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DEVELOPMENT, DEGENERATION AND NEURAL NETWORK OF THE BODILY SELF

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ABSTRACT

The question addressed by this dissertation is how the human brain builds a coherent representation of the body, and how this representation is used to recognize its own body. Recent approaches by neuroimaging and TMS revealed hints for a distinct brain representation of human body, as compared with other stimulus categories. Neuropsychological studies demonstrated that body-parts and self body-parts recognition are separate processes sub-served by two different, even if possibly overlapping, networks within the brain.

Bodily self-recognition is one aspect of our ability to distinguish between self and others and the self/other distinction is a crucial aspect of social behaviour. This is the reason why I have conducted a series of experiment on subjects with everyday difficulties in social and emotional behaviour, such as patients with autism spectrum disorders (ASD) and patients with Parkinson's disease (PD). More specifically, I studied the implicit self body/face recognition (Chapter 6) and the influence of emotional body postures on bodily self-processing in TD children as well as in ASD children (Chapter 7). I found that the bodily self-recognition is present in TD and in ASD children and that emotional body postures modulate self and others' body processing.

Subsequently, I compared implicit and explicit bodily self-recognition in a neuro-degenerative pathology, such as in PD patients, and I found a selective deficit in implicit but not in explicit self-recognition (Chapter 8). This finding suggests that implicit and explicit bodily self-recognition are separate processes subtended by different mechanisms that can be selectively impaired.

If the bodily self is crucial for self/other distinction, the space around the body (personal space) represents the space of interaction and communication with others. When, I studied this space in autism, I found that personal space regulation is impaired in ASD children (Chapter 9).

Keywords: self-awareness, implicit and explicit recognition, body, face, personal space.

OVERVIEW OF THE THESIS

The aim of this dissertation is to investigate the distinction between self and others and the interpersonal regulation of own personal space.

A sense of identity is necessary in order to successfully interact with others people. The sense of identity is based on different cognitive abilities, such as self-recognition of own body and the interpersonal regulation of our behaviors. Features of these two aspects of the self have been reviewed in Chapter 1.

Studies using different methods (behavioral, fMRI, TMS studies) have shown that the recognition of one’s own body is independent from the recognition of other people’s bodies. Recent evidence suggests that a specific neural network is dedicated to “self-body” recognition. This brain network seems to be, at least partially, distinct from that responsible for general body-related information processing. A similar distinction was also found for face and “self-face” recognition. In Chapter 2 and 3 the literature about the cognitive mechanism of the recognition of our own body and face and their underpinning cerebral networks were revised. How the brain built the presentation of self-body and the development of the healthy and pathological bodily self-recognition was revised in Chapter 4.

When we interact with others people we have to be aware not only of own body but also of the others’ bodies. During interaction we automatically regulate our posture and our position in the space in respect of those of other. For this reason in Chapter 5 the literature about the regulation of own personal space was revised.

In Chapter 6 and 8 the development and the degeneration of the bodily during the life span were investigated. In particular, in Chapter 6 the development of implicit bodily self-recognition was studied in children wit typical development and in children with a deficit in distinguishing self from others, such as children with autism spectrum disorders (ASD). In Chapter 8, the deterioration of the bodily self-recognition was studied in patients with a deficit of body-awareness, such as patients with Parkinson’s disease. In these two Chapters a matching-to sample task was adopted to evaluate the implicit ability to recognize own body. Moreover, in patients with Parkinson’s disease the implicit self-body recognition was compared with the explicit self body recognition.

In Chapter 7 a variation of the same matching-to sample task was used to study if other informations can favor the self/other distinction. Specifically in this chapter the influence of emotional body postures on implicit bodily self-processing was studied in healthy and in autistic children. Finally in Chapter 9 we investigated how we regulated our personal space during social experience. Particularly, we studied whether the personal space is differently regulated by the presence of an unknown individual and by a brief social interactions with other people in healthy and autistic children.

Part of the studies described in this thesis are published in:

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Gessaroli, E., Andreani, V., Pellegri, E. and Frassinetti, F. (2013) Self-face and self-body recognition in autism. Research in Autism Spectrum Disorders, 7: 793–800.

Zamagni, E., Dolcini, C., Gessaroli, E., Santelli, E. and Frassinetti, F. (2011) Scared by you: modulation of bodily-self by emotional body-postures in autism. Neuropsychology, 25:270-6.

CHAPTER 1. SELF-KNOWLEDGE

Neisser (1991) proposes that from the outset infants develop two kinds of implicit self-knowledge: knowledge about the self in relation to others (the interpersonal self) and knowledge about the self in relation to physical objects (the ecological self). Following Neisser, perceiving and acting in the social or physical realm correspond to two basic kinds of implicit self-knowledge developing from birth. The interpersonal self grows out of the infant's transactions with others, in particular the developing sense of shared experience and reciprocity. In the physical domain, infants develop a sense of their own body in relation to other objects (the ecological self). The ecological self is the sense infants develop of their own physical body as a differentiated and situated agent in the environment. The ecological self develops as infants interact with physical objects and also as they perceive their own body directly via self-exploration (Amsterdam, 1972; Rochat & Morgan, 1995; Rochat, 1998).

Thus for humans, it is really important to firstly develop a sense of self and then use this self-awareness to interact with others. For this reason in this thesis aspects of both the interpersonal and ecological self will be explored. First the cognitive processes and underlying brain networks of the ecological self will be explored, specifically in reference to the self-recognition of one's own body. Second we explore how we regulate the distance between our body and the other's body during interpersonal relationships.

1.1.The ecological self

Distinguishing the self from others is necessary for self-awareness and social interaction. This distinction is thought to depend on multisensory integration. Indeed, we recognize ourselves because the brain processes some visual, auditory or somatosensory stimuli as "me". All these inputs participate in the recognition of different aspects of one's physical self, such as one's face, voice, body or its movement.

For example Rosa and coworkers (2008) showed that adults rarely mistake their own recorded voice for someone else’s voice. Even though people recognize that the recorded voice sounds different from the voice as we normally hear it, people most often still recognize the recording as their own voice.

Another example of self-recognition was given by Loula and coworkers (2005). They asked participants to perform a self-identification task while observing sagittal displays of point-light depictions of themselves, their friends, and strangers while performing various actions. The researchers found higher sensitivity to one’s own motion. The researchers conclude that since everyone has little experience of viewing their own body moving, such self-advantage can be explained by the activation of observers’ own action motor representation.

In the same vein, Tsakiris and coworkers (2006) carried out a study in which participants had to decide whether in a projected image they viewed their own right hand or someone else’s right hand covered with identical gloves. Participants experienced a passive displacement of their own right index finger, either generated by the experimenter or by participants’ own left hand. The results showed that the performance was significantly better when the displacement of the participants’ right index finger was self-generated. As argued by Tsakiris and coworkers (2007) this shows that ‘‘Self recognition was significantly more accurate when subjects themselves were the authors of the action’’.

We recognize ourselves also thanks to our physical appearance.

One of the first researchers to study the ability to recognize one's own physical features was Gallup. Gallup (1970) conducted an experimental test using a relatively simple approach. Individually housed chimpanzees were confronted with a full-length mirror outside their cages for a period of 10 days. The chimpanzees initially reacted as if they were seeing another chimpanzee and engaged in a variety of social displays directed toward the reflection. These social responses waned after the first few days. Rather than continue to respond to the mirror as such, the chimpanzees began using the mirror to respond to themselves by engaging in mirror-mediated facial and bodily movements and self-directed responses such as grooming parts of the body only visible in the mirror. The transition from social to self-oriented responding gave the impression that the chimpanzees had learned to recognize themselves. To assess this possibility Gallup devised the mark test. Each chimpanzee was anesthetized and, while unconscious, a red mark was applied to the brow above one eye and the top half of the opposite ear. A non-odorous, non-irritant dye was used, so that upon recovery from the anesthetic the chimpanzees would have no knowledge of the marks. Observations in the absence of the mirror confirmed this as the chimpanzees rarely touched the marks. When the mirror was reinstated, however, the effect was dramatic: the chimpanzees looked at their reflection and guided their fingers to the marks on their faces that could only be seen in the mirror. In addition to touching the marks repeatedly and looking at their fingers, some even smelled their fingers.

Such abilities to recognize one's own physical features are purportedly possessed by only a small selection of primate species, including humans (Reiss and Marino, 2001 and Suarez and Gallup, 1981), and they are considered as behavioral markers of self-awareness.

A large number of studies report that infants recognize themselves in the mirror at 14–18 months (Amsterdam, 1972; Nielsen & Dissanayake, 2004). However, recent research has shown that infants develop self-other discrimination in specular images long before this age (Rochat & Striano, 2002).

The mirror self-recognition is only one particular self-recognition behavior. We normally also recognize our body when seeing videos or photos. In the following chapters we analyze studies that used videos or photos to understand the cognitive mechanisms of self-recognition.

The ability to recognize that the other is distinct from the self is considered an early marker of typical development, and it is central to the ability to form social bonds and engage in successful social interactions (Lewis and Brooks-Gunn, 1979; Rochat and Striano, 2000; Keenan et al., 2003).

Conversely, a diminished ability to discriminate whether stimuli are related to the self or to others is associated with deficits in interpersonal interactions, often seen in various psychopathologies. For instance, individuals with schizophrenia exhibit both social deficits and impairment in self-recognition processes (Irani et al., 2006). Patients with autism or Parkinson disease also exhibit both social deficits and impairment in self- recognition processes (Messer et al., 2000; Uddin et al., 2008; Gamarra et al., 2009). For this reason in this thesis we analyze the self-other differentiation processes as the first step to developing social ability as the regulation of the space between two interacting people.

1.2 The interpersonal self

When a person notices that he or she is being looked at, or is being approached by another person, he/she becomes aware that the attention or intentionality of another person is directed at him/her. This awareness is a basic mindset during social interaction. This aspect of self is obviously distinct from the physical self because it inherently requires the existence of another person. This category of self could be labelled “interpersonal self”.

The interpersonal self has a lot of aspects: for example the comparison of the actual self with the socially-presented/perceived self, the adaptation of our behavior to social roles or the evolutionary development of the personality in affective relationships. In this thesis we analyze a specific aspect of the interpersonal self: the personal distance that people prefer to maintain during interpersonal meetings. In a specific chapter we will analyze the interpersonal regulation of own personal space.

CHAPTER 2. SELF FACE RECOGNITION IN ADULTS

To remember and recognize our face is essential for social interaction. Indeed we sometimes have anxiety or thoughts about the appearance of our face. We can think that our image could be helpful or not for our aims. To be aware of our own characteristics could be helpful in evaluating for example, the reaction that other people have in respect to our image.

The ability to recognize our face develops quite early but can be lost after brain injury or other cerebral illness. In the following paragraphs we try to understand the cognitive processes and the underlying cerebral network of own face recognition.

2.1 Neuropsychological cases

The mirror sign is the loss of the ability to recognize one’s reflected face in a mirror while the ability to recognize others’ faces often remains intact.

This neuropsychological symptom is reported in a variety of contexts. The earliest example found in the literature was a 1928 report describing a 68-years-old man with senile dementia who, when presented with a mirror, became irritated and said, “You see, there’s the guy again!” and walked behind the mirror with offerings of money and tobacco in an apparent effort to cheer up the image (Klein, 1928). In 1982, the first American report of the mirror sign was a case series of seven individuals with probable Alzheimer’s disease who exhibited the syndrome of mirrored-self misidentification (Foley et al., 1982). There is an association between the mirror sign and cognitive dysfunction. Most case reports describe patients with existing diagnoses of dementia (Hemphil, 1948; Phillips et al., 1996). However, the mirror sign has also been reported in patients with histories of traumatic brain injury, neoplasms, encephalopathy, paranoid schizophrenia, schizoaffective disorder, affective disorder, head trauma, epilepsy, cerebrovascular disease, pituitary tumor, multiple myeloma, multiple sclerosis, viral encephalitis, frontal lobe pathology, and AIDS (Molchan et al., 1990; Coltheart et al. 2007).

Recent studies have also described a legitimate mirror sign, without general cognitive decline, supporting the classification of mirror sign as a distinct entity (Spangenberg, 2005; Villarejo et al., 2010).

The potential explanations for this symptom include deficits in facial recognition, impaired spatial processing, decreased executive functioning (Breen et al., 2001), an impaired sense of uniqueness (Margariti et al. 2006), a disconnection between visual input and emotional response, conflicting positive and negative feelings about oneself or others (Enoch et al. 1979), confabulation, and generalized depersonalization or derealization (Feinberg and Roane; Feinberg and Keenan 2005).

The mirror sign provides evidence that our face image is special for the brain and that specific brain networks are involved in its recognition.

2.2 The contribution of the right hemisphere in self-face recognition

Keenan and coworkers (1999; 2000; 2001) showed that own-face recognition is correlated with right hemisphere activity.

In a first study, Keenan and coworkers (1999) submitted right handed healthy adults to a reaction time experiment in which they had to press three different keys when identifying either their own face, that of a familiar person or that of a stranger. Participants showed shorter reaction times with their left than with their right responding hand when stimuli depicted their own face. Since reaction times are shorter when subjects respond to stimuli that have strongly lateralized hemispheric processing with the hand controlled by that hemisphere (Berlucchi et al. 1997; Hodges et al. 1997), it is possible to assume that the right hemisphere, controlling the left hand, plays a role in own-face recognition.

As further evidence of the own-face recognition correlation with right hemisphere activity, Keenan and coworkers (2000) used another face identification task and again examined hand response differences. In this task pictures of famous faces were combined with pictures of the participants' face (self) and of their co-workers' face (familiar). These images were presented as a `movie' in which one face transformed into another. In the first instruction set, the movies began with either the participant's face or a co-worker's face, and the sequences gradually morphed into a famous face. Participants were instructed to stop the movie when the face in the sequence became famous.

Under the second instructional set, the instructions and the order of the images were reversed. The movies began with the famous faces and participants had to stop the movie when it became their own or their familiar co-worker's image. Under the first instructional set participants responded significantly later to the `movie frame' when the starting image was their own face (self) and they were using their left hand to respond. When the movies started with the famous faces and participants had to stop the movie when it became their own or their familiar co-worker's image (Instruction set 2), a significantly earlier frame was identified in the “Self Left hand” condition.

This study, using different dependent variables than the response times, shows that any effects obtained cannot be attributed to simple motor differences between hemispheres. Indeed the task used was sensitive to shifts in perceptual/identification biases.

Given that there is a reaction time advantage (Keenan et al., 1999) as well as a categorization difference (Keenan et al., 2000) between self and familiar images when participants employ their left but not right hand, is possible that participants identify images as their own when the right hemisphere is preferentially accessed. The researchers proposed that an attentional component of self may be mediated by the right hemisphere.

With a third study, Keenan and coworkers (2001) indicated that own-face recognition selectively depends on neural substrates of the right hemisphere. In this study five right-handed patients were submitted to the Wada test, an anaesthetization of one cerebral hemisphere used to provide information regarding cerebral dominance for language and other cognitive phenomena. These patients were submitted to Wada tes before surgical treatment for epilepsy. Patients were presented with a picture showing a morph of a face that was composed of their own face and a famous face, during the time when either the right or the left hemisphere of their brain was anaesthetized. Patients were instructed to remember the presented picture. After recovery from anaesthesia, patients were given a forced-choice task in which they had to choose the picture of the face that they had been shown. The two choices were the pictures from which the morphed image had been generated (self and famous), although neither choice had actually been presented during anaesthesia. Following anaesthesia of the left hemisphere, all five patients selected the ‘self ’ face as the one they thought had been presented; however, after anaesthesia of the right hemisphere, four out of the five patients selected the famous face (see Fig. 1).

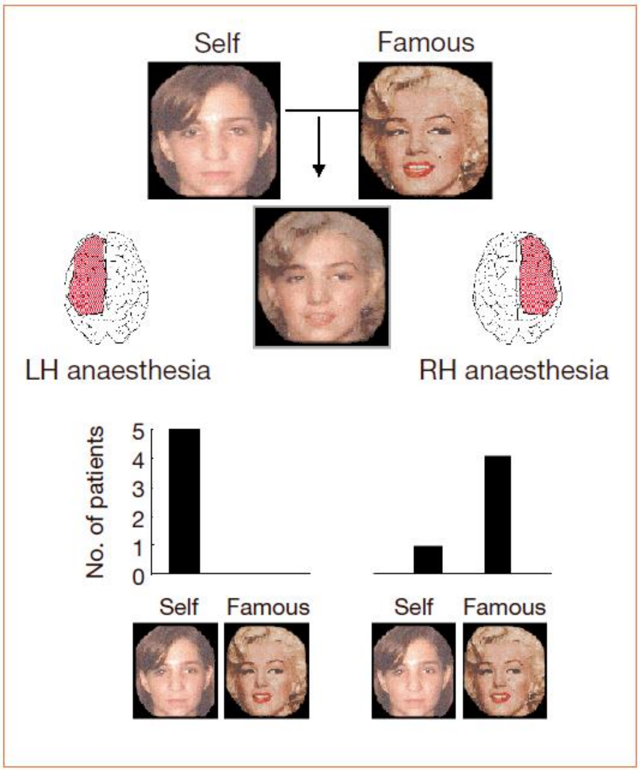

Figure 1: The original and morphing pictures used in the experiment and the response after anaesthetization of the patient’s right hemisphere (RH) or left hemisphere (LH).

To verify whether a similar effect operates in healthy participants, a second experiment was run in which ten normal subjects received transcranial magnetic stimulation to the motor cortex of the right hemisphere (RH) or left hemisphere (LH) during self–famous or familiar–famous morph display. The results of this experiment show that the amplitude of the resulting motor evoked potentials (MEPs) were significantly greater for the RH than for the LH during presentation of self morphs.

All these results suggest that the right hemisphere may be critically engaged in detecting one's own face, but the specific cerebral areas in the right hemisphere selectively activated by images of one's own face is not clear.

To answer this question, Uddin and coworkers (2005) submitted right-handed normal subjects to an event-related functional magnetic resonance imaging (fMRI) study. During the scan, subjects viewed digital morphs of their own face and a gender-matched familiar face and were instructed to press a button with the right hand if the image looked like their own face, and another button if it looked like a familiar or scrambled face. The contrast between trials containing more "self" and trials containing more familiar "other" against a baseline shows a signal change in the right inferior parietal lobule and in the right inferior frontal gyrus.

A limitation of the above described study is that fMRI provides only correlational information about the relationship between a given brain area and a particular cognitive task. Causal relationships between brain and behavior can be tested with TMS, a technique involving transient disruption of normal brain activity using focal magnetic pulses that target specific brain areas.

Uddin and coworkers (2006) used TMS to create a 'virtual lesion' over the parietal component of the right fronto-parietal network described above (2005) to test whether this region is necessary for discriminating own-faces from other familiar faces.

Each experimental subject participated in two TMS sessions, one for the right and one for the left 'virtual lesions' of the inferior parietal lobules. During each session, subjects performed a behavioral task consisting of watching morphed images of themselves and of a familiar other. Digital morphs between the participant' s face and the familiar face resulted in six unique faces, each morphed to a varying extent (0, 20, 40, 60, 80 and 100%). Subjects were asked to press a button if the presented image looked like their own face ('self'), and another button if it looked like someone else's face ('other'). Performance before and after TMS were compared. The 'self' responses were defined as correct, if the image contained mostly the self-face (0, 20 and 40% morphs), or false alarms, if the image contained mostly the other face (60, 80 and 100% morphs) (see Fig. 2a).

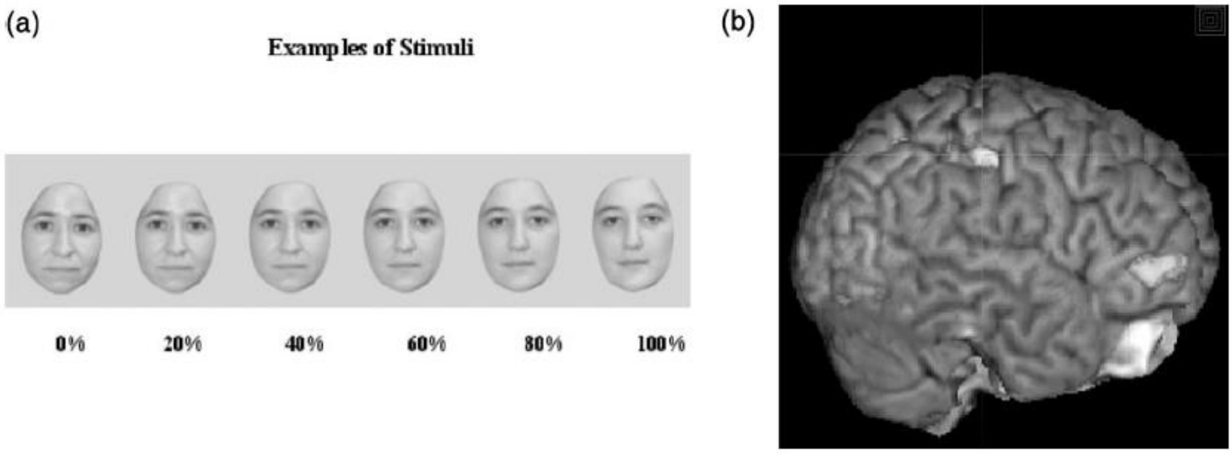

Figure 2. Examples of stimuli presented during the task (a), the cortical region (IPL) deactivated with TMS (b) (Uddin et al. 2006).

