grounding for ACs. But, crucially, other dimensions we identified are entirely novel, deriving from concepts' use in a simulated interaction. ACs induce higher conversational uncertainty, elicit why and who questions, and more interactive exchanges (use of the second person); conversely, CCs yield more what, where, and when questions.

The second is that ACs and CCs are not holistic categories but incorporate differently characterized kinds. Within ACs, the most concrete PSTQ oppose to the most abstract PS concepts. We identified both the content of each kind and the specificities linked to the use of the corresponding word. EMSS concepts differ from other kinds, both in terms of their content – the strong role of interoception – and their role in the conversation.

It should be noted that our study did not aim to compare the distinction of abstract-concrete concepts as a continuum vs. discrete categories. However, we believe that by demonstrating that different dimensions, both semantic and pragmatic, weigh differently depending on the kind of concepts/sentences, we demonstrate that concepts are not arranged along a continuum between the two extremes defined only by the concreteness/abstractness dimension. Moreover, our results further corroborate the idea that concepts are multidimensional and multifaceted constructs. When considered as broad categories, concrete concepts are primarily grounded in sensorimotor experiences, and abstract concepts are mostly grounded in inner and social-linguistic experiences. However, at the more fine-grained level, the role of some dimensions overlaps between different types of concepts. For example, interoceptive contents characterized both food and emotional concepts, sensorimotor proprieties (visual and actions) are associated with tools and abstract physical-quantitative concepts.

The third is that investigating concepts in everyday use allows detecting their richness and flexibility. A possible limit in generalizing our results is that they concern a simulated conversation. We should design new methods to investigate concepts in real-time interactions, benefiting from insights from pragmatics and using social interactive tasks. The absence of studies adopting interactive methods in the investigation of abstract concepts is particularly striking in light of the spread of interest in the role of social interaction in a variety of fields. For example, research on basic cognitive processes has recently highlighted that some specific effects on spatial representation and attentional processing emerged only when participants are sharing a task (e.g., e.g., Sebanz, Knoblich & Prinz, 2003; Ciardo, Lugli, Nicoletti, Rubichi & Iani, 2016; Lugli, Iani, Milanese, Sebanz & Rubichi, 2015; for a review see Dolk et al., 2014). The last twenty years have seen a proliferation of studies on sensorimotor communication and signalling review: Pezzulo et al., 2019) and on various forms of synchronization occurring during conversations (e.g., Wohltjen & Wheatley, 2021), intended as a form of joint action (Galantucci & Sebanz, 2009; Pickering & Garrod, 2021). In neuroscience, the development of new, sophisticated techniques, like hyperscanning, has allowed the focus on interactive aspects during conversation (meta-analysis: Kelsen et al., 2020). Curiously, this interest in interactive aspects has not invested the investigation of conceptual representation (for exceptions see, Zdrazilova et al., 2018; Fini et. al., 2021). In a recent paper, Barsalou et al. (2018) argued that most studies in this field used single, decontextualized words and stated that we need to study concepts in situated action. We agree and think we need to go even further and start investigating concepts in situated interactions.

CONCLUSIONS

This dissertation has addressed the issue of abstract concepts for contemporary theories of cognition and conceptual knowledge. The analysis treated the ongoing theoretical debate on the representational format of abstract concepts, comparing the major contending theories: amodal, embodied/grounded, and hybrid approaches (Chapter 1, § 1.1). I examined and defended a multiple grounded perspective advanced by recent Multiple Representation Views (MRVs, Chapter 2) because it seems to offer a thorough account of abstract concepts by recognizing (i) the role of sensorimotor, interoceptive, linguistic, and social experiences in shaping their representation (ii) the variety inherent in the abstract semantic domain, and (iii) their variability across contexts and individuals.

The theoretical arguments and empirical studies comprised in this dissertation aim to fill some important research gaps in the investigation of abstract concepts. First, most previous studies of the representation of abstract concepts contrasted them with concrete concepts as a homogeneous conceptual domain, thus neglecting their heterogeneity (Chapter 1, § 1.3.3, § 1.4). Whereas classical accounts of concepts defined abstract concepts negatively as concepts lacking a concrete, physical and manipulable referent, more recent Multiple Representational Views attempt to redefine them by considering other fundamental dimensions, beyond the sensorimotor ones. Among these approaches, I specifically focused on the Words as Social Tools (WAT) theory which assumes that the modality of acquisition of concepts plays a crucial role in subsequent representation. In particular, abstract concepts would benefit from linguistic input, either through overt or covert speech, and social interactions underlying their acquisition and use. Notably, the WAT theory argues that the contribution of embodied/sensorimotor, inner, linguistic, and social dimensions to the grounding of concepts depends on the level of *abstractness* (i.e., being detached from physical reality, § 1.3.1) of specific concept kinds. Against this background, Study I demonstrated through a data-driven analysis of the ratings of 495 abstract nouns that abstract concepts, just like concrete concepts, are not a holistic category but comprise subclusters characterized by different grounding sources. Study II corroborated the proposed classification, showing that sensory modalities and motor aspects are more pivotal for quantitative and spatiotemporal abstract concepts (e.g., reflex, sum), interoceptive states contribute to the representation of emotional abstract concepts (e.g., joy, anger), self-sociality concepts (e.g., energy, separation), whereas language-based experiences are relevant for the most abstract philosophical and spiritual concepts (e.g., virtue, immortality). These findings confirm that the clear-cut distinction between "abstract" and "concrete" concepts should be radically reconsidered in favor of more subtle distinctions between semantic domains.