The results of this experiment show that 1 Hz rTMS to the right inferior parietal lobule (IPL) induced more false alarms (identifying an image containing more 'other' than 'self'). On the contrary, applying 1 Hz rTMS to the left IPL had no effect. Thus, the right IPL appears to be an essential component of the neural network for visual self-other discrimination (see Fig 2b).

2.3 Neuropeptides and self-face recognition

Specific cerebral areas are active during self-other discrimination but there are also specific neuropeptides that play an important role in this process?

Cross-species research has demonstrated that several evolutionarily conserved neuropeptides play a key role in diverse social behaviors (Nelson and Panksepp, 1998; Panksepp, 2009; Bos et al., 2012). Among them, the neuropeptide oxytocin appears to regulate fundamental aspects of mammalian social affiliative behaviors and social cognition (Car-ter, 1998; Meyer-Lindenberg et al., 2011). In addition, oxytocin administration improves responsiveness to others (Kosfeld et al., 2005), and social behavior in individuals with autism (Guastella et al., 2010). For these reasons Colonnello and coworkers (2013) studied the potential role of the oxytocinergic system in blurring or enhancing the ability to differentiate between one's self and other's related stimuli using a placebo-controlled, double-blind study.

In this study, healthy participants received either oxytocin or placebo intra-nasally and after 45min, the researchers measured participants' ability to differentiate their own identity while viewing a photo of themselves morphing into the photo of an unfamiliar face. The results of this experiment showed that oxytocin administration shortened the latency of self-other differentiation.

Oxytocin therefore increases the ability to recognize differences between the self and others. These findings are consistent with the hypothesis that impaired oxytocin signaling may be involved in the development and manifestation of human psychopathologies in which self-recognition is altered.

CHAPTER 3. SELF-BODY RECOGNITION IN ADULTS.

Distinguishing one’s own bodily features from those of other people is essential to our everyday life. This ability is one of the key components of self-awareness and allows social interactions.

Own-body recognition is studied using different techniques and analyzing the performance of patients with cerebral lesions. Below I analyze some of these different approaches.

3.1 Brain activation during self-body recognition.

In an fMRI study, Devue and coworkers (2007) measured the cerebral activity of healthy participants while performing a task in which they had to indicate the real appearance of themselves and of a close colleague among intact and altered pictures of faces and bodies.

The first aim of this study was to examine the cortical mechanisms of visual own-face recognition. The lack of convergence as to precise anatomical locations underlying own-face recognition motivated this aim (Keenan, 1999, 2000, Turk, 2003; Pletek, 2002). Previous studies differed between each other with regard to the familiarity of the control face compared with the participants’ own face. Depending on the contrasts used in these studies, the control face was unfamiliar (Sugiura et al., 2000), recently learned (Sugiura et al., 2005), famous (Platek et al., 2004a) or personally known to the participant (Kircher et al., 2000, 2001; Platek et al., 2006; Sugiura et al., 2005; Uddin et al., 2005a). As the control face Devue and coworkers used personally known, gender-matched, people because control of familiarity is more efficient when one’s own face is compared with a highly familiar face. Because distinguishing two highly familiar people from each other is presumably very easy, the researchers designed a task in which participants would have to identify their real facial appearance and that of their colleague among intact and altered pictures presented during a first event-related scanning session. The participants' task consisted of an "intact–altered" judgment both on pictures of themselves or of a close colleague. The facial alterations consisted of moving the eyes inwards or outwards.

Considering the lack of studies about own-body recognition, the second aim of Devue's study was to investigate whether specific cortical regions underlie own-body recognition compared with the recognition of a familiar person's body. During a second event-related scanning session participants had again to identify their real body-shape appearance and that of their colleague among intact and altered pictures. The body alterations consisted in increasing or decreasing the waist-to-hip ratio by changing the width of the hips.

The third aim of the study was to investigate which cerebral regions are selectively activated by self-processing regardless of presented stimulus (body or face). For that purpose, data related to the participants' own face and body were collapsed and compared with the data related to the processing of their colleague's face and body.

Finally, considering that faces and bodies are associated with distinct neural correlates, Devue and coworkers included two event-related control sessions in which participants passively viewed intact and scrambled pictures of their face or body. These two sessions allowed the researchers to determine the cerebral areas associated respectively with general face and body shape processing, along with the neural substrates associated with the processing of these two kinds of stimuli.

In this experiment, both the cerebral activation and behavioral data were collected. In terms of accuracy, intact faces were better recognized than intact bodies and altered bodies were better recognized than intact bodies. Participants' reaction times were faster for faces than for bodies and were faster for themselves than for their colleague.

The neuroimaging data of this experiment showed that faces and bodies elicited responses in close but segregated regions of the occipital cortex. Perception of faces was associated with bilateral cerebral activity in the middle occipital gyrus, extending to the fusiform gyrus on the right and to the cerebellum on the left, as well as with activation of a large frontal area on the right side. Perception of bodies was associated with activity in the fusiform and lateral occipital complex bilaterally, and with activity in the left middle occipital gyrus. This is in agreement with previous studies that identified distinct regions of the extrastriate cortex that are specifically devoted to faces (occipital face area, OFA, Puce et al., 1996; Peelen and Downing, 2005) and bodies (extrastriate body area, EBA, Downing et al., 2001; Peelen and Downing, 2005).

When comparing intact own-face with intact colleague's face stimuli, significantly different responses were identified in the right inferior frontal gyrus and in the right insula. This finding is in line with previous studies reporting that the right inferior frontal gyrus is involved in the distinction between self and others (Uddin et al., 2005a) or in the attentive processing of one's own-face (Sugiura et al., 2000). The implication of the right insula in visual own-face recognition was also reported earlier (Kircher et al., 2000, 2001).

These results are consistent with a right hemispheric dominance model of self-recognition and self-awareness (Keenan et al., 2000c, 2003b; Platek et al., 2004a, 2006).

Comparing the activity elicited by intact own-body and intact colleague's body stimuli, there were significant differences in response in the right superior frontal sulcus, right cingulate cortex, left inferior frontal gyrus, as well as in the anterior insula bilaterally.

Finally, Devue and coworkers examined whether specific regions were implicated in the processing of self-related pictures independently of the stimulus domain. When activation associated with seeing intact stimuli depicting the colleague (faces and bodies) was subtracted from activation due to seeing stimuli depicting the participant herself, a significant response was found in the right anterior insula and in the right dorsal anterior cingulate consistent with the literature (Fink et al., 1996; Kircher et al., 2000, 2001;Craik et al., 1999; for a review, see Northoff and Bermpohl, 2004). The implication of the anterior cingulate is in line with data showing that this region is involved in processing self facial resemblance (Plantek et al., 2005). Since this region is also implicated during the processing of face familiarity or self-referent information, Platek and coworkers suggested that this region might be generally involved when making decisions about self-referential information. The Devue and Platek results are also consistent with Northoff and Bermpohl (2004)'s hypothesis that the cingulate gyrus could play a role in abstract self-processing, that is independent of the stimulus domain or of the sensorial modality.

From these results, it appears that after a partly segregated structural processing of the shape of faces and bodies in posterior areas, the distinction between self and others might be processed in more anterior regions.

3.2 Neuropsychological cases

In line with neuroimaging data, neuropsychological studies have also revealed a privileged role of the right hemisphere in self-recognition. Indeed, right brain-damaged (RBD) patients are more often impaired in awareness of their own body than left brain-damaged (LBD) patients. Indeed, patients with a lesion of the right hemisphere may be affected by a disorder of spatial representation and awareness, called unilateral neglect that may involve different sectors of space. When the deficit involves personal space, it is called personal neglect (Guariglia & Antonucci, 1992). In this case, patients do not orient attention to their contralesional hemibody and/or limbs. In addition to neglect or independently from it, RBD patients with left-side hemiplegia may show hemisomatognosia, when they deny ownership of their contralesional body parts (Meador, Loring, Feinberg, Lee, & Nichols, 2000;Feinberg, Haber, & Leeds, 1990), or anosognosia for hemiplegia, when they deny their motor deficits (Karnath, Baier, & Nagele, 2005; Marcel, Tegner, & Nimmo-Smith, 2004; Bisiach, 1999; Bisiach, Vallar, Perani, Papagno, & Berti, 1986).

Taken together, neuroimaging and neuropsychological studies suggest that distinct regions of the extrastriate cortex are specifically devoted to faces (ventral occipital face area, OFA, Puce et al., 1996; Peelen and Downing, 2005) and bodies (extrastriate body area, EBA, Downing et al., 2001; Peelen and Downing, 2005) and that one's own body can be separately represented. Frassinetti and coworkers (2008) used the performance of patients with a unilateral lesion of the right or the left hemisphere to verify whether the right hemisphere is specialized for processing own-body parts, as compared to other people's body parts. If this is the case, the ability to recognize own-body parts should be selectively impaired after lesion involving specific brain areas. Patients with lesion of the right (right brain-damaged [RBD]) or left (left brain-damaged [LBD]) hemisphere and healthy participants were submitted to a visual matching-to-sample. Stimuli depicted their own body parts or other people's body parts. Participants were required to decide which of two vertically aligned images (the upper or the lower one) matched the central target stimulus. In this experiment, explicit own-body recognition was not required so the paradigm indirectly evaluates the recognition of self body-parts.

Neurologically healthy participants were facilitated in performing the visual matching-task when one of the stimuli belonged to participant's own body compared to when they belonged to someone else. This effect was called 'self-advantage'.

Since the advantage is manifest in a task in which explicit recognition of the corporeal self is not necessary, this phenomenon appears to depend upon an early, possibly automatic activation of corporeal self-recognition processes that, once activated, may facilitate the perceptual judgments that are based on the visual appearance of the body and its parts.

In this experiment the ‘self-advantage’ was also found in left brain-damaged (LBD) patients, but not in right brain-damaged (RBD) patients. Moreover, RBD were impaired compared to LBD patients and normal subjects in visually matching their own body parts, whereas this difference was not evident in performing the task with other people’s body parts.

This pattern of results indicates that the right hemisphere is preferentially involved in the recognition of ‘‘self body parts,’’ as patients with a lesion of the right hemisphere show difficulties to perform the match-to sample task with ‘‘self’’ related body parts, whereas their performance is comparable to that of patients with lesions to the left hemisphere when performing the same task on body parts belonging to other people. In this study the patients’ lesions were analyzed to verify if ‘‘self body-parts’’ processing is subtended by a specific network. The results showed that the “self body-parts’’ processing involves right frontal and parietal areas. The role of these areas in this processing is demonstrated by the fact that these areas are damaged in RBD patients who are impaired in ‘‘self body-parts’’ recognition, but not in RBD patients unimpaired in this function.

However, it was not clear whether such a right fronto-parietal network is a general network for the visual representation of one’s own body and body-parts, that is the ‘corporeal self’, or whether own-face and own-body-parts processing are separate functions sub-served by different networks. If the corporeal self is a modular function, the ability to recognize ‘self body-parts’ and ‘self face-parts’ might be selectively impaired after lesion involving different and specific brain circuits. To test this hypothesis, Frassinetti and co-workers (2009) submitted a group of RBD patients and an age-matched group of healthy subjects to a variant of the visual matching-to-sample task. In one condition, stimuli depicted the participant’s own body-parts or other people’s body-parts, whereas in another condition stimuli depicted the participant’s own face-parts or other people’s face-parts (see Fig.3)

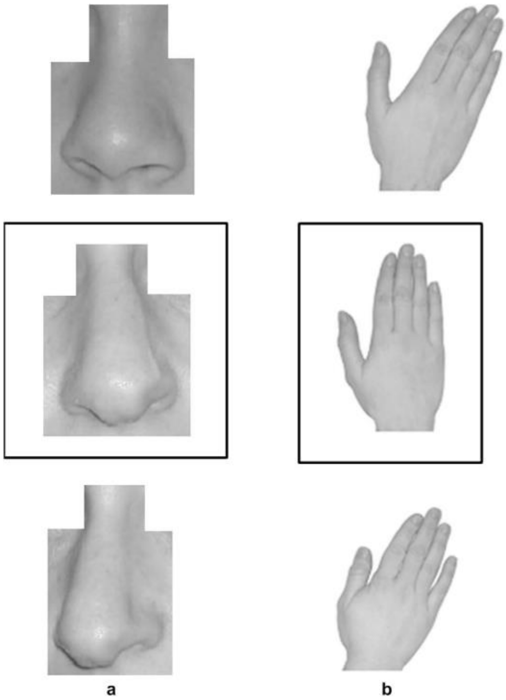

Figure 3 An example of stimuli representing face-parts (a) and body-parts (b). Participants were required to decide which of the two images (the upper or the lower one) matched the central target stimulus, presented within a black frame (taken from Frassinetti et al., 2009).

First of all, this study showed that healthy participants were more accurate in processing pictures representing their own as compared to other people’s body- and face parts, showing the so-called self-advantage. These results confirm previous findings of Frassinetti and coworker (2008). The second result of this study is that RBD patients revealed a simple dissociation, in that some patients who were impaired in processing self-related body parts showed a preserved self-advantage in processing self-related face-parts, thus providing initial evidence of a modular representation of the corporeal self.

The idea that the visual representation of the corporeal self is based on a modular functional organization is in accordance with both neuropsychological studies in RBD patients affected by anosognosia and with neuroimaging findings in neurologically healthy subjects. Indeed, patients with anosognosia can be unaware of their motor deficit at the contralesional lower limb, but not at the contralesional upper limb (Von Hagen and Ives, 1937; Berti et al., 1996; see, for review, Vallar and Ronchi, 2006). Similarly, multiple circuits, involving right posterior and frontal regions, play different roles in the visual recognition of one's own body (Sugiura et al., 2006).

Finally to identify the brain network of the self-advantage in body-parts, Frassinetti and coworkers (2010) divided RBD patients into two groups on the basis of the absence (G1) or presence (G2) of self-advantage in body-parts processing. The analysis of cerebral lesions of the two groups showed that areas involved by G1 patients' lesions were more anterior and ventral compared to those involved by G2 patients' lesions. Moreover, the self-related areas, as previously identified by a subtraction method on a larger sample of patients (Frassinetti et al., 2008), were plotted against the same template showing substantial sparing of these areas in G2, and a partial overlap with G1 patients' lesions.

The above studies investigate the recognition of bodily self through the physical appearance but in our daily life we can recognize our body not only for its image but also for other information that are simultaneously presented, like our bodily movement or our bodily emotional expression. The following study analyzed how this additional information can modulate the self-advantage for own body image.

Frassinetti and coworkers (2009) investigated whether the visual information provided by the movement of self body-parts may be separately processed by right brain-damaged (RBD) patients and constitute a valuable cue to reduce their deficit in self body-parts processing. To pursue these aims, a group of RBD patients and a group of neurological healthy subjects were submitted to a matching-task in two conditions. In the dynamic condition, participants were shown pair of movies of moving self or other's body-parts (hand, foot, arm and leg). In the static condition, participants were shown pair of still images of the same self or other's body-parts. In each condition the task consisted of deciding whether the two stimuli in the pair were physically the 'Same' or 'Different', regardless of the self/other identity (see Fig. 4).

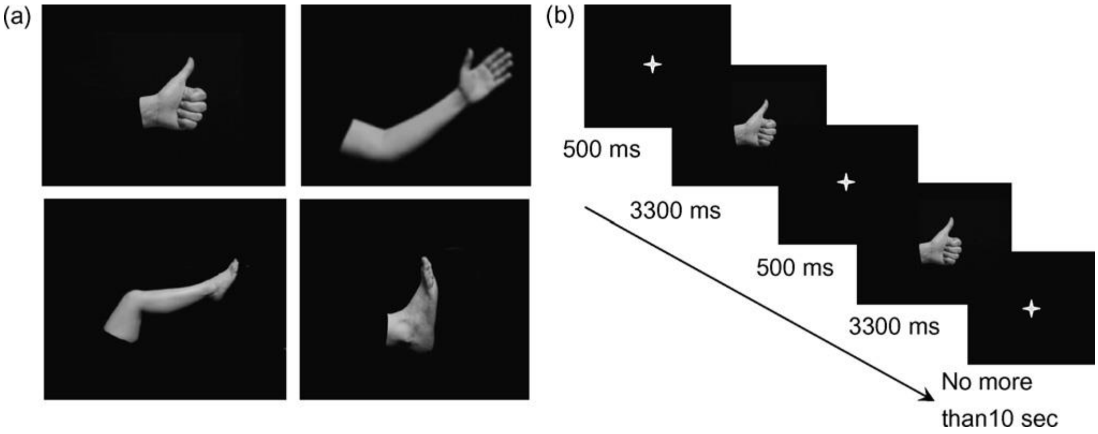

Figure 4 (a) One example of each stimulus category depicting different body-parts, as presented the static condition. (b) Schematic representation of the time-sequence of events for each trial.

The results of this experiment showed that in healthy participants, the self-advantage was present both in the dynamic and static condition, but it was more important in the dynamic condition. Interestingly, in RBD patients self-advantage was absent in the static, but present in the dynamic condition. These findings suggest that visual information from self body-parts in motion may be processed independently in patients with impaired static self-processing, thus pointing to a modular organization of the mechanisms responsible for the self/other distinction.

These result are in line with Sugiura’s fMRI study (2006), which supported the existence of a right parieto-frontal network with higher sensitivity for self-related movies than pictures, and a more posterior network with higher sensitivity for static self-pictures than movies.

Thus it is possible that multiple brain networks support visual self-recognition, pointing to a modular organization of the mechanisms responsible for self/other distinction. Therefore, if it is not possible to recognize ourselves using physical cues we can use other information.

These studies (Frassinetti et al. 2008, 2009, 2010) have demonstrated the human ability to implicitly recognize one’s own body. But which is the mechanism at the basis of the self-advantage effect?

The authors (Frassinetti et al., 2011) tested the hypothesis that the implicit self-advantage revealed by the visual matching task is not merely due to visual perceptual facilitation, but may be due to a combination of visual, somatosensory, proprioceptive, and motor information. According to this hypothesis, the body self-advantage should emerge when self-body recognition is implicitly required and should be specific for body-parts and not for inanimate-objects. In contrast, if the self-advantage is due to a mere visual–perceptual facilitation, it should be independent of the implicit or explicit request (and could be extended also to objects). To disentangle these hypotheses, healthy participants were implicitly or explicitly required to recognize either their own body-parts or inanimate-objects. The Implicit task was the same task previously described. In the Explicit task, two stimuli depicting the same body-parts or the same type of inanimate-object, matched for visual similarity, were simultaneously presented in each trial, in the upper and the lower position. A white frame replaced the central target stimulus. Participants were requested to indicate whether the upper or the lower image corresponded to their own body-parts or object, and to press a central response key, when neither image corresponded to their own stimuli (see Fig. 5).

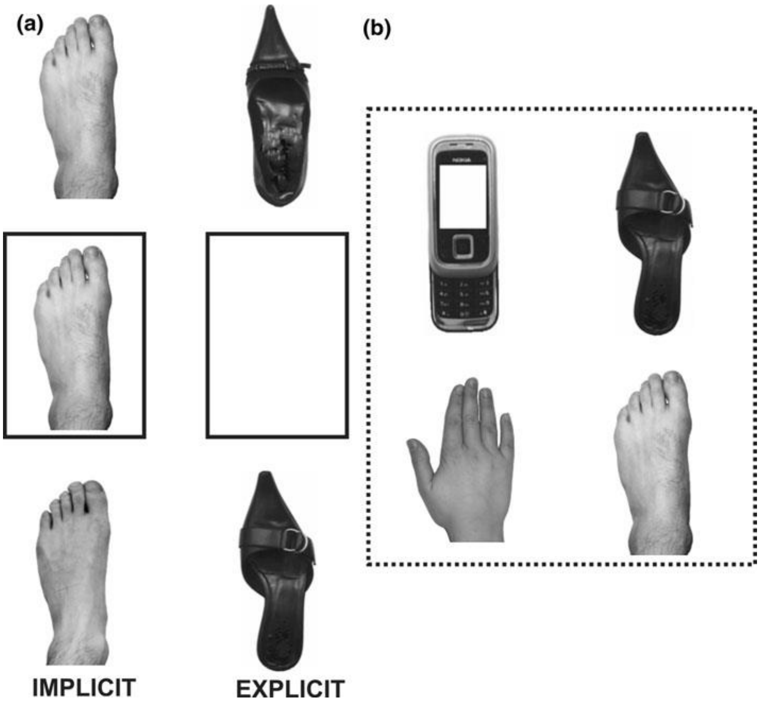

Figure 5 **a** An example of a single trial. **b** Examples of the experimental stimuli. For each category (body-effectors and inanimate objects).

Participants were more accurate in the implicit task with self rather than with others' body-parts. In contrast, the self-advantage was not found when an explicit recognition of one's own body-parts was required, suggesting that the body self-advantage relies upon a sensorimotor, rather than a mere visual representation of one's own body. Moreover, the absence of both self/ other and implicit/explicit effects, when processing inanimate- objects, underlines the differences between the body and other objects.

These findings were further confirmed by a behavioural and an fMRI study (Ferri et al., 2011; Ferri et al., 2012). In the first study (Ferri et al., 2011) the implicit and explicit self-hand recognition were compared. Participants were submitted to a laterality judgment task (implicit task) of self and others' hands.

In this task participants were requested to report the laterality (left or right) of hands presented in different angular orientations (0°, 60°, 120°, 180°, 240°, 300°). In order to perform this task participants simulate a motor rotation of the body parts so as to match that of the observed stimulus. Previous studies have showed that the mental motor rotation of body parts shares the same temporal and kinematic properties with actual body rotation in space (Decety et al. 1991; Parsons 1994). This idea is also corroborated by evidence showing that longer mental rotation times are needed for stimuli orientations corresponding to body part positions difficult to be maintained (Petit et al., 2003). Considering that left-right judgment of body parts relies upon the visuo-motor representation of one's own body (Cooper et al.1975), Ferri and coworkers hypothesized that the laterality judgment should be easier when the displayed stimulus is one's own hand. Indeed, only in this case, the displayed stimulus matches with the mentally rotated hand (self-advantage).

In the explicit task, the same participants were submitted to an explicit recognition of own hands. Participants were required to explicitly judge whether the same stimuli used for the first task (self and other’s hands presented in different angular orientations) corresponded or not to their own hand (see Fig. 6)

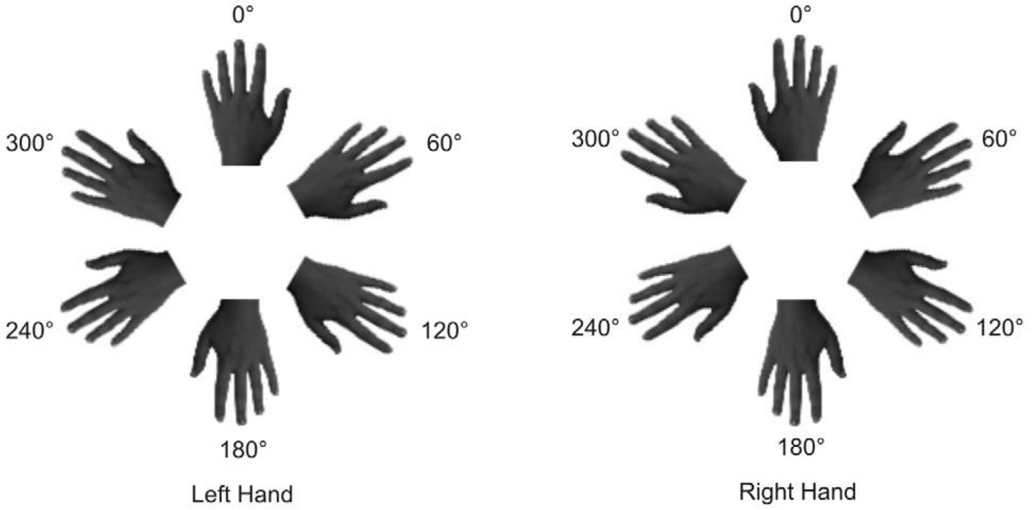

Figure 6 Experimental stimuli consisted of pictures depicting the dorsal view of right and left hands in six different clockwise orientations.

Images of participant’s hands or of three other people’s hands were presented one at a time in ‘self’ trials and ‘other’ trials, respectively.

In the first experiment participants showed faster reaction times when judging one ’ s own right hand compared with all the other hand stimuli, regardless of the magnitude of the rotation. This self-advantage was not present when participants performed the explicit self-recognition. Furthermore in the first task, the classical bell-shaped function of RTs constitutes the behavioral signature of mental rotation. On the other hand, the absence of such a function in the RTs of the second task shows that a motor simulation is not required to accomplish the explicit task.

Thus, Ferri and coworkers confirmed that implicit and explicit recognition of the bodily-self dissociate and that only an implicit recognition of the bodily self is mapped in motor terms. This motor representation allows the self-advantage to emerge.

When subjects imagine their own hand rotating into the stimulus position, the imagined body part is translated into its motor representation, engaging sensorimotor rather than visual processes (de Lange, Helmich, & Toni, 2006)

In an fMRI study, Ferri and coworkers (2012) used the same hand laterality judgment task to verify whether mental rotation of pictures depicting one's own hands leads to a different activation of the sensorimotor areas as compared with the mental rotation of pictures depicting others' hands. The researcher found that the general representation of the bodily self encompasses the SMA and pre-SMA, the anterior insula, and the occipital cortex, bilaterally. Crucially, the representation of one's own dominant hand seems to be confined within the left premotor cortex. (see Fig. 7)

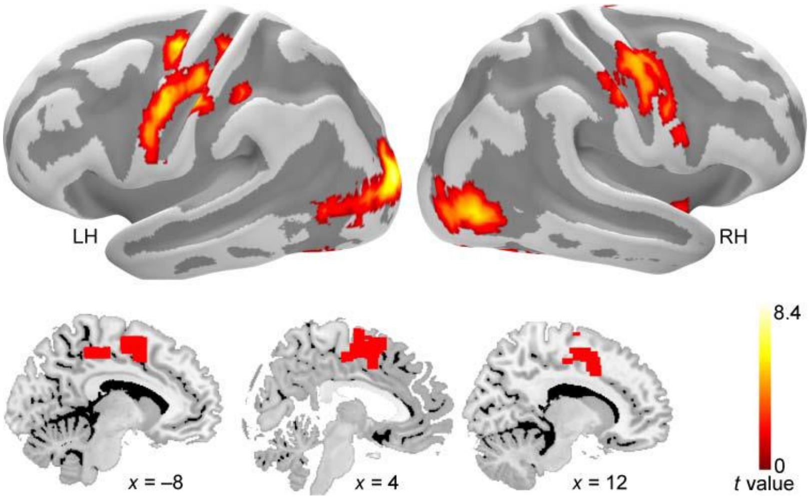

Figure 7 Regions showing higher activation during the mental rotation of one's own right hand as compared with the mental rotation of one's own left and other's hand. Group activation data are rendered on the cortical surface of a "canonical" brain (Mazziotta et al., 1995).

This data seem to support the existence of a sense of bodily self, encased within the sensorimotor system. The researchers propose that such a sensorimotor representation of the bodily self might help us to differentiate our own body from that of others.

CHAPTER 4. BODY SELF-RECOGNITION IN DEVELOPMENTAL AGE

In the literature, corporeal self recognition in adults is well documented. As described above some behavioral and neuroimaging studies have shown the cognitive cerebral network underpinning this ability in adult subjects. However the development of this ability is less well studied.

Most of the developmental studies addressing self-recognition focused on mirror self-recognition (Amsterdam, 1972; Bertenthal & Fischer, 1978; Lewis & Brooks, 1978; Marsh, Ellis, & Craven, 2002). These studies showed that by the middle of the second year, when facing their own specular image, young children begin to manifest clear signs of a conceptual sense of their own public appearance. They display unambiguous self-referencing behaviors when a spot of rouge has been surreptitiously placed on their face and they begin to show embarrassment while viewing their own mirror reflection (Bertenthal & Fisher, 1978; Lewis & Brooks-Gunn, 1979). These behaviors demonstrated the emergence of an explicit self-awareness in infants aged 14–18 months.

But what development precedes and eventually prepares infants to manifest explicit self-knowledge?

Rochat and Striano (2002) suggest that an implicit sense of self is developing from birth, long before children begin to manifest explicit (conceptual) self-knowledge by the second year.

Observing infants of least 3 months of age, placed in front of mirrors, it is possible see that they tend to engage in long bouts of self-exploration, observing their own movements and it seems that they enjoy the experience of visual–proprioceptive contingency afforded by mirrors. They manifest positive affect, including smiling, reaching for the part of the body reflected in the mirror, and often demonstrating sudden bursts of joyful activities (Amsterdam, 1972).

Other research has shown that young infants are responsive to particular aspects of their own specular image.

Schulman and Kaplowitz (1976) showed that prior to 6 months of age, infants tended to look more often at a clear rather than a blurred image of themselves, and show less interest in the distorted image compared with the flat non distorted mirror image.

Distorted and non distorted mirror images both have visual–proprioceptive contingency, so it is possible that young infants might already be able to discriminate between specular images that are spatially more or less eccentric relative to what they calibrated of their own body via direct visual exploration of limb movements.

In a study conducted in 2002, Rochat and Striano placed 4- and 9-month-old infants facing a live image either of themselves or of another person (experimenter) mimicking them.

All the infants appeared to perceive and act differentially when facing the specular image of themselves or of another person (experimenter) mimicking them. From 4 months of age, infants smile more, look more, and have more protracted first-look duration toward the others' than self-stimuli. Since children look longer to novel than already known stimuli (Fantz, 1964; Harel, Gordon, Geva, & Feldman, 2010), it is assumed that the images depicting others' bodies are novel compared to self-body stimuli. This evidence suggests that already at 4 months of age the children have gained a certain level of knowledge about their body image and then that there could be a developmental progression from a self-other differentiation to an explicit identification of the self-image as self-awareness over the first year of life.

There is now good evidence that infants discriminate between perceptual events that are either self- or not self-produced early on. Rochat and Hespos (1997) tested newborn infants within 24 hours from their birth to see whether they would manifest a discrimination between double touch stimulation specifying themselves, and external (one way) tactile stimulation specifying non-self objects. The experimenters used the robust rooting response all healthy infants manifest from birth and by which tactile stimulation at the corner of the mouth is followed by the infant's head turn with mouth opening toward the stimulation. Following a simple procedure, the experimenters recorded the frequency of rooting in response to either external tactile stimulation, the experimenter stroking the infant's cheek, or in response to tactile self-stimulation when infants spontaneously brought one of their hands in contact with their cheek. The results showed that newborns tended to manifest rooting responses almost three times more often in response to external compared to self-stimulation. These observations suggest that already at birth, infants pick up the intermodal invariants (single touch or double touch combined with proprioception) that specify self- versus external stimulation, showing evidence of an early sense of their own body, hence an early perceptually-based sense of themselves as differentiated entities.

Implicit self-recognition also seems to persist in adulthood (Frassinetti et al. 2008, 2010) passing from childhood.

Frassinetti and coworkers (2011) investigated the bodily-self processing in 4–17 year old children and the development of its neuronal bases, submitting typically developing children and unilateral brain damaged children (5 right and 12 left sided) to the visual matching-to-sample task described above (Frassinetti et al., 2008). The results of this study showed that healthy children performed the task better with self than with other people's stimuli, showing a benefit of self processing for both body and face.

Regarding brain damaged children, a double dissociation was found: right brain damaged patients were impaired in self but not in other people's body parts, showing a self-disadvantage, whereas left brain damaged patients were impaired in others' but not in self body parts processing. These results support the hypothesis that during development, self and others' body parts processing are different and sustained by separate cerebral substrates.

Comparing this result with the neural correlates of the corporeal self as identified in adults, it is possible to note that neural correlates of the corporeal self in children are only partially similar to those previously identified in adults (Frassinetti et al., 2008). Indeed, the present results on children suggest that, as in adulthood, the right hemisphere is specialized in processing "self", while the left hemisphere is specialized in processing "others"' body-parts. Differently, left hemisphere damage in adults seems not to be related to "others"' body-parts processing.

The difference between the performance of adults and child LBD patients have two possible explanations. The first one would be the possibility that a specific module to recognize others' body parts is functional only during development, disappearing when the brain achieves full maturation. The temporary functionality of this module selective for others' body parts would be related to the need to fully acquire self/other distinction capability along development. The second possibility to explain this difference would be that the lesion location in the two studies is different. Observing the children's anatomical graphic representations of this study and lesions in Frassinetti et al. (2008), it is notable that the adult's lesions were more anterior than the children's ones.

Finally, the third result of this study is that own-body and own-face parts processing seem separate to others' body and others' face-parts processing. Indeed, when compared with controls, RBD children were impaired in self-body but not in own-face processing and LBD patients were impaired in others' body but not in other's face parts processing. This means that self-recognition in RBD children and other-recognition in LBD children are not impaired when the stimulus represented is a face. So, the corporal self during development also seems dissociated for body and face-parts.

CHAPTER 5. THE INTERPERSONAL REGULATION OF OWN PERSONAL SPACE

During social interaction people automatically regulate the distance maintained between themselves and others. This distance is called personal or interpersonal space.

5.1 What is the interpersonal space?

Edward T. Hall first described the concept of interpersonal space in 1959. Interpersonal space can be defined as an invisible zone surrounding a person, which allows that person to regulate his interactions with other people. This invisible zone can be envisioned as a bubble around a person.

Hall identified in the “bubble” four zones: Intimate, Personal, Social and Public (see Fig. 8). The Intimate Zone ranges from touching to about 18 inches (46 cm) apart and it is reserved for lovers, children, as well as close family members. The Personal Zone begins about an arm's length away; starting around 18 inches (46 cm) from the person and ending about 4 feet (122 cm) away. This space can be used in conversations with friends or to chat with associates. The Social Zone ranges from 4 to 8 feet (1.2 m - 2.4 m) away from the person and it is reserved for strangers and new acquaintances. The Public Zone includes anything more than 8 feet (2.4 m) away, and it is used for speeches, lectures, and theater.

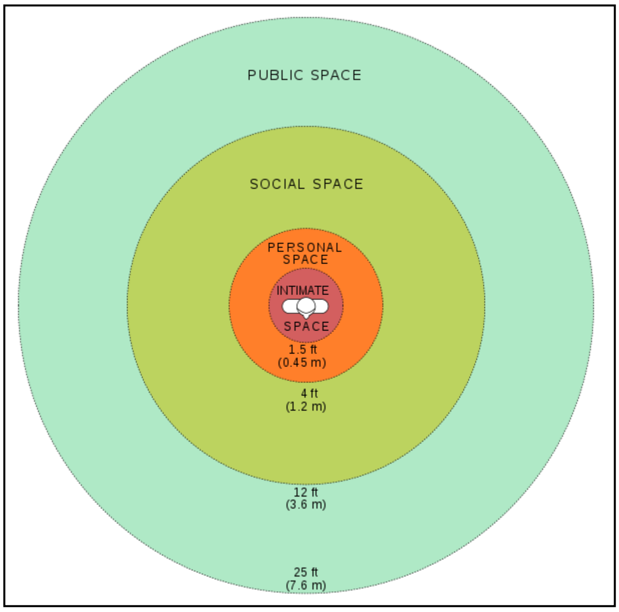

Figure 8: Diagram of Edward T. Hall's personal reaction bubbles (1966), showing radius in feet and meters.

Most of the time, a person becomes aware of his or her interpersonal space by the feeling of irritation or malaise when another person invades his/her space without permission or with the wrong intention.

5.2 How do you measure the interpersonal space?

Personal space can be measured in different ways such as with projective techniques, unobtrusive observation of natural spacing or with the stop-distance procedure (Hayduk, 1981a, 1981b, 1983).

The projective measures include: silhouette placements, Kuethe's (1964) felt figure placements, Duke and Nowicki's (1972) "comfortable interpersonal distance" and the CID scale. The CID scale is a piece of paper with eight lines extending out from a central hub. Subjects imagine they are standing on the hub and place marks on the lines indicating the minimum distances for which they would be comfortable with another's approach (Pedersen, 1973). Projective measures (requiring manipulation of miniature figures, silhouettes, dolls, or paper and pencil drawings) are particularly vulnerable to methodological criticism because they do not directly involve real human spacing.

On the other hand, during the stop-distance procedure the subject approaches or is approached by an assistant until the subject just begins to feel uncomfortable about the nearness of the other.

Although the stop-distance procedure is not conducted in naturalistic settings, it is one of the measures most frequently used because it is reliable, measures preferred interpersonal distance under varied conditions and allows for standard testing conditions and repeated measures (for reviews see Aiello, 1987; and Hayduk, 1983).

5.3 The normal and pathological variations of the interpersonal space.

The size of the interpersonal space is found to vary as a function of such variables as the age, the sex, the familiarity between interacting parties, the reason of the interaction or the intercultural differences (Hall, 1966; Watson, 1970; Cristani et al., 2001; Beaulieu, 2004).

Some researchers showed that there are significant differences in personal space between children of different ages. For example Lomranz and coworker (1975) measures in an ecological context 3, 5, and 7 year old children’s personal space when they approached boys or girls of their own age. The researcher found that the 3-year-old subjects kept less distance from their age peers rather than 5- or 7-year-old ones. For all subjects, irrespective of age, the sex of the interacting child was relevant, in that less distance was kept from girls than from boys. These results were explained considering that girls are expected to be more reserved and socially less aggressive and that mothers in our culture are the central figures with whom the child comes in contact. Also Weinstein (1971) found that kindergarten (age 5) and first-grade children keep less distance from a same-sex peer than do second and third graders. Finally some studies showed that from 5 years of age, there is a gradual increase in the space used for interpersonal interaction (Okano, 1985; Folarin, 1989; Pegan & Aiello, 1982; Sara.no & Helmuth, 1981) and at about 12 years of age, the characteristics of children's personal space become similar to those of adults (Aiello, 1987).

Another variable could modify the interpersonal space: the first kind of physical proximity maintained with a caregiver. The infant's confidence in the accessibility of its attachment figures is considered an important modifier to the setting of its proximity set-goals. For example, Cassidy and Berlin (1994) observed that infants and children classified as insecure-ambivalent employ an adaptive strategy of maintaining close proximity to their attachment figure. In discussing possible consequences of avoidant attachment, Main (1990) suggested that physical or emotional rejection on the part of the attachment figure might lead to avoidance and distance-maintaining strategies in the infant. Later in life, strategies that infants use to regulate proximity to their attachment figures may become internally represented in their working models of interpersonal relationships. Therefore, secure or insecure attachment in infancy may lead to different strategies for personal space regulation. In line with the previous study, Bar-Haim Y and coworkers (2002) showed that children who had an insecure attachment relationship in infancy displayed smaller personal space boundaries, and tolerated larger intrusions into their personal space as compared with children who had secure attachments in infancy. The authors explained the insecure children behavior as an infants' preoccupation and uncertainty regarding the availability and responsiveness of their attachment figures.

It was also demonstrated that psychiatric and neurological illness (Deus, 2006; Kennedy et al. 2009) as well as developmental psychological or neurological disorder (Vranic, 2003; Kennedy & Adolphs) can interfere with the regulation of interpersonal space.

In this respect, Kennedy and coworker (2009) described the regulation of interpersonal distance in a patient (SM) with bilateral amygdala damage. In their experiment, Kennedy and coworker asked to

SM to indicate the position at which she felt most comfortable as a female experimenter approached her or she approached experimenter, controlling the gaze direction (direct/averted) and the starting position (close/far). SM showed a reduced personal space compared to both any comparison subject and the control group. Finally, to better investigate the patient's lack of discomfort at close distances, the authors asked her to rate her level of comfort/discomfort standing at different distances from the experimenter. With this questionnaire, the author discovered that even when SM and the experimenter stayed in nose-to-nose distance with direct eye contact, SM stated to be perfectly comfortable.