Second, literature on contextual flexibility suggests that the meaning of abstract words is more variable across individuals than concrete ones, likely because they are less supported by environmental structures. Nevertheless, research has primarily focused on cross-cultural and cross-linguistic variation in abstract concepts and less on individual differences that might arise from idiosyncratic prior knowledge tied to different experiences with an abstract domain (Chapter 4, § 4.2). To address this gap, we choose the subdomain of institutional concepts (i.e., parliament, justice) as a case study to examine individual differences in the representation of concepts at the boundary between concrete and abstract ones. Study III showed that law experts rated institutional concepts as more associated with the sense of touch, positive emotions, and specific contexts than a control group, suggesting that expertise might contribute to rendering abstract concepts more concrete. Preliminary results from Study IV, based on a picture-priming task, indicated that law experts had a greater advantage over non-experts in categorizing institutional concepts when primed by social situations. Further research is needed to determine whether this effect is due to experts' high confidence in processing institutional concepts or their ability to embed knowledge into collaborative practices.

Third, a major limitation of current studies on the representation of abstract concepts is that focusing on single, decontextualized words does not inform how the comprehension and production of abstract concepts develop and fulfill their communicative function during linguistic exchanges (Chapter 4, § 4.3.1). In this regard, the novel interactive paradigm introduced in Study V offers insights into the conversational dynamics triggered by abstract sentences, which generate higher uncertainty and require more clarifications from the interlocutor compared to conversations prompted by concrete sentences. As this work analyzed simulated conversations, further investigations on real-time dialogues about abstract and concrete topics would be useful to validate these findings.

To bring the discussion to a more general level, the arguments and evidence developed in this dissertation allow drawing some preliminary answers to the questions raised in the introduction. Embodied and Grounded theories of cognition can account for abstract concepts by (a) defining them as a multidimensional and heterogeneous set of concepts that benefit from several sources of grounding, including sensorimotor/embodied aspects, affective and internal states, social and linguistic experiences whose weight varies according to the specific semantic domain and contextual constraints; (b) recognizing that abstract concepts consist of complex and flexible representations, such that individuals might re-enact different features of an abstract concept depending on their knowledge and the context in which they instantiate it; (c) bridging the gap between research on processing abstract words in isolation and research on processing abstract concepts in real-time social interactions to elucidate the mechanisms underlying their use.

This dissertation provides initial evidence that studying abstract concepts in a more fine-grained way – taking into account their varieties and multiple dimensions, possibly assessing individual differences, and using interactive methods – might lead to a deeper understanding of their nature and representation. Future research could further profit from data-driven approaches to examine a wide variety of subsets of abstract concepts and refine the oversimplistic abstract-concrete dichotomy in light of other relevant dimensions. On the other hand, the use and development of new ecological approaches could be of great benefit to future investigations on abstract concepts that might integrate existing studies on individual processing of single abstract words with findings from dyadic or collective conversations about abstract topics. These approaches would open new avenues for theoretical and applied research. Since abstract concepts are notoriously difficult to learn and master (see § 2.4.5.1), studying how experts conceptualize their domains of knowledge (e.g., mathematics, physics, philosophy) might allow the identification of key properties and dimensions that can serve as scaffolding for laypeople or novices. This might be useful to complement teaching, which typically focuses on the achievement of linguistic knowledge based on formal definitions, with additional experiential information based on perceptual and emotional contents, as well as motor and social interactions that convey the meaning of specific abstract terms (for a recent discussion on embodied education, see Shapiro & Stolz, 2019). Moreover, a careful examination of how abstract concepts are mastered and used at both individual and collective levels could have deep implications for understanding practices of negotiation, alignment, or disagreement among social actors faced with redefining complex abstract constructs at the core of our societies, such as values, rights, sociocultural, religious, and political concepts.

To the extent that abstract concepts still pose a challenge to scientific research, I suggest keeping in mind that failure to take into account their varieties and flexible use can lead to incomplete and misleading accounts. For this reason, it is high time to move towards the study of concepts in the context of social interactions, as this can provide a unique window into the extraordinary ability of humans to understand and share abstract ideas.

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