This study showed that the bilateral damage to the amygdala results in no detectable personal space boundary and an abnormally small interpersonal distance preference, suggesting that this area is a vital brain substrate for proximity. This hypothesis is consistent with the results found in monkeys with bilateral amygdala lesions, who stay within closer proximity to other monkeys or people (Kluver et al. 1937; Emery et al., 2001; Mason et al. 2006)

To further demonstrate that amygdala activity is useful in regulating interpersonal distance, Kennedy and coworkers conducted an fMRI study in which they found that the amygdala responded to a greater degree when the participants knew that an experimenter was maintaining a close distance to them compared to when they knew that an experimenter was maintaining a far distance.

Taken together, these data showed that the amygdala is vital for human adults to regulate their interpersonal distance. However, since the developmental course of SM's lesion is unknown, Kennedy and coworker's results (2009) cannot demonstrate if the amygdala is necessary for triggering innate emotional responses to close others or learning the association between close distances and aversive outcomes. To answer this question, it would be useful to study this mechanism in children with typical and atypical development.

CHAPTER 6. RECOGNITION OF OWN FACE AND BODY IN AUTISM

6.1 Introduction

For humans social life it is vital not only to recognize socially relevant stimuli, such as faces (Grill-Spector et al., 2004; Gauthier et al., 2000) and bodies (Urgesi et al., 2004; Downing et al., 2001; Peelen & Downing 2004; Schwarzlose et al., 2005), but also to distinguish between ourselves and other.

Several psychological studies suggest that the progress in cognitive skills, leads infant to mature the awareness of being a separate entity early on (Mahler, 1975; Neisser, 1991). This is the first step of the self-recognition and the self-awareness. Much research documents the emergence by 14 to 18 months of behaviours indicating self-recognition in mirrors or in other reflective surfaces (Amsterdam, 1972; Nielsen & Dissanayake, 2004). However, recent research seems to support the hypothesis that infants develop self-other discrimination in specular images long before mirror self-recognition (Rochat & Striano, 2002). Rochat & Striano (2002) found that from 4 months of age, infants appeared to perceive and act differentially when facing the specular image of themselves or of another person (experimenter) mimicking them. Infants smile more, look more, and have more protracted first-look duration toward the others' than self-stimuli. Since children look longer to novel than already known stimuli (Fantz, 1964; Harel et al., 2010), it is assumed that the images depicting others' bodies are novel compared to self-body stimuli. This evidence suggests that already at 3-4 months of age the children have gained a certain level of knowledge about their body image and then that there could be a developmental progression from a self-others differentiation to an explicit identification of the self-image as self-awareness over the first few years of life.

As far as studies exploring self/other face/body processing in pre-schooler and scholar children, Sui and Zhu (2005) found a self-reference advantage in memory in children as young as 5 years old. The authors asked children to study a list of colourful object pictures presented together with self or other’s face images. When incidental free recall of objects was carried out, the children were more accurate to recall objects associated with self compared to others’ face images. This self-advantage was found in 5 but not in 4 year old children.

If, as descrived in Chapter 1, the distinction of the self from others is a key aspect of social behaviour and is a precursory ability of later conceptual self-development (Rochat & Striano, 2002), it is interesting to investigate these functions in children with Autism Spectrum Disorder (ASD).

Experimental studies on self awareness in autistic children report contradictory results. Some studies have highlighted the difficulty of these children with the concept of self, of other and of interaction self-other (Mitchell & O’Keefe, 2008; Millward et al., 2000; Frith & Frith, 1999; Lee & Hobson, 1998; Uddin et al., 2008). In contrast, other studies have shown a preserved self-other processing (Neuman & Hill, 1978; Dawson & McKissick, 1984; Spiker & Ricks, 1984; Ferrari & Matthews, 1983; Zamagni et al., 2011). Numerous studies have demonstrated that self-awareness is a multidimensional function. Mental components of self-awareness, essential to social cognition, as for example the use of pronouns (Fay, 1979), the mental judgment (Happè & Frith, 1996; Mitchell and O’Keefe, 2008, Williams et al., 2010), and the autobiographical memory (Crane, et al., 2010; Millward et al., 2000) are impaired in ASD (Frith, 2003), on the contrary concrete aspects of self-awareness, as the bodily self-recognition, are unimpaired in autism.

A number of studies, suggest that the mental aspects of self-awareness are diminished and/or atypical in autism spectrum disorder (ASD). For instance, individuals with ASD have difficulty identifying and reflecting on their own mental states (Frith & Happe´ 1999), as well as their own emotions (Ben Shalom et al. 2003; Gaigg & Bowler 2008; Hill et al. 2004). Moreover several studies showed a diminished ability to explicitly differentiate themselves from otherselves using personal pronouns (Jordan 1989; Kanner 1943; Lee et al. 1994).

However, not all aspects of self-awareness are impaired in ASD. Indeed children with ASD are able to compare the currently perceived mirror or specular self-image with the mental representation of their bodily self-image (Povinelli, 2001). In this respect there is converging evidence (Ferrari & Matthews, 1983; Spiker & Ricks, 1984) demonstrating that children with ASD recognize own image in the mirror at the same mental age of typical developmental children. Moreover Dissanayake and co-workers (2010) have shown that ASD and TD children between 5 and 9 years were equally able to recognize themselves in delayed video feedback showing a memory of their own appearance. In line with the previous results also Lind and Bowler (2009) have found a preserved temporally extended self-awareness in autism spectrum disorder (ASD). Lind and Bowler (2009) have shown an unimpaired performance in ASD on the delayed self-recognition, despite showing significant impairments in theory-of-mind task performance, and a reduced propensity to use personal pronouns to refer to themselves.

The above mentioned studies investigate only an explicit recognition of own body but our body could be recognized also in an implicit way. For this reasons here we investigate the implicit bodily self-recognition a concrete aspect of the self-awareness. As described in Chapter 3, previous studies have demonstrated that healthy adults are more accurate in implicitly processing pictures representing their own as compared to other people’s body- and face parts, showing the so-called “self-advantage” (Frassinetti et al.,2008 2010). As described in Chapter 3, this self-advantage is due to an implicit self-recognition because in this studies was never required an explicit recognition.

In the present study, children with ASD were submitted to a visual matching-to sample task similar to that previously used to assess the implicit access to the bodily self-image in adults (Frassinetti et al., 2008; Frassinetti et al., 2010). Stimuli depicted the participant’s own body (hands, feet) or face (eyes, mouths) parts or other people’s body or face-parts. Participants were required to decide which of two vertically aligned images (the upper or the lower one) matched the central target stimulus. An explicit recognition of their body (face) parts was never required. The performance of children with ASD was compared with the performance of two control groups matched for mental and chronological age.

We predicted that TD children would perform the task better when they visually matched their own, compared to others' body and face-parts, showing the so-called "self-advantage". If, according to our hypothesis, bodily self-advantage is a preserved function in ASD children, we expect that autistic children will show the self-advantage as well as TD children. More specifically, concerning face stimuli, since eyes and mouth are differently processed in ASD and TD children (Pelphrey et al., 2002; Joseph & Tanaka, 2003), a different influence of ownership on these face-parts processing was expected. Indeed, people with autism show a distinct gaze pattern when looking at faces, spending more time at the mouth and often looking less into the eyes (Pelphrey et al., 2002). Thus, we expect that autistic children will elaborate better mouth than eyes.

6.2 Material and methods

Participants

The 55 children who participated in this study were assigned to three experimental groups. The first group included 17 children with autism syndrome selected from two Centres for children with ASD (Prato and Reggio Emilia, Italy). They will hereby be designated as the group of individuals with ASD. They were diagnosed according to the DSM-IV (APA, 1994) criteria for autism. The ADOS-G scale (Lord, et al., 2000), given by a trained clinical psychologist, defined all participants as ASD children. None of them had known associated medical disorders at the time of testing and the visual examination was found to be normal. IQ scores were measured with the WISC-R, submitted to children in a session differ from the experimental session. The total score (IQ-T) (verbal and performance) of 13 ADS children ranged from 43 to 72 (mean 62.15; SD=8.48). The score of performance (IQ-p) of the other 4 ASD children, unable to perform the verbal tests, ranged from 43 to 59 (mean 49.5; SD=6.8).

Two control groups of typical developing individuals were recruited for the experiment: the first group was constituted of 20 typical developing individuals matched for mental age (TD1) and the second group of 18 typical developing individuals matched for chronological age (TD2). TD children were recruited in a school.

The ASD children were chronologically older than TD1 children (average ASD=12.8 years, sd=3.7; TD1=8,5 years, sd= 2.21, $F_{1, 35}$=18.74, p<.001) but they were not different for their *mental age*[1] (average *mental age* ASD=8,2 years, sd=1.3 years; TD1=8,2 years, sd= 2.2, $F_{1, 35}$=0.1, p=.75).

The ASD and TD2 groups did not differ with respect to *chronological age (*average ASD=12.8 years, sd=3.7; TD2=13.6 years old, sd=2.4, $F_{1, 33}$=0.65, p=.42) but they were different for their *mental age* (average *mental age* ASD=8,2 years, sd=1.3 years; TD2=12,89 years, sd= 2.42, $F_{1, 35}$=50.85, p<.001). Participants' parents gave informed consent to their children's participation in the study, which was approved by the local ethics committee. All procedures were in agreement with the 1975 Helsinki Declaration.

Stimuli and Procedure

Stimuli were grey-scale pictures taken with a digital camera in a session prior to the experiment (1 week before). This session was conducted in a room with constant artificial light and a fixed distance between the camera lens and the stimuli (40 cm), which were always photographed in the same position. The original photos were modified by means of Adobe Photoshop software, equalized for luminance/contrast and presented on a uniform white background. The picture size

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[1] The mental age was calculated, on the score of performance (IQ-p), by using the formula (chronological age X IQ/100)

was 230 X 220 pixels. Stimuli represented body-parts (hands, feet) or face-parts (eyes, mouths) that could be other people's parts (other) or the subject's parts (self). Other people's stimuli were matched for size, skin color, chronological age, and gender, in comparison with each participant's stimuli. Stimuli that served as own body/face for one participant were used as other's face/body for a different participant.

In each trial three stimuli of the same category were simultaneously presented up-right, vertically aligned along the vertical meridian of the computer screen. The central stimulus was presented in a black frame and corresponded to the target stimulus. Each trial started with a central fixation cross and the experimenter started a new trial only when the participant was ready. Participants were tested individually in a quiet room. Participants sat in front of the computer screen, at a distance of about 30 cm, and were required to decide which of the two images (the upper or the lower one) matched the central target stimulus (un-speeded forced-choice paradigm). Trial duration was not limited and no time pressure was exerted on subjects' performance. The accuracy of participant' s verbal responses was recorded by the experimenter, pressing a response key. (see Fig. 9).

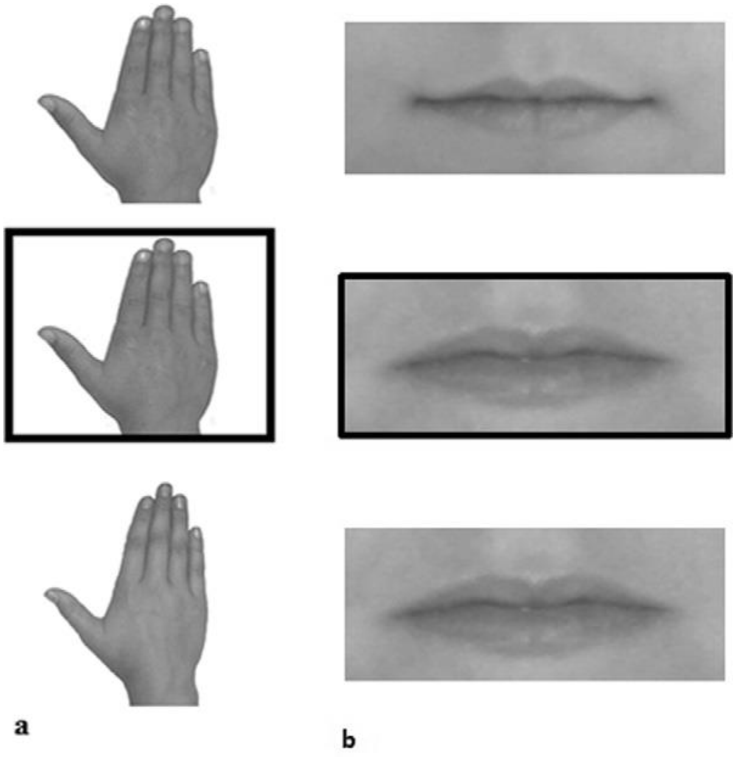

Figure 9: An example of stimuli used: body-parts (a) and face-parts (b). Participants were required to decide which of the two images (the upper or the lower one) matched the central target stimulus.

Stimulus presentation and randomization in a block were controlled using E-prime V1.1 software (Psychology Software Tools, Pittsburgh, PA) running on a computer. The experiment consisted of two blocks (48 trials each), one with body-parts and the other block with face-parts. In both blocks, half of the trials contained at least one stimulus representing the participant’s own body/face-part (‘self’ trials), whereas the other half contained stimuli representing body/face-part from three other people (‘other’ trials). To rule out the possibility that higher repetition rates of self compared to others’ stimuli led to a “priming” effect during the task, in each block self stimuli appeared the same number of times than each of the other individual’s stimuli.

In the block with body parts, stimuli were counterbalanced for side of the body (i.e., left and right). The order of blocks was randomised among participants.

6.3 Results

To investigate self-advantage in children with typical development (TD-1 and TD-2) and in children with autism spectrum disorder (ASD), an ANOVA[2] was conducted, with Group (ASD, TD1 and TD2 children) as between-subject variable and with Stimuli (Body, Face) and Ownership (Self, Other) as within-variables. Pair wise comparisons were conducted with the “Tukey honest for unequal N” test when necessary. Effect size is provided as partial eta square.

Furthermore, the performance of each group was separately investigated to explore whether a specific single body- or face-part is better processed than another body- or face-parts. To characterise the performance of each group, separate ANOVAs were conducted on error percentage, with Body-Part-Type (foot, hand) or Face-Part-Type (eyes, mouth) and Ownership as within-subjects variables.

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[2] The error percentages were normally distributed (Kolmogorov-Smirnov $d<0.22$, $p>0.2$ in each group), and therefore, comparisons were performed using parametric statistical test.

ASD and TD children matched for mental (TD-1) and chronological age (TD-2)

The variable GROUP [F (2,52) = 18.74; p < .0001; η_p^2 = .42] was significant: ASD children showed a significant higher error rate (12%) than TD-1 (4%) and TD-2 (3%) children (p < .0001, for both comparisons). The two controls groups were not statistically different (p=.84). Moreover, the variable Ownership [F (1,52) = 35.34; p < .0001; η_p^2 = .41] was significant. The error rate was significantly lower with self than with others' stimuli (4% vs 8%; self-advantage effect). The variable Stimuli and the interactions between the three variables were no significant (see Fig. 10).

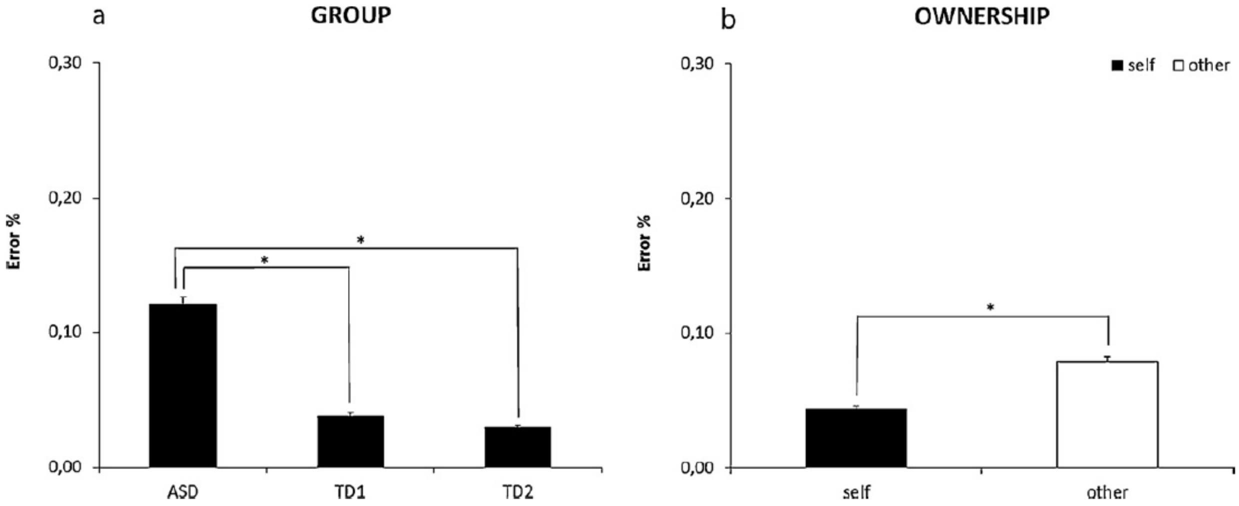

Figure 10 : a) Mean percentages of error in ASD (autism spectrum disorder) and TD (typically development) children matched with pathological group for mental age (TD-1) and chronological age (TD-2). b) Mean percentages of error in recognition of self and others' stimuli. Bars represent s.e.m. (standard error mean) inter-subjects.

ASD children

The variable Ownership was significant both when Body-Part-Type [F (1,16) = 6.06; p < .03; η_p^2 = .27] (self =11% vs. Other= 16%) and when Face-Part-Type were analysed [F (1,16) = 7.32; p < .02; η_p^2 = .31] (self =9% vs. Other= 13%) (see Fig.3a). The variables Body-Part-Type was not significant whereas the variable Face-Part-Type was significant [F (1,16) = 10.02; p < .001; η_p^2 =

.38] (eyes =% 14 vs. mouth= 8%) The interactions Body and Face-Part-Type with the variable Ownership were not significant.

TD 1 children (same mental age)

The variable Ownership was significant both when Body-Part-Type [F (1,19) = 7.65; $p < .01$; η_p^2 = .28] (self =2% vs. Other= 6%) and when Face-Part-Type were analysed [F (1,19) = 6.59; $p < .02$; η_p^2 = .26] (self =2% vs. Other= 6%) (see Fig.3b). The variables Body-Part-Type and Face-Part-Type as well as their interaction with the variable Ownership were not significant.

TD 2 children (same chronological age)

The variable Ownership was significant both when Body-Part-Type [F (1,17) = 7.27; $p < .02$; η_p^2 = .30] (self =2% vs. Other= 4%) and when Face-Part-Type were analysed [F (1,17) = 4.55; $p < .05$; η_p^2 = .20] (self =1% vs. Other= 3%) (see Fig.3c). The variables Body-Part-Type and Face-Part-Type as well as their interaction with the variable Ownership were not significant (see Fig. 11).

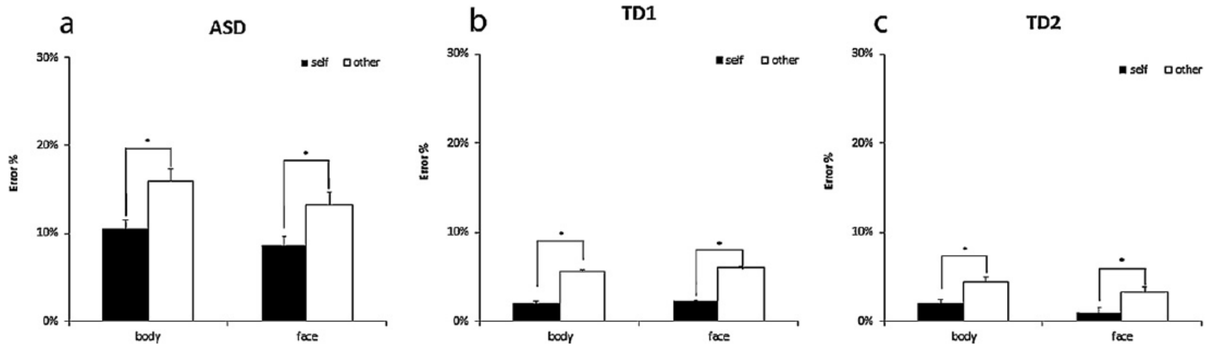

Figure 11: Mean percentages of error in recognition of self and other people's body-parts and face-parts in each group: a) ASD, children with autism spectrum disorder; b), TD-1, children with typical development, matched with ASD children for mental age; c) TD-2, children with typical development, matched with ASD children for chronological age. Bars represent s.e.m. (standard error mean) inter-subjects.

6.5. Discussion

The main aim of this study was to investigate whether the implicit self body/ face parts recognition is present also in children with autism. To this aim ASD and TD children were submitted to a modified version of the visual matching-to sample task, previously used to indirectly assess the functioning of adult bodily self-processing (Frassinetti et al., 2008; Frassinetti et al., 2010).

The first result of the present study is that TD children showed an advantage in performing the task with stimuli depicting their own compared to other's body-parts (hands, feet) and face-parts (eyes, mouths). This pattern of results suggests the presence of an implicit bodily self-processing in 8 years old children.

More important for the aim of this study, also ASD children showed a better performance with self than with others' body and face-parts, suggesting that they are able to distinguish self and others' stimuli and to take an advantage in processing self-compared to others' stimuli.

As described in Chapter 3, existing literature on adults concerning body perception suggests that our own body sub serves a special processing in contrast to others' bodies, and that when our own body is compared with someone else's body, self-stimuli show an advantage (Aranda et al., 2010; Daprati et al., 2007; Knoblich & Flach, 2003) and recruit specific underlying neural substrates (Calvo-Merino et al., 2006; Hodzic et al., 2009; Myers & Sowden, 2008; Ferri et al., 2012). Similarly, as described in Chapter 2, recognition of one's own face is consistently faster than the recognition of a stranger's face (Tong & Nakayama, 1999) and a specific neural network is dedicated to self-face stimuli (Kircher et al., 2000; Sugiura et al., 2000, 2005, 2006).

Behavioural studies in developmental age have demonstrated awareness in healthy infants of their physical appearance in the first years of life (Amsterdam, 1972; Bertenthal & Fisher, 1978; Bahrick, et al., 1996; Lewis & Brooks-Gunn, 1979; Rochat & Striano, 2002; Rochat, 2003). Rochat and Striano (2002) showed that at already 4-9 months of age, the infants are able to distinguish self image from the other's image suggesting early self-other differentiation. Bertenthal and Fisher (1978), by using five tasks performed in front of the mirror, documented the emergence of behaviors that indicate explicit awareness of the proper image by 14 to 18 months.

Regarding previous studies conducted on children as old as participants of the present experiment, an advantage was found in recalling stimuli associated, in a previous presentation of the same stimuli, with self face image (Sui & Zhu, 2005). More recently Zamagni et al. (2011) demonstrated a self-advantage effect in children from 9 to 13 years old in a visual matching-to-sample task with *self* and *others*' body-images.

The presence of the self-advantage also in children with ASD showed that in ASD children the mechanism that allow to implicitly access to this representation are spared.

As expected, our findings show a different influence in face-part-type processing, in ASD children. Indeed, autistic children were more accurate with stimuli representing mouth than eyes. However this effect was not modulated by ownership. The better performance of autistic children with mouth is in line with previous studies (Pelphrey et al., 2002; Joseph & Tanaka, 2003, Neumann Spezio et al., 2006; Bar-Haim et al., 2006). Behavioral abnormalities in eye-gaze perception and joint attention, as well as difficulties in understanding the mentalistic relevance of gaze, have already been documented in this disorder (Baron-Cohen et al., 1996, 1997, 2001; Charman et al., 1997; Dawson et al., 1998; Leekam, et al., 1998). So, it is possible that the characteristic tendency of these children not to look into others' eyes will result in them having difficulties with this type of stimulus. In this direction are also the results of Neumann et al. (2006) showing that people with autism fixated the location of the mouth in facial expressions more than did matched controls, even when the mouth was not shown and even in faces that were inverted.

Finally, error rate was higher in ASD group compared to both TD1 and TD2 groups. This result is expected comparing ASD with TD2 children, because the two groups are different for mental age.

On the contrary this result was less expected comparing ASD with TD1 children because the two groups were matched for mental age. We hyphotize that this result is due to an impairment of ASD children in inhibiting the wrong response. Indeed, in our task it was required to choose the image matching the central one and to inhibit the wrong response. In this respect, previous studies have demonstrated that individuals with ASD are impaired in inhibiting prepotent responses due to the executive dysfunction (Hill, 2004; Happé et al., 2004). Moreover, Robinson and co-worker (2009) showed that the difficulties in inhibition of ASD children are independent of IQ, and relatively stable across the childhood years. However, in our study ASD children were not submitted to a specific battery of executive function so this hypothesis should be verified in future studies.

In conclusion, our study explores an important aspect of bodily self-representation in ASD using a behavioural paradigm which allows to evaluate the implicit access to the representation of bodily self. The present results support the theory that there are different “levels” of self and that not all of these levels are impaired in autism. It is surprising how children with ASD, as well as children with typical development, when look at a picture representing their body, cannot avoid to recognize themselves. This recognition is implicit since never it was asked to explicitly recognize one’s own body. This preserved implicit access to self-body processing could be useful for a rehabilitative program to develop a more strength self-concept in autistic children.

CHAPTER 7. INFLUENCE OF EMOTIONAL BODY POSTURES ON IMPLICIT BODILY SELF-PROCESSING.

7.1 Introduction

The ability to distinguish between bodily self and others and the advantage in processing self rather than others' body-stimuli, (the so-called "self-advantage") is well established in adult healthy subjects (Frassinetti, Maini, Romualdi, Galante, & Avanzi, 2008; Frassinetti et al., 2009, 2010; Jeannerod, 2003; Decety & Sommerville, 2003). The critical issues of the normal development of corporal self-recognition and its dysfunction remain poorly understood. As described in Chapter 4, several developmental studies have addressed self-recognition with a large body of research focusing on mirror self-recognition (Bertenthal & Fisher, 1978; Amsterdam, 1972). Mirror self-recognition is, however, only one particular aspect of self-recognition. Observing ourselves in mirrors is not representative of the way in which we normally perceive and recognize our body (Knoblich, 2002). Despite the wealth of studies devoted to understanding self-recognition in mirrors, little is known about children's ability to discern self from the other's body. Considering the processing of self-information in autism, early studies (Kanner, 1943; Asperger, 1944) underlined that individuals with autism spectrum disorders (ASD) are completely self-focused or "egocentric in the extreme." More recent data showed that this egocentrism may be evident in "a lack of distinguishing self from other" (Lee & Hobson, 2006, 1998; Mitchell & O'Keefe, 2008). Moreover, individuals with autism have also difficulties in self-referential cognitive processing. More specifically, these difficulties concern the self-conscious emotion recognition and experience and the self referential understanding of emotions (Hobson, Chidambi, Lee, & Meyer, 2006; Hill, Berthoz, & Frith, 2004; Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007; Lombardo et al., 2010; Silani et al., 2008). The presence of both egocentrism and impairments in self-referential cognitive processing in autism has led to formulate the "absent self" hypothesis (Frith, 2003; Happe´, 2003; Baron Cohen, 2005; Frith & de Vignemont, 2005; Hobson et al., 2006). The absent-self hypothesis proposes a lack of specific higher-order self-awareness in autism that causes deficit in the social life. The importance of the body as a channel for socialization and for the communication of emotions (emotional body language [EBL]) is well known. Moreover, bodily emotions enhance the activity of brain areas (EBA and FBA) involved in processing bodies and body parts (Hadjikhani & de Gelder, 2003; Gre`zes, Pichon, & de Gelder, 2007). Although an impairment of emotion processing is one of the features of autism, the level at which alterations occur is an open question. An impairment of facial emotional processing in individuals with autism has been shown in various experimental tasks, such as in matching or in labeling emotions (Celani, Battacchi, & Arcidiacono, 1999; Hobson, Ouston, & Lee, 1988; Tantam, Monaghan, Nicholson, & Stirling, 1989). However, in other studies, no differences were found between children with autism and controls in discriminating between different emotional expressions (Grossman, Klin, Carter, & Volkmar, 2000; Robel et al., 2004; Loveland et al., 1997). Few studies have investigated the perception of emotional signals expressed by the whole body in ASD. Using behavioral measures and functional MRI (fMRI), Hadjikhani et al., (2009) compared the perception of bodily expressed emotions in adult individuals with ASD and in controls. They found in ASD an abnormality in the network of brain areas that are normally engaged in the perception of bodily expressed emotions. Indeed, brain activation patterns in individuals with ASD do not show evidence of differentiation between bodily expressions of fear and bodies engaged in neutral actions. These findings are in line with behavioral data (Moore, Hobson, & Lee, 1997; Hubert et al., 2007). Moore et al. (1997) found that children with autism were as able as nonautistic children in recognizing point-light displays of walking people, but that they were impaired in spontaneously commenting on the emotional and subjective states depicted. Similarly, Hubert and colleagues (2007) demonstrated that adults with autism performed significantly worse than controls in recognizing emotions from point-light displays even though they performed as well as control participants in recognizing simple actions and objects manipulations. The authors interpreted their results as evidence that emotional perception difficulties are not restricted to faces but also affect the perception of body expression of emotion. Here, we formulate the hypothesis that the bodily self is a low-level function compared to the higher-order self-awareness, essential to social cognition, and that the bodily self is spared even if the higher-order self-awareness is impaired in high-functioning autism spectrum disorder (HF-ASD) children. We additionally hypothesized that bodily self can be modulated by postures associated with different emotions. Indeed, one’s own way of expressing emotions, through body posture, should add information about the bodily self. We predicted that in TD children, emotional body postures will modulate the bodily self-recognition when subjects self-generate postures associated with different emotions (the self as expressed through emotional behaviors), but not when bodily emotions’ expression is merely reproduced from another person’s posture. As far as ASD children, at least two hypotheses can be put forward. The first one is that, the implicit processing of emotional body postures is different in ASD and in TD children. If this is the case, the influence of emotional body postures on bodily self processing is different in the two groups. Alternatively, if the implicit processing of emotional body postures is similar in ASD and in TD children, one might expect similar modulation of emotional body postures on bodily self-processing in the two groups. To test these hypotheses we contrasted, in two separate experiments, the effects of postures associated with emotions in bodily self-recognition in 16 HF-ASD children with those of 16 typically developing (TD) age- and IQ-matched children, in a visual matching- to-sample task. In Experiment 1, subjects were photographed while expressing endogenously (self-generated) emotional body postures, whereas in Experiment 2 subjects did so exogenously (i.e., imitated upon request). Emotions were positive (happiness), negative (fear), or neutral. In each experiment, subjects were shown stimuli depicting their own body, or other people’s bodies to test whether the advantage observed in adults with self over others’ bodies is also present in ASD and TD children populations, as well as how it is modulated by emotional body postures.

7.2 Materials and methods

Participants

Two experimental groups participated in this study. The first group included 16 high-functioning children with autism syndrome, selected from a center for children with ASD (Reggio Emilia, Italy). They will hereby be designated as the group of individuals with ASD. They were diagnosed according to the DSM–IV (American Psychiatric Association, 1994) criteria for autism and to the ADOS G scale (Lord et al., 2000), given by a trained clinical psychologist. None of them had known associated medical disorders at the time of testing and visual examination was found to be normal. ASD participants were matched to a control group of 16 typically developing individuals (TD). The two groups did not differ with respect to age (average age ASD = 11 years, SD = 2 years; TD = 11 years, SD = 2; p = .77) and IQ (average full scale ASD = 91, SD = 15.3; TD = 98, SD = 14.6; p = .16). Subjects' parents gave informed consent to their children's participation in the study, which was approved by the local ethics committee. All procedures were in agreement with the 1975 Helsinki Declaration.

Stimuli

Stimuli were color pictures extracted from videos of participants' body, captured using a video camera. Subjects, wearing a black T shirt and a pair of black trousers, were videotaped in a frontal position in an uniformly illuminated room while standing against a white background. The extracted pictures were successively edited using Adobe Photoshop CS3 to cut out the head, to equalize body size across participants, and to center the stimulus on the background.

Recording of bodily emotions. Participants were videotaped in two different conditions: expressing self-generated emotional postures and imitating stereotyped postures selected from a pilot study (see below).

In Experiment 1 (self-generated postures) children were videotaped while expressing the three target emotions of happiness, fear, and neutral through body postures. They were free to interpret and express the emotions as they felt, with only minimal guidance as to the sorts of situations in which children might experience those emotions (i.e., for happiness it was suggested to the children that they might want to think about winning a game or obtaining a good rating at school). One expression for each of the three selfexpressed emotions was recorded, for a total of three pictures for each subject. These pictures were matched, for each emotion, with two other children's pictures. Other children were shown self body pictures and were videotaped while they were imitating the selfexpressed emotional body postures. Thus, in this experiment, all emotions were expressed in the way that corresponded to the way in which the experimental subject expresses the emotions and, additionally, self and others' pictures were visually similar (see Fig. 12 a).

In Experiment 2 (imitated postures) children were videotaped while imitating the three body postures selected in the pilot study and shown by an experimenter serving as an actor (see Fig. 12 c). As a consequence, the emotions were expressed in a way that did not correspond to that in which the experimental subject personally expresses the emotions.

For both experiments, in each trial three stimuli representing the same emotion were simultaneously presented, horizontally aligned along the horizontal meridian of the computer screen, until the subject's response was obtained. Note that the three stimuli presented in each trial were visually similar, since in Experiment 1 other people imitated the "self" postures (see Fig. 12 b) and in Experiment 2 subjects (self and others) imitated postures selected in the pilot study (see Figure 12 d). The central stimulus was presented in a black frame and corresponded to the target stimulus. In half of the trials, at least one of the stimuli represented subject's own body (self condition), whereas in the other half, stimuli represented other children's body (other condition). Stimuli that served as "own body" for one participant were used as "others' body" for a different participant. The same "other body" was used for each emotional expression.

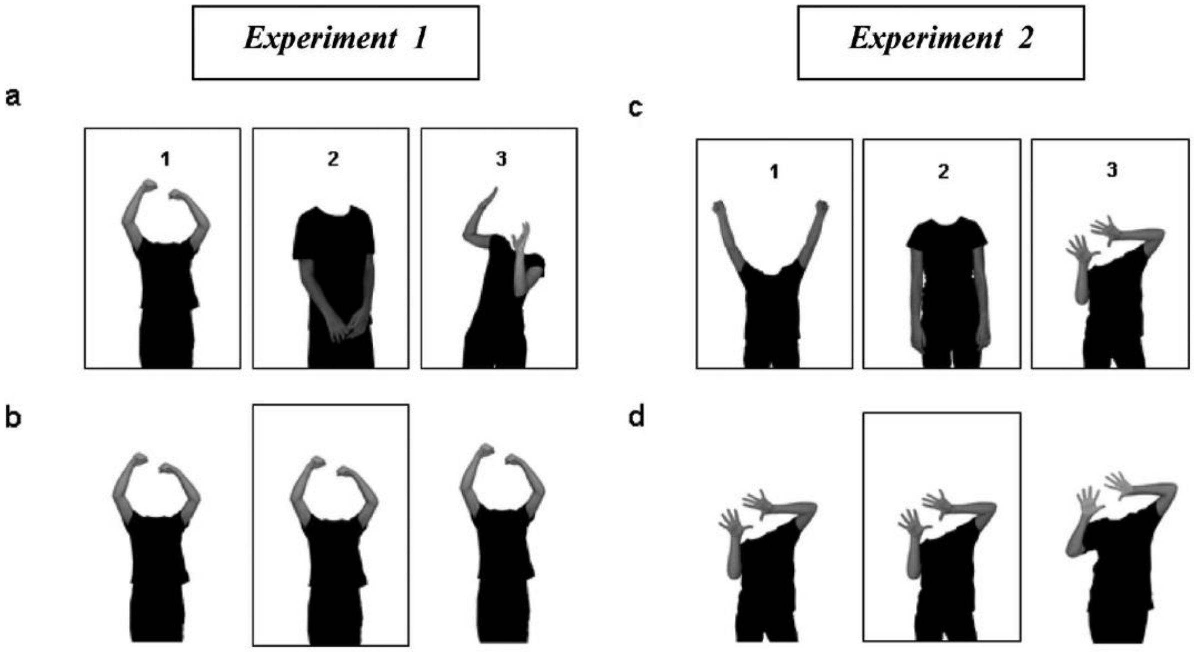

Figure 12: a) Stimuli for Experiment 1 (endogenously generated emotional body postures). 1) Happiness; 2) Neutral; 3) Fear. b) An example of a single trial for Experiment 1. Participants were required to decide which of the two lateral images (right or left) matched the central sample stimulus. c) Stimuli for Experiment 2 (exogenously generated emotional body postures). 1) Happiness; 2) Neutral; 3) Fear. d) An example of a single trial for Experiment 2. Participants were required to decide which of the two lateral images (the right or the left one) matched the central sample stimulus.

Procedure

Subjects sat in front of the PC screen, at a distance of about 30 cm. Subjects were asked: “Which of the two lateral body images (the right or the left one) matched the central sample stimulus?” In the instructions it was not specified whether the match should be made in terms of the body portrayed or of the body expression. In this respect, it is important to note that no explicit recognition of the two variables (ownership and emotions) was required. Subjects were instructed to press a previously assigned response key to respond. Key-press response times (RTs) and response accuracy were recorded. Stimulus presentation and randomization in a block were controlled using E-prime V1.1 software (Psychology Software Tools, Pittsburgh, PA) running on a PC. Each experiment consisted of 24 trials: 12 trials contained the subject’s own body (in 6 trials the own body was the target picture and in 6 trials the own body was the right or left stimulus) and 12 trials contained two others' bodies (A and B, in 6 trials the body "A" was the target and in 6 trials the body "B" was the target). Owner and Emotion variables were randomized between trials. All participants performed both experiments in one single session, with 5 practice trials before running the first experiment. Experiments were submitted in counterbalanced order across subjects.

7.3 Pilot Study

Healthy children (average age = 11 years, range 9–12 years), were videotaped while expressing with their body one of four target emotions of happiness, anger, fear, and neutral. To facilitate self-generated emotional postures, children were told short stories with a corresponding emotional content. A total of 16 pictures representing four types of postures for each emotion, extracted from videos and edited as described above, were selected and then shown to a different group of 13 children (average age = 11 years, range 9–14 years). Children categorized each picture into one of the same four target emotion categories and attributed a score corresponding to the emotional intensity of each image (1 = low, 2 = medium, 3 = high). When subjects did not correctly recognize emotional postures, the score was 0. The posture for each emotion with highest scores was selected for Experiment 2. Since "anger", independently from the type of posture, obtained the lowest score, being inconsistently recognized, it was discarded and the study focused the three emotions that were consistently recognized correctly (neutral, happiness, and fear).

7.4 Results

Separate ANOVAs on RTs and on the percentage of correct responses (accuracy) were conducted for each experiment, with group (ASD and TD) as between-participants variable and emotion (neutral, happiness, and fear) and owner (self and other) as within participants variables. The

Newman–Keuls test was used for all post hoc comparisons. The effect size (eta square = η2) was reported for all the significant effects.

Experiment 1

Analysis conducted on the RTs showed a significant main effect of group [F(1, 30) = 5.43, p = .03, η2= 0.15], because TD controls were faster than ASD children (2383 ms vs. 3397 ms). The variable owner was significant [F(1, 30) = 12.68, p = .001, η2= 0.30], subjects being faster in processing self rather than others' stimuli (2600 ms vs. 3180 ms). The interaction emotion X owner was significant [F(2, 60) = 6.72, p = .001, η2= 0.30]. Post hoc comparisons showed that self-advantage was evident with stimuli representing neutral (2511 vs. 3263, p = .001), and happy (2503 vs. 3479, p = .0002) bodily expression, but not with stimuli representing fearful body postures (2787 vs. 2797, p = .96). Moreover, with other's body, subjects were faster with stimuli representing fear compared to neutral and happiness (p = .02 and p = .001, respectively). With self body, subjects' performance was not statistically different among emotional expressions. This pattern of results was similar in patients and in healthy subjects since the three-way interaction was not significant (p=.13) (see Figure 2a–b).

A similar ANOVA conducted on the mean of correct responses showed a significant effect of the variable owner [F(1, 30) = 14.6, p = .001, η2 = 0.33], subjects being more accurate with stimuli representing self (97%) than other's body (92%). The variable group (ADS = 95% and TD = 95%) and the variable emotion (N = 95%, H = 94% and F = 95%) and their interactions were not significant.

Experiment 2

In the ANOVA conducted on mean response times with group as between-subjects variable and emotion and owner as within subject variables, only the variable owner was significant [F(1, 30) =

5.70, p = .02, η2= 0.16], subjects being faster in processing self rather than others' stimuli (3230 ms vs. 3488 ms). The variables group, emotion and their interactions were not significant (see Fig. 13c–d).

When the similar ANOVA was conducted on the mean of correct responses variables group (ASD = 96%, TD = 98%), emotion (N = 97%, H = 97% and F = 95%) and owner (self = 97%, other = 96%) and their interactions were not significant.

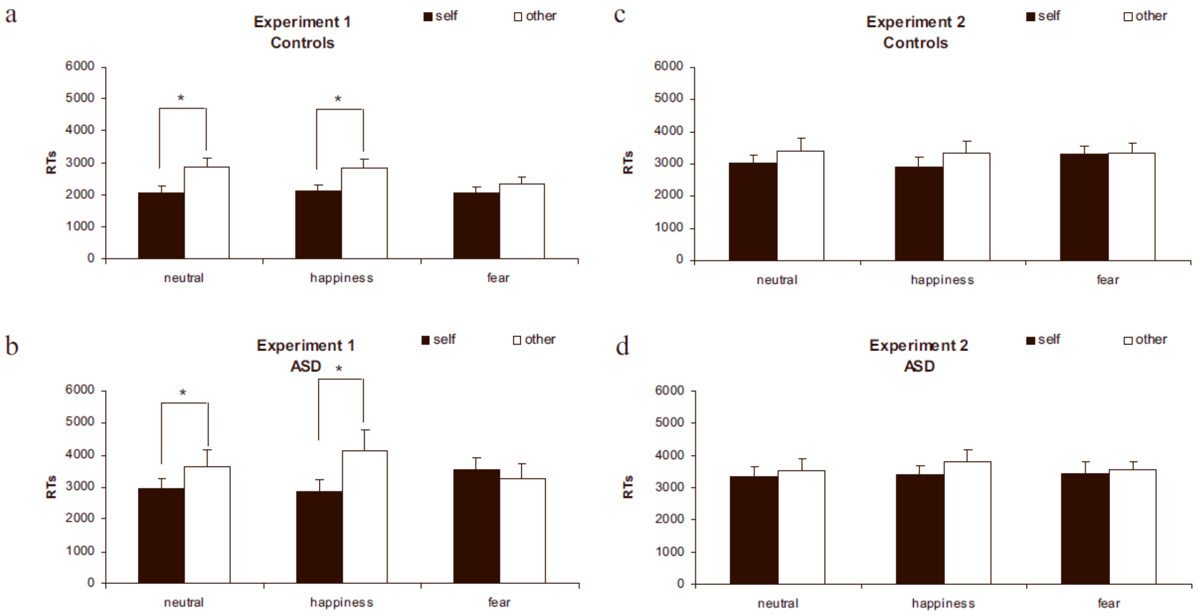

Figure 13: Mean reaction times of typically developing (a– c) and ASD (autism spectrum disorder) children (b– d) in the visual-matching task, in Experiment 1 (a– b, endogenously generated emotional body postures) and in Experiment 2 (c– d, exogenously generated emotional body postures). The results are displayed as a function of ownership (self, other) and emotions (neutral, happiness, and fear). Bars represent SEM (standard error mean) intersubjects. Differences significant at p = .05 are starred.

The results of the second experiment showed that adding information derived from the participant's exogenous, not self-generated, bodily emotions did not modulate the self-body processing.

Even if the analysis across both experiments1[3] revealed that this modulation was present in both experiments, it was stronger in the first one, when body postures were endogenously generated. The different results between the Experiments 1 and 2 should be due to a reduced variability of postures across individuals with exogenously generated postures (Experiment 2) compared to endogenously generated postures (Experiment 1). To exclude this possibility an ANOVA was conducted on standard deviation values with group as between subjects variable and experiment (Experiment 1 and 2), owner (self, other), and emotion (neutral, happiness, and fear) as within-subject variables. Only the variable group was significant [F(1, 30) = 10.17, p = .003, η2= 0.25]; the variability was overall larger in ASD than TD children (1522 ms vs. 835 ms), with no difference among emotional postures [F(2, 60) = 0.41, p = .66].

7.5 Discussion

Using a visual-matching task, in which explicit recognition of the corporeal self was not necessary we found a bodily "self-advantage" in ASD, as well as in TD children, since both groups were faster with self than other stimuli. Therefore, the bodily self-advantage, described in adult healthy subjects (Frassinetti et al., 2008, 2009 and 2010), was found also in 9–13-year-old children with typical and atypical development. The presence of this self-recognition during the developmental age is in line with the literature of developmental psychology (see Rochart, 2003 for the five levels of self-awareness). It is known that by the middle of the second year, young children show a self-recognition assessed by mirror recognition, personal pronoun use, and pretend play (Bertenthal & Fisher, 1978; Lewis & Ramsey, 2004). Interestingly, the bodily self-advantage was present also in ASD children. A part of the prior research showed that individuals with autism do not benefit from

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[3] To compare the performance in the two experiments, a further Anova was conducted on RTs with group as between-participants variable and experiment (Experiment 1 and 2), emotion, and owner as within-participants variables. The variable experiment was significant [F(1, 30) = 7.18, p = .01, η2= 0.19], since participants were faster in the first than in the second experiment (2890 ms vs. 3359 ms). Interestingly, the variable owner [F(1, 30) = 4.20, p = .0001 η2= 0.40] and its interaction with the variable emotion [F(2, 60) = 6.20, p = .004 η2= 0.25] were significant, showing a self advantage with stimuli representing neutral (2843 vs. 3361, p = .0001), and happy (2831 vs. 3522, p = .0001) bodily expression, but not with stimuli representing fearful body postures (3072 vs. 3119, p = .73).

processing information in self-relevant ways. Behavioral studies showed a reduced self-reference effect in autism (Lombardo et al., 2007; Henderson et al., 2009). In addition, neuroimaging studies suggest that the neural systems involved in self-representation are atypically in autism. In this respect, Lombardo and colleagues (2010) conducted a functional MRI (fMRI) study where participants (ASD and neurotypical adults) were scanned while reflecting on the self or a familiar nonclose other (the British Queen) in either a mentalistic or a physical way. They found atypical responses in subjects with ASD in the critical areas involved in coding for self-information. Moreover, a reduced functional connectivity between areas involved in higher-level conceptual self-representation and areas involved in lower-level embodied representation was found. However, the above-mentioned researches used complex tasks such as questions on mentalizing judgments of the self and others. In the present study, participants performed a variant of a visual matching-to-sample task that has been previously shown to indirectly assess the proper functioning of corporeal self processing in Chapter 6. The bodily self investigated here is a low level of self-awareness that could be preserved in autism. Indeed, "there is not a single sense of self or a self-specific neural system" (see Tsakiris, 2010, for a review). Rather, the self is a complex multidimensional construct. Bodily self represents only one component of the self. It is possible that in autism some components of the self can be impaired while others can be spared. Indeed, not all studies showed an impairment in self-processing in ASD. For example, Williams and Happe´ (2009) found that participants with ASD recalled their own actions better than others' actions showing the so called "self-reference effect." Moreover, the severity of the impairment in self-body processing could be related with the social impairment in autism, similar to what found for other aspects of the self (Lombardo et al., 2010). However, the current data cannot by themselves support this hypothesis.

The second result of the present study is that the self-advantage is modulated by emotional body postures. This modulation is stronger when body postures are endogenously, rather than exogenously, generated. This social modulation of the self was comparably present in autistic and control children. The self-advantage was indeed found in both groups with expressions of happy and neutral, but not fearful body postures. The presence of self-advantage with neutral stimuli indicates that postures expressing emotions may influence or modulate, without being a “necessary factor” for, bodily self recognition. The lack of self-advantage with bodily fearful expression is compatible with the idea that humans comparably elaborate self and others’ bodily signals of fear. In addition, there was a selective advantage for others’ fearful stimuli (others’ fear sensitivity) over others’ happy and neutral stimuli, with no difference among self emotional stimuli. For the social evolution of species, the recognition of the signs of fear in others is very important and might temporarily eliminate (or override) self– other distinctions. Indeed, others’ fearful body postures signal a threat and at the same time specify the action to be undertaken by the individuals fearing for their safety, as suggested also by studies on monkeys (de Gelder & Partan, 2009). Therefore, considering that recognize the fear expressions of other people allow us to warn against potential threats, it is of considerable interest that functional imaging research has found increased activity in the amygdala for tasks in which participants view fearful expressions, with no amygdala activation for happy expressions (Vuilleumier, Armony, Driver, & Dolan, 2001; Morris, Ohman, & Dolan, 1998; Hadjikhani et al., 2009; de Gelder, Snyder, Greve, Gerard, & Hadjikhani, 2004). Interestingly, the amygdala plays a central role in linking fear signals with appropriate defensive and attentional responses (Vuilleumier, Richardson, Armony, Driver, & Dolan, 2004).

The most interesting result of this study is that even if ASD were overall slower than TD children in performing the matching task, there was no qualitative difference between ASD and TD children with respect to this explored function. Indeed, bod –postures modulate the self/others’ distinction in ASD as in TD children. These findings clearly support the hypothesis that bodily self/other recognition and its modulations by emotional body postures are low-level functions that, possibly owing to their crucial role for the survival of social species, may be preserved in subjects with autism spectrum disorders.

This result is only apparently in contrast with previous studies on the perception of bodily emotions in autism (Hadjikhani et al., 2009; Hubert et al., 2007). Indeed, in the study of Hubert and colleagues (2007), the tasks were different from the present one. Moreover, Hadjikhani and colleagues (2009) showed a different pattern of cortical and subcortical activation in ASD and TD children. It is possible that the similar modulation of emotional body postures that we found in ASD and TD children, involves partially different neural networks in the two populations. Future studies will clarify the neural bases of the emotional modulation of the self and others' body in subjects with typical and atypical development.

CHAPTER 8. THE LOSS OF IMPLICIT SELF-BODY RECOGNITION IN PARKINSON DISEASE.

8.1 Introduction

Parkinson's disease (PD) is a degenerative and progressive disease of the central nervous system (CNS), which is characterized by the death of neurons in the substantia nigra, with consequent diminution of dopamine, leading to typical motor alterations (Agid, 1991) such as tremor, rigidity, slowness of voluntary movements and walking and posture balance alterations (Conley, 1999). Recently, Gamarra and coworkers (2009) demonstrated that such motor impairments and the distortion to the body structure induce alterations of the body image and self-concept in PD patients. Body image consists of the picture formed by the mental images or representations of the body. In Gamarra et al.'s study, body image perception and self-concept in PD patients were evaluated respectively through "The My Body Image Test" and "The Factorial Self-Concept Scale". PD patients presented worse perception of their body image and a reduced self-concept in relation to controls. Alterations of body image in PD patients were also described by other authors.

Sandyk (1997) described three PD patients who exhibited macrosomatognosia of one or both upper limbs. Macrosomatognosia refers to a disorder of the body image in which the patient perceives part of his body (or his entire body) as disproportionally large (Fredericks, 1963; 1969). Macrosomatognosia has been associated with lesions in the parietal lobe, particularly the right parietal lobe, which integrates perceptual-sensorimotor functions concerned with body image. It has been observed most commonly in patients with paroxysmal cerebral disorders such as epilepsy and migraine. In the three PD patients described by Sandyk (1997) the spontaneous drawing of the figure of a man demonstrated disproportionately large arms. Furthermore, it was observed that the arm affected by tremor or, in the case of bilateral tremor, the arm showing the most severe tremor, showed the greatest abnormality. This association implies that dopaminergic mechanisms influence neuronal systems in the right parietal lobe that constructs one's body image.

More recently, it was found that the right hemisphere is specifically involved in recognition of images depicting one's own rather than other peoples' bodies. This evidence comes from studies conducted on brain-damaged patients. In a visual matching task, when healthy subjects were required to decide which of two vertically aligned images depicting their own body or face parts or other people's body or face parts, matched the central target, they were facilitated when one of the stimuli belonged to their own body or face compared to when they belonged to someone else (Frassinetti et al., 2008, 2009, 2010). This effect, called 'self-advantage', was also found in patients with a lesion of the left hemisphere, but not in patients with a lesion of the right hemisphere (Frassinetti et al., 2008). Moreover, some right-brain-damaged patients were impaired in processing self-related body parts but not self-related face parts, thus providing initial evidence of a modular representation of the corporeal self.

Interestingly, in healthy subjects the self-advantage effect emerges only when participants are implicitly required to recognize their own body. By contrast, the self-advantage does not emerge when an explicit recognition of one's own body is required (Frassinetti et al., 2011; Ferri et al., 2011). These data suggest that implicit and explicit self-body recognition rely upon different mechanisms. For implicit self-body recognition, behavioral and neuroimaging data have suggested that this facilitation in discriminating self versus other people's body parts is based mainly on the sensorimotor representation of one's own body (Frassinetti et al., 2011; Ferri et al., 2011; Ferri et al., 2012). The explicit self-body recognition is based on different cognitive processes, most likely involving visual information, memory and attention capacities (see Frassinetti et al., 2011).

Here we tested the implicit and explicit self-body and face parts recognition in PD patients. Patients with Parkinson disease and healthy controls were submitted to two visual tasks in two separate experiments. In both the experiments, subjects were shown stimuli depicting their own or other people's body-parts (hand, foot) and face-parts (eyes, mouth). In the first experiment, subjects were required to decide which of two vertically aligned images (the upper or the lower one) matched the central target stimulus. In this experiment participants were never explicitly asked to identify one’s own body or face parts, so we used this experiment as an implicit measure of self-body and self-face recognition. In the second experiment participants were required to decide whether the upper or the lower image corresponded to their own body or face part. In this experiment we used an explicit self/other discrimination task.

If motor and proprioceptive deficits affect the sensorimotor representation of one’s own body, PD patients should be impaired in the implicit but not in the explicit bodily self-recognition. Since the sensory-motor deficit in PD patients affect both face and body (Marsili et al., 2014) , this impairment in implicit recognition should regard self-face as well as self-body-parts.

8.2 Method

Participants

Twenty participants with no history of previous neurological or psychiatric disease (mean age = 69.2 years; st.dev. ±6.9) and twelve patients with Parkinson Disease (PD) (mean age = 70.6 years; st. dev. ±8.9), gave their informed consent to participate in the study, which was approved by the local ethics committee. All procedures were in agreement with the 2008 Helsinki Declaration. Patients were recruited consecutively at the Fondazione Salvatore Maugeri (Clinica del Lavoro e della Riabilitazione, IRCCS – Istituto Scientifico of Castel Goffredo, Mantova, Italy) and were selected according to DSM-IV criteria for the Diagnosis of Parkinson’s Disease. All the patients were in stage I and II of the modified Hoehn and Yahr staging scale (1967). Exclusion criteria were as follows: (1) vascular, pharmacological or atypical Parkinsonism; (2) presence of other neurological or psychiatric diseases nonrelated to PD; (3) abusive use of alcohol or illicit drugs; (4) any serious clinical disease able of produce functional impairment (5) Mini-Mental Score

Examination (MMSE) lower than 24 points. The control group met the same inclusion and exclusion criteria.

Stimuli

The experimental stimuli consisted of grey-scale pictures of participant's and other people's body- (hand and foot) and face-parts (eyes and mouth) (Fig. 14). Flash photographs were taken with a digital camera, perpendicular to each part of the body and face, which were always photographed in the same position while standing against a uniform white background. Participant's face and body parts were photographed in a session prior to the experiments (1 week before). This session took place in a controlled environment with constant artificial light and a fixed distance between the camera lens and the body/face-parts (40 cm).

The pictures were equalized for visual properties such as brightness and contrast and digitally edited (Adobe Photoshop) for extracting the background, equalizing the size across participants, isolating the relevant portion of the body-part and centering it on a uniform white background.

Other people's body-face parts were selected from a database as the best match for size, skin color, age, and gender, in comparison with each participant's face and body parts.

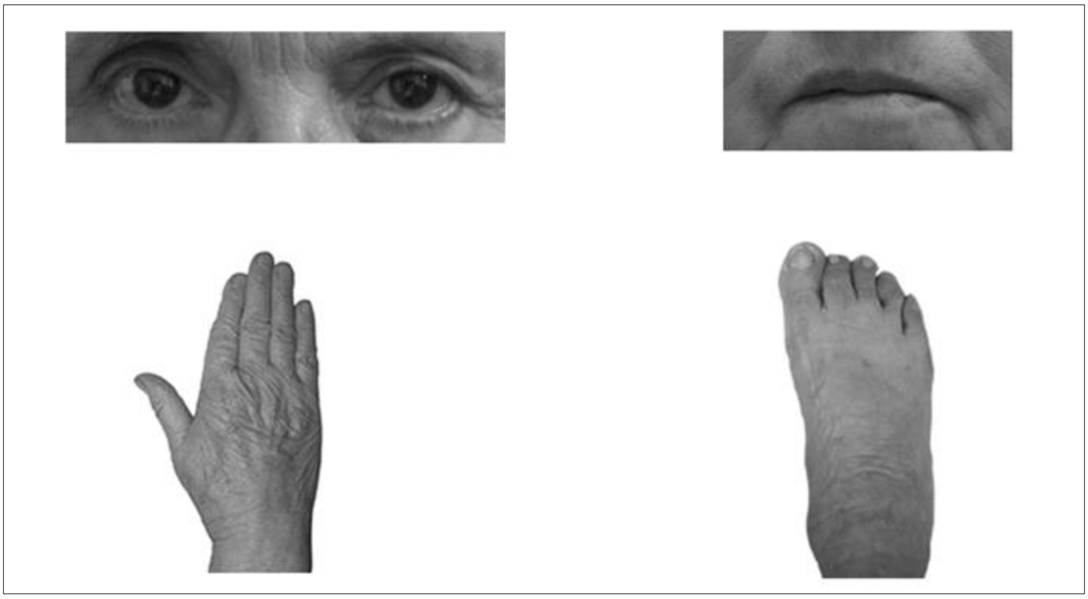

Figure 14: Examples of the experimental stimuli. For each category (body-parts and face-parts), two stimuli (hand/foot and mouth/eyes) were presented.

Procedure

In the implicit experiment three stimuli of the same category (hands, feet, eyes or mouths) were aligned along the vertical meridian of the computer screen. The central stimulus, which corresponded to the target stimulus, was presented within a black frame (see Fig. 15a). Stimuli presented in each trial were matched for visual similarity. Participants sat in front of the PC screen, at a distance of about 30 cm. They were required to decide whether the upper or the lower stimulus matched the target stimulus by pressing an upper or a lower (vertically aligned and previously assigned) response key, with their right index finger. Participants were instructed to respond as accurately as possible. The trial was timed-out as soon as participants responded. RTs and response accuracy were recorded. The implicit experiment consisted of 96 trials divided into two blocks, one with body-parts (48 trials) and one with face-parts (48 trials).

In the explicit experiment two stimuli of the same category (hands, feet, eyes or mouths), were simultaneously presented in each trial. The stimuli were the same as in implicit experiment, except that there was no target stimulus within the central frame. As in the implicit experiment, the stimuli were aligned along the vertical meridian of the computer screen (see Fig. 15b). Participants were required to decide whether the upper or the lower image corresponded to their own body or face part by pressing an upper or a lower (vertically aligned and previously assigned) response key, with their right index finger. If none of the stimuli corresponded to their own body or face part, they had to press a central response key. Participants were instructed to respond as accurately as possible. The trial was timed-out as soon as participants responded. RTs and response accuracy were recorded. The explicit experiment consisted of 32 trials divided into two blocks, one with body parts (16 trials) and one with face parts (16 trials).

Stimulus presentation and randomization in a block were controlled using E-prime V1.1 software (Psychology Software Tools, Pittsburgh, PA) running on a PC.

Each block of the two experiments were constituted by half self trials (each presenting at least one picture of participant's own body or face parts), and half others' trials (each presenting only pictures of three other people's body or face parts). All participants performed the Experiments in one single session, with 12 practice trials before each block.

The implicit experiment was always conducted before the explicit experiment. The order of the blocks in each experiment was randomized between subjects.

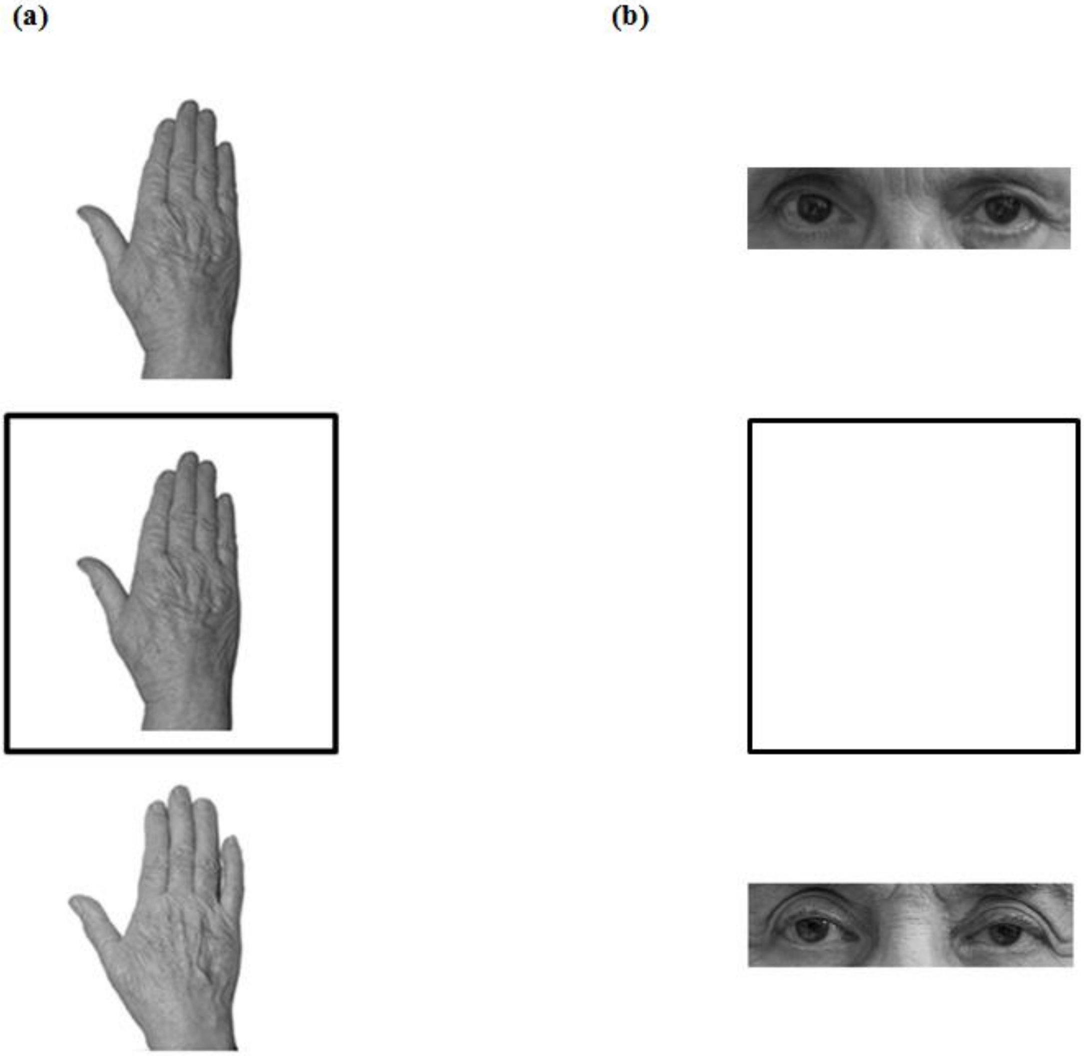

Figure 15 Examples of a single trials. (a) Implicit task: participants were requiredto decide which of the two images (the upper or the lower one) matched the central stimulus target. (b) Explicit task: participants were required to judge whether and which image, between the upper or lower, corresponded to their own face or body-parts.

8.3 Results

The mean percentage of correct responses (accuracy) was analyse. First, to characterize the performance of the control group, an ANOVA was conducted with Stimulus (body or face parts) and Ownership (self and other's stimuli) as within-subject variables. Pairwise comparisons were conducted with the ''Tukey honest for equal N'' test when necessary.

Then, a further ANOVA was performed to compare PD patients' performance with age-matched controls, with Group (controls and patients) as between-subject variable and Stimulus and Ownership as within-subject variables. In this case, pairwise comparisons were conducted with the ''Tukey honest for unequal N'' test.

The same ANOVAs were separately conducted for the Implicit and the Explicit tasks.

Results of the Implicit Task

Healthy subjects

A significant effect of the variable Ownership [F(1.19)=5.76, $p<0.02$; η^2_p =0.23] was found, since controls performed better with their own rather than with other people's stimuli (97% vs. 95%, $P < .03$), showing the so-called self-advantage effect. The variable Stimulus ($p=0.17$) and the interaction between Stimulus x Ownership ($p=0.27$) were not significant.

Comparison between controls and patients' performance

When the performance of the two groups was compared, the variable Group [F(1.30)=10.74, $p<0.003$; $\eta^2_p = 0.26$] was significant: control subjects (96%) were more accurate than patients (90%). The interaction between Group X Ownership was also significant [F(1.30)=11.29, $p<0.002$; $\eta^2_p = 0.28$]. Post hoc analysis revealed that patients with PD performed substantially worse with their own (89%) than with others' body stimuli (92%, $p< .03$), showing a self-disadvantage effect. Moreover, with self-stimuli PD patients were less accurate compared with controls (89% vs 97%, p<.03) whereas with others' stimuli no significant differences were found between the two groups (92 vs 95% p=.34) (see Fig. 16)

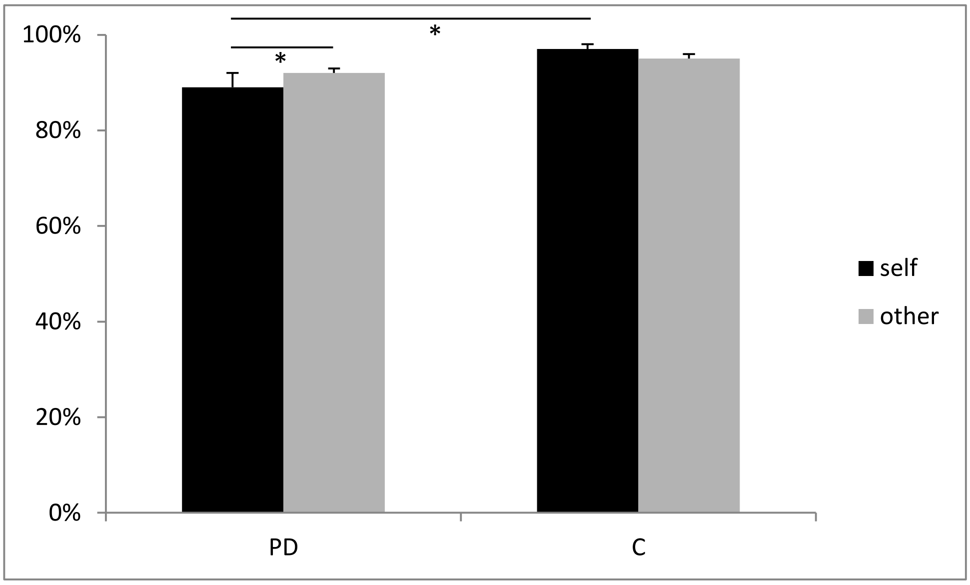

Figure 16: Implicit Task : Mean percentage of correct responses of self and other people's stimuli in the two groups (PD = Parkinson's disease patients; C = Controls). Bars represent S.E.M. (standard error mean) inter-subjects.

Results of Explicit Task

Healthy subjects

Statistical analysis, conducted on the accuracy, didn't showed significant effects. Crucially for the aim of the present study, no differences were found between self and others' stimuli (self=69% vs other=64%; p=0.26).

Comparison between controls and patients

When the performance of the two groups was compared no significant effects were found. More precisely, no difference was found between patients' and controls' accuracy (57% vs 67, p=.12) and between self and others' stimuli (63% vs 62%, p=.86). The interaction between the two variables was also not significant (p=.14) (see fig. 17 for mean values)

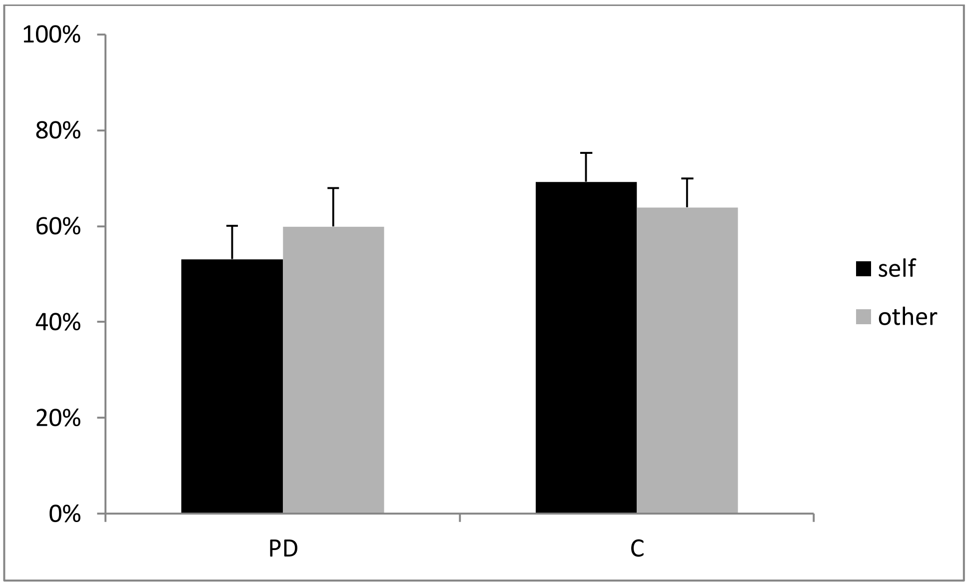

Figure 17: Implicit Task : Mean percentage of correct responses of self and otherpeople’s stimuli in the two groups (PD = Parkinson’s disease patients; C = Controls). Bars represent S.E.M. (standard error mean) inter-subjects.

8.4 Discussion

The most interesting result of the present study is that PD patients in the implicit task not only did not show the self-advantage effect, but also showed a self-disadvantage effect: they were less accurate with self than with others’ stimuli. Moreover with self-stimuli, PD patients’ performance was worse than controls’ performance, whereas this difference was not significant with stimuli depicting others’ parts. This demonstrates that PD patients are not generally impaired in performing the task, rather they are specifically impaired in processing self-related stimuli.

It is important to note that this deficit is confined to the implicit task and is not extended to the explicit task. Indeed no differences were found between PD patients and controls in the explicit recognition of both self and others’ stimuli. This finding is even more interesting when considered in the context of a second finding of the present study—namely the fact that for all participants solving the explicit task proved more difficult, in terms of lower accuracy, than the implicit task. This result confirms that implicit self recognition is selectively impaired in PD patients.

Behavioral and neuroimaging data (Frassinetti etal., 2011; Ferri et al., 2011; Ferri et al., 2012) suggest that the *implicit body self-advantage* relies upon the integration of visual information with other modalities, having the sensorimotor body representation as the crucial role. Thus, the self-disadvantage effect in PD patients can be the result of the rigidity and the difficulty of locomotion experienced with the progression of the disease. Somatosensory and motor problems could have induced alterations in these patients of their own body somatosensory representation. Thus, when the displayed hand is their own hand, patients failed to match with the representation of their own hand, with consequently greater amount of errors in this condition compared to when the displayed hand is another person's hand. The observation that the self-disadvantage effect was found both for self-body parts and face-parts corroborates the hypothesis of a deficit of sensory-motor representation. Indeed motor and somatosensory problems characterized not only patients' bodies but also patients' faces. Indeed a decreased mobility in the muscles of the face and a loss of facial expression (hypomimia) are the major symptoms of this disorder.

A further explanation of the self-disadvantage effect could be alterations of the central nervous system in PD patients. Subcortical dopaminergic pathways may influence cortical neuronal systems in the right hemisphere. In PD, besides the dopaminergic damage in substantia nigra, pathological and neurochemical changes have been observed in cortical and subcortical structures, including the serotonergic raphe nuclei, the noradrenergic locus coeruleus and the cholinergic nucleus basalis of Meynert (Halliday et al., 1990). These subcortical neurotransmitter systems send diffuse projections to the neocortex and chronic deafferentation from these subcortical systems results in diminished cortical metabolic activity, especially in the posterior cerebral regions. The disconnection of various subcortical regions from the neocortex and the subsequent effect on thalamocortical and corticocortical connections contributes to the development of various cognitive deficits observed in these patients, including disorders of body representation (Eberling et al., 1994). Since neuropsychological studies have demonstrated a critical role of the right hemisphere in implicit self-body recognition (Frassinetti et al, 2008; 2009; 2010), a functional impairment of the right hemisphere in PD patients could explain their deficit in implicit self-body processing.

Regarding healthy subjects, the present study confirms and extends previous findings. The dissociation between the self-advantage effect in the implicit but not in the explicit task is here for the first time extended to face stimuli and to older people. Indeed, previous studies (Frassinetti et al., 2011; Ferri et al., 2011) were conducted on young people (range 20-55 years old), using only pictures representing body and not face parts.

In conclusion, these findings provide initial neuropsychological evidence that self-processing can be altered in Parkinson disease.

CHAPTER 9. INTERPERSONAL SPACE REGULATION IN AUTISM SPECTRUM DISORDERS.

9.1 Introduction

People automatically and reliably regulate their interpersonal space to obtain a comfortable distance of interaction (Hall, 1966). As described in Chapter 5, this behavior is part of the interpersonal self and is absent only when we are alone, but is sufficient that in the same place are present two or more people that we cannot avoid to regulate our spatial position taking into account that of other. Interpersonal distance can be described as a bubble of space surrounding a person (Hall, 1966), into which intrusion by others causes discomfort.

A number of studies have shown that the size of the personal space varies depending on social context. A person who is placed in a potentially threatening context will have an expanded personal pace; a person in friendly company will have a reduced personal space (Dosey et al. 1969; Graziano et al. 2006; Felipe et al. 1966). Moreover, the size of interpersonal space can change as a function of different factors, including gender (Lomranz et al. 1975), age (Aiello, 1987), infant–caregiver attachment (Cassidy et al. 1994; Bar-Haim et al. 2002) and familiarity between interacting parties (Watson, 1970; Cristani et al. 2012). Studies have also documented that psychiatric (Deus et al. 2006), neurological (Kennedy et al. 2009) and developmental disorders (Vranic, 2003) can interfere with the regulation of personal space.

Recently, Kennedy and coworkers (Kennedy et al. 2009) described the regulation of interpersonal distance in a patient (SM) with bilateral amygdala damage. In their experiment, the authors asked SM to indicate the position at which she felt most comfortable as an experimenter approached her, or she approached the experimenter. SM showed a substantially reduced personal space compared to comparison subjects. A questionnaire, in which the patient rated her level of comfort/discomfort standing to different distances from the experimenter, put in evidence that SM was perfectly comfortable also at a nose-to-nose distance with the experimenter. These study showed that bilateral damage to the amygdala results in no detectable personal space boundary and an abnormally small interpersonal distance preference, thereby suggesting that this brain structure is part of the neural substrate regulating the distance between individuals. This hypothesis was confirmed, in the same study (Kennedy et al., 2009) by fMRI data showing a greater activation of the amygdala when participants knew that an experimenter was maintaining a close distance to them, compared to when they knew that an experimenter was maintaining a far distance. This conclusion is consistent with the results of non-human primate studies, revealing that monkeys with bilateral amygdalar damage preferred to stay in closer proximity to other monkeys or people compared to monkeys without lesion (Kluver et al. 1938; Emery et al. 2001; Mason et al. 2006).

Because personal space represents the space of interaction and communication with others, it is critical to study this space in subjects with everyday difficulties in social and emotional behavior, such as patients with autism spectrum disorders (ASD). Autism is a neurodevelopmental disorder characterized by marked and enduring deficits of interpersonal interaction, including behavioral avoidance and unresponsiveness (Richer et al. 1976; Wing et al. 1979; Fein et al. 1986; Hobson, 1993, Klin et al. 2002), and failure to spontaneously interact with people (Happè et al. 1996; Volkmar et al. 2000). Moreover, it has been proposed that dysfunction of the amygdala may be responsible, at least in part, for the impairment of social and emotional functioning that is a core feature of autism (Bachevalier, 1994; Baron-Cohen et al. 1999; Howard et al. 2000; Adolphs et al. 2001). However, relatively little is known about the way in which autistic individuals regulate the physical distance from other people during social interactions. Although anecdotal observations and some meager evidence (Kennedy et al. 2010) suggest that the ability to reliably regulate one's distance from other people may be impaired in ASD, interpersonal distance has never been directly measured in individuals with autism in a laboratory test.

In the present study, our primary aim was to provide a direct measure of the personal space of children with typical development (TD) and children with an impairment in social approach, such as autism (ASD). The second aim was to investigate the modulation of personal space by a brief social interaction with an unfamiliar other in these two populations of children. To this end, we measured personal space using a modified version of the stop-distance procedure (Hayduk, 1981a; Hayduk, 1981b; Hayduk, 1983). This paradigm represents one of the most frequently used measure of personal space regulation, allowing reliable estimates of preferred interpersonal distance under varied conditions and repeated measures (for reviews, see Aiello, 1987 and Hayduk, 1983). In our experiment, personal space was measured as the distance at which children felt most comfortable as an unfamiliar adult confederate approached them or they approached the confederate. Each participant was tested twice, i.e., before and after a break during which participant interacted with the confederate.

Prior research has suggested that an excessively functioning amygdala may account for abnormal fears and enhanced anxiety in autistic children, leading to impaired social interactions and avoidant behaviors in these patients (Hirstein et al 2001; Amaral et al. 2003; Schulkin, 2006; Corbett et al. 2006; Markram et al. 2008; Swartz et al. 2011). Accordingly, we hypothesized that ASD children, due to increased fear and hyperarousal following personal space violations, would fail to reliably and flexibly regulate personal space, thereby maintaining a farther and rigid distance from others. As a consequence, we predicted that interpersonal distance would be larger in ASDs than in TD children and it should be modulated by a brief social interaction in TD but not in ASDs children.

9.2 Methods

Ethics statement

The study involved children with autism spectrum disorders and children with typical development in a behavioral experiment. Subjects' parents gave written informed consent to their children's participation in the study, which was approved by the ethics committee of the Centro Autismo, Ausl Reggio Emilia, where the experiment was performed, and by the ethics committee of the Department of Psychology of the University of Bologna. The experiment was conducted according to the ethical guidelines of the Declaration of Helsinki.

Participants

Fifteen male children with autism spectrum disorders (ASD) participated in the study. The autistic children were recruited through referrals from a center for children with ASD (Reggio Emilia, Italy). They will hereby be designated as the group of individuals with ASD. All had received a formal diagnosis of an ASD by an independent clinician, according to the standard Diagnostic and Statistical Manual of Mental Disorders-IV criteria (American Psychiatric Association, 1994) and all were high functioning. The diagnosis was confirmed using the Autism Diagnostic Observation Schedule-Generic (ADOS-G) scale (Lord et al. 2000), given by a trained clinical psychologist. ASD children had all fluent language abilities. They had no other diagnosed neurological (e.g. cerebral palsy or epilepsy) or medical disorders, and none of them were taking antipsychotic drugs at the time of testing.

We compared the ASD children to 23 male children with typical development (henceforth TD children). TD children were recruited in local schools and were free of current or past psychiatric or neurological illness as determined by history.

ASD and TD groups did not differ with respect to both mental[4] (TD = 9.17 years, sd = 1.03 years; ASD= 9.07 years, sd =2.43 years; [F(1,36) = 0.05; p = .85], and chronological age (TD = 9.56 years, sd = 1.73 years; ASD = 9.73 years, sd =2.37 years; [F(1,36) = .06; p = .80]; see Table 2).

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[4] The mental age was calculated by using the formula (chronological age X IQ/100). The Total IQ scores were measured with the WISC-III, submitted to children in a session different from the experimental session.

Table 2. Subject Demographics for Children Participating in the Study

	ASD Group (N=15) (Mean/SD)	**TD Group (N=23)** (Mean/SD)
Chronological Age	9.73 (+/- 2.37)	9.56 (+/- 1.73)
Mental Age	9.07 (+/- 2.43)	9.17 (+/- 1.03)
Full Scale IQ	92.73 (+/- 16.08)	97.61 (+/- 10.76)
ADOS (Full Scale)	15.6 (+/- 3.37)	NA
ADOS (Social interaction)	8 (+/- 2.24)	NA
ADOS (Communication)	5.8 (+/- 3.12)	NA
ADOS (Imagination)	1.2 (+/- 0.77)	NA
ADOS (Behaviors)	1.67 (+/- 1.72)	NA
Diagnosis	9 (F84.9) 6 (F84.0)	NA

IQ assessed with Wechsler Intelligence Scale for Children–Third Edition (WISC-III) or Wechsler Abbreviated Scale of Intelligence (WASI)

Procedure

We applied an adapted version of the stop-distance paradigm used by Kennedy et al. [14]. All participants were tested in the same room (7 x 4 m) by one experimenter and one confederate. The role of the experimenter and confederate was taken in turns. Care was taken to ensure that the experimental setup remained identical across participants.

Testing began with a participant positioned at a fixed location in the room and the confederate standing, facing the participant from a far starting position (five meters), or from a close starting position (30 cm). In half of the trials, the female confederate was always the one moving, at a natural gait either toward (i.e., far starting position) or away (i.e., close starting position) from the participant. In the other half of the trials, the participant was always the one moving, either approaching or withdrawing from the confederate (see Fig. 18). Participants were instructed to tell the confederate to stop at their preferred distance (i.e., the distance between themselves and the confederate at which they felt most comfortable), in the trials when the confederate was moving, and chose their ideal interpersonal distance in the trials when they were moving. During the approach/withdrawal movement, the confederate made no eye contact, maintained a neutral facial expression, and never touched the participant. The interpersonal distance was measured with a digital laser measurer (Agatec, model DM100, error ± .003m), as the distance between the confederate' toes and the participant's toes.

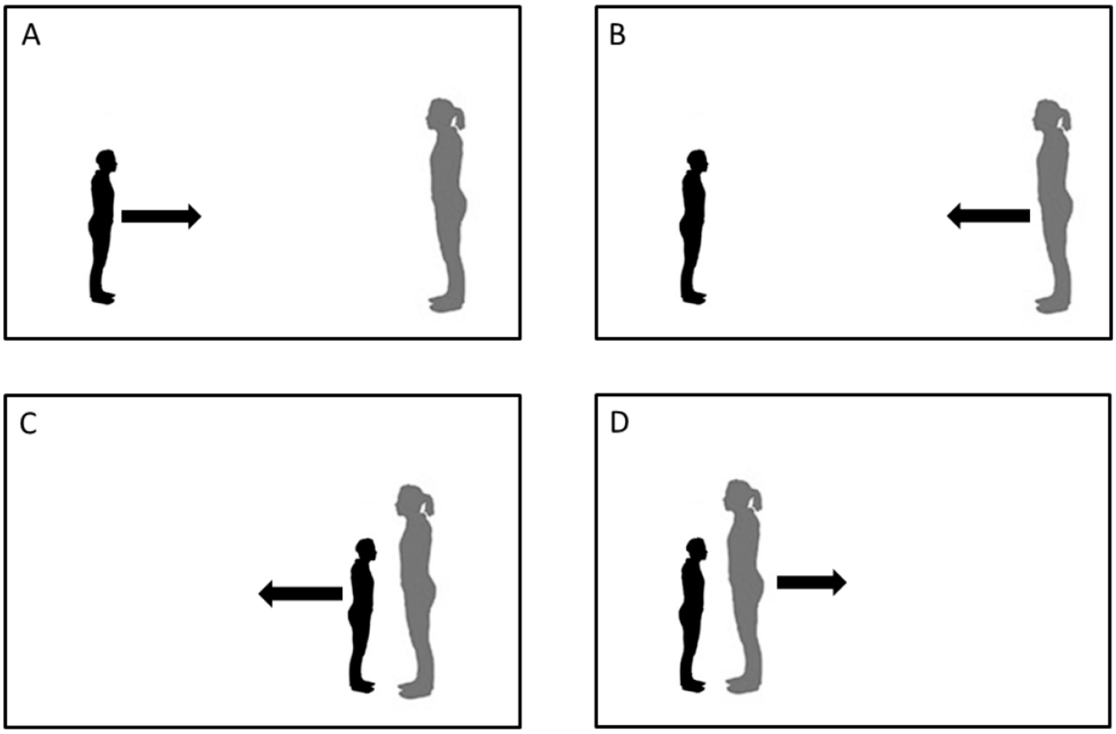

Figure 18: Experimental procedure. In the first condition (A) the participant approached the confederate starting from a far distance (5 m). In the second condition (B) the confederate approached the participant starting from a far distance (5 m). In the third condition (C) the participant moved away from the confederate starting from a close distance (face to face). In the fourth condition (D) the confederate moved away from the participant starting from a close distance (face to face).

The same procedure was repeated twice, before and after a 10-minute time interval. During the time interval, the confederate invited the subject to seat down on a cushion placed in the same room and to read together an illustrated book chosen by the participant. The children could choose one illustrated book among fifteen different ones, which had been suggested by the their teachers or psychologists as being particularly interesting for each child. During the interaction, the confederate read the book and asked three questions concerning the content of the book, while each participant was invited to make comments and ask questions to the confederate. In order to measure the amount of this social interaction, the experimenter assigned a score between 0 and 3 to each of three behaviors: i) the child's ability to answer to the confederate's questions, ii) the child's ability to make comments about the book, and iii) the child's ability to ask questions to the confederate. These three ratings were averaged together to obtain an index of social interaction.

Before starting the experiment all participants received an explanation of the task and had four practice trials with the experimenter. Then the confederate was introduced.

To sum up, we run a 2x2x2 design with starting position (close and far), person moving (confederate and participant) and session (before and after social interaction) as factors. Each cell of the experimental design comprised 3 trials, thus yielding a total of 24 completely randomized trials.

9.3 Results

The effect of social interaction on personal space regulation was verified in children with TD and in children with ASD by comparing the interpersonal distance in the two groups before and after the interaction with the adult confederate. To this aim, a mixed-design analysis of variance (ANOVA) was conducted on the measure of interpersonal distance expressed in mm, with group (ASD and TD) as a between-subject variable, and session (before and after social interaction) as a within-subject variable. For the purpose of this analysis, data were collapsed across person moving (confederate and participant), and starting position (close and far) condition.

The variable group was significant [$F(1,36) = 14.84$; $p < .0001$; $\eta_p^2 = .292$], revealing that the interpersonal distance was larger in ASD children than in TD children (2850 mm *vs.*1595 mm, respectively; see Fig. 19). There was also a marginally significant effect of session [$F(1,36) = 3.80$; $p = .06$; $\eta_p^2 = .096$], showing that interpersonal distance was larger before (2175 mm) than after (2022 mm) the social interaction.

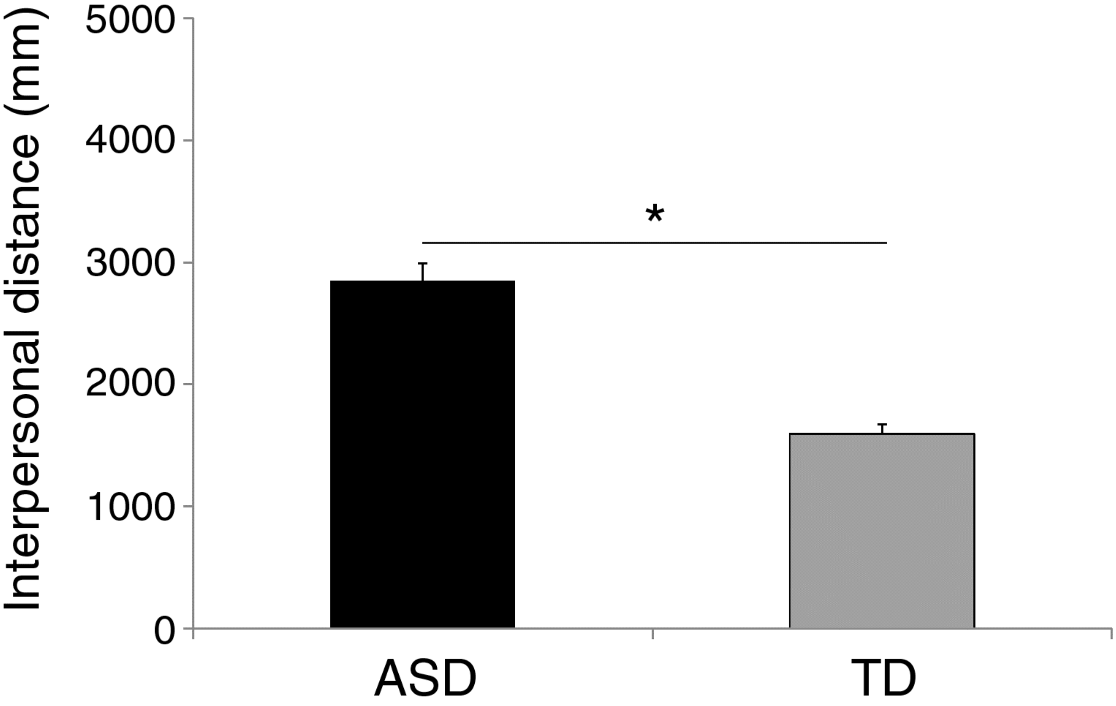

Figure 19: Mean preferred distance from the confederate in children with autism spectrum disorders (ASD), and children with typical development (TD). Asterisk indicates significant comparison ($p < 0.05$). Error bars denote s.e.m.

Critically, the main effects were qualified by a significant group X session interaction [$F(1,36) = 7.73$; $p < .01$; $\eta_p^2 = .177$]. Indeed, post-hoc analysis showed that the social interaction between participant and confederate during the interval did not modulate personal space in ASD children (before = 2826 mm, after = 2874 mm, $p = .95$), whereas it modulated personal space in TD children, reducing the distance after (1461 mm), as compared to before (1730 mm), the social interaction ($p < .003$; see Fig. 20). Moreover, interpersonal distance was larger in ASD children than TD children both before and after social interaction ($p < .0002$ for both comparisons).

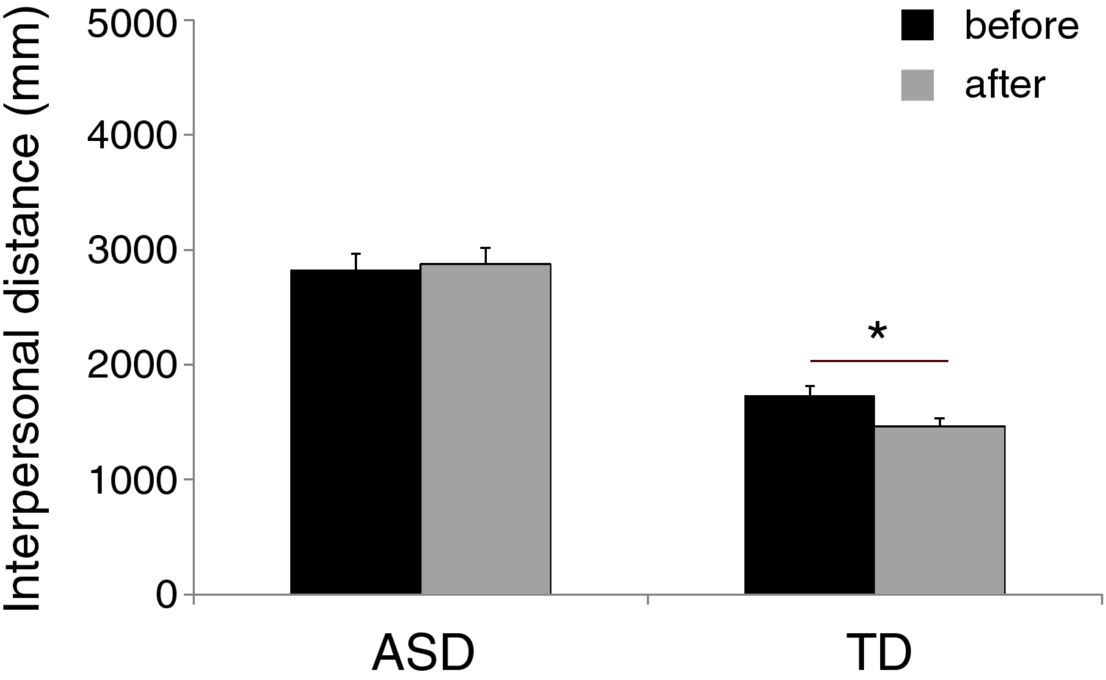

Figure 20: Mean preferred distance from the confederate before and after a brief social interaction in children with typical development (TD) and children with Autism Spectrum Disorder (ASD). Asterisk indicates significant comparison ($p < 0.05$). Error bars denote s.e.m.

For completeness, we also run an additional ANOVA that included all the variables, and specifically group (ASD and TD) as a between-subject variable, and person moving (confederate and participant), starting position (close and far), and session (before and after social-interaction) as within-subject variables. As before, this second ANOVA demonstrated that the variable group [$F(1,36) = 14.84$; $p < .0001$; $\eta_p^2 = .292$], session [$F(1,36) = 3.80$; $p = .06$; $\eta_p^2 = .096$], and the group X session interaction [$F(1,36) = 7.73$; $p < .01$; $\eta_p^2 = .177$] were significant. We also found that the interaction between group, person moving, and starting-position was significant [$F(1,36) = 8.24$; $p < .006$; $\eta_p^2 = .186$]. Post-hoc analysis of this three-way interaction showed that, in ASD children, the interpersonal distance was significantly larger when the participant moved away from (3376 mm) rather than toward (2413 mm) the confederate ($p < .0001$). By contrast, this difference was not significant when the confederate moved away or approached the ASD participant (when starting close = 2630 mm; when starting far = 2979 mm, $p = .26$).

In TD children, this difference was not significant neither when the participant moved away or approached the confederate (when starting close = 1781 mm; when starting far = 1417 mm), nor when the confederate moved away or approached the participant (close starting position = 1.493 mm; far starting position = 1.688 mm; all $p > .05$). Note, however, that the interpersonal distance remained larger in ASD children than in TD children, regardless of person moving (confederate or participant), or starting position (close or far) ($p < .001$ in all comparison).

The lack of modulation of interpersonal distance may depend on poor or reduced social interaction with the confederate in ASD compared to TD children, and not on a deficit of personal space regulation. To explore this possibility, an index of social interaction, ranging form 0 to 3, was computed for each participant by averaging together the scores assigned by the experimenter to three behaviors observed during the child-confederate interaction (see Method). Although the social interaction index of the ASD group was somewhat lower than control group (2 and 2.3, in ASD and TD children, respectively), the analysis did not reveal a significant main effect of group, [$F(1,36) = 0.71$; $p < .4$]. Nevertheless, to ensure that our findings were not driven by subtle group differences in the amount of social interaction with confederate, the main ANOVA was repeated with the social interaction index as covariate. The previously significant group X session interaction remained significant, [$F(1,35) = 6.8$; $p < .01$; $\eta_p^2 = .16$]. As a further control analysis, we ranked ASD participants based on the index of social interaction and divided participants into good-interaction (ASDgi, n = 7) and poor-interaction (ASDpi, n = 8) groups thorough a median split. Finally, an ANOVA was performed on the measure of the personal space difference (interpersonal distance after interaction – before interaction), with group (ASDpi, ASDgi) as between-subject variable. The variable group was not significant [$F(1,13) = 1.01$; $p = 0.33$]. Overall, these data suggest that the lack of modulation of interpersonal distance were not due to reduced social interaction with the confederate during the interval in ASD compared to TD children.

Control experiment

Our data suggest that social interaction influences personal space in TD and not in ASD children. However, to ensure that this effect in TD children was not simply due to the time interval between the first and the second measure, or to a familiarization with the task or with the confederate, rather than to the effect of social interaction between the confederate and the subject, an additional control group of 23 age-matched TD children (TD-C) was tested.

The TD-C group was submitted to the same procedure previously described with the only difference that during the time interval participant and confederate did not read a book together, but the subject read a book by himself, while the confederate was busy doing something else in the same room. If the reduction of the personal distance observed in TD children was due to time interval *per se*, then it should be found both in the TD and in the TD-C group. By contrast, if the reduction of the interpersonal distance in TD was due to the interaction between confederate and subject during the time interval, then it should be found only in TD but not in TD-C group. TD-C children and TD were compared by an ANOVA with group (with and without social interaction) as a between-subject variable, and with session (before and after time-interval), as a within-subject variable.

The variable session was significant [$F(1,44) = 11.49$; $p < .001$; $\eta_p^2 = .21$], showing that interpersonal distance was smaller after (1592 mm) than before (1733 mm) the time interval. In line with the hypothesis, the group X session interaction was significant [$F(1,44) = 9.48$; $p < .001$; $\eta_p^2 = .18$]. Post-hoc comparisons (Tukey for equal N) showed a reduction of personal space in the group with social interaction (TD group, before = 1730 mm, after =1460 mm, $p < .0002$), but not in the group without social interaction (TD-C group, before = 1735 mm, after = 1722 mm, $p = .97$). Moreover, the personal space was significantly different between the two groups after ($p < .0001$) but not before ($p = .92$) time interval (Fig. 21).

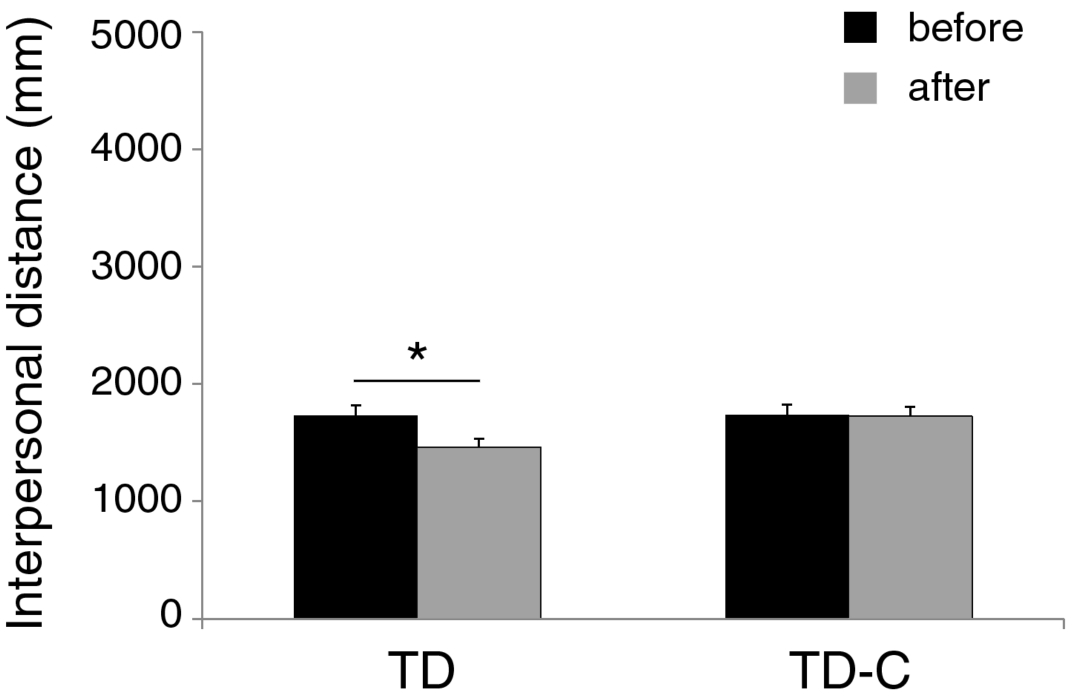

Figure 21: Mean preferred distance from the confederate in two groups of children with typical development before and after a time interval, during which the confederate interacted (TD group), or not (TD-C group), with the participant. Asterisk indicates significant comparison ($p < 0.05$). Error bars denote s.e.m.

9.4 Discussion

In this study, we investigated personal space regulation in children with typical development (TD) and in children with high-functioning autism, before and after a brief interaction with an unfamiliar adult confederate. While previous anecdotal observations have suggested that ASD children have some difficulties in appropriately regulating one's distance from other people during social interactions, the empirical evidence supporting this claim has been conspicuously lacking. Here, a stop-distance procedure, previously described in Chapter 5, was used to measure the interpersonal space in ASD and TD children. We provide new evidence that interpersonal space regulation is impaired in high-functioning ASD children. Specifically, we found that ASD children are less tolerant of close proximity to an unfamiliar adult and prefer farther interpersonal distance compared to TD children. Moreover, results showed that interpersonal distance is larger in autistic children when they *move away* from, rather than toward, the confederate, suggesting that these children feel more uncomfortable and react (i.e., step away) more strongly following personal space violations (i.e. close starting position) than TD children.

A critical finding of the present study concerns the modulation of a brief social interaction on personal space regulation. As described in Chapter 5, previous studies focused on the effects on personal space of long-lasting interaction, such as infant-caregiver attachment (Cassidy et al. 1994; Bar-Haim et al. 2002) and familiarity between interacting partners (Watson, 1970; Cristani et al. 2011). Here, we report that a transitory social interaction with an unknown adult results in a rapid, on-line adjustment of the interpersonal distance in TD children, indicating that personal space regulation exhibits dynamic properties and higher flexibility that may facilitate social interactions and communication in normal individuals. Such interpersonal distance changes were not simply due to the effects of time interval between the first and the second interpersonal distance measurement, or to participants' familiarization with the stop-distance procedure or the adult confederate, as demonstrated by the results of a control experiment. Indeed, when during the interval between first and second stop-distance procedure normally developing children read a book alone without interacting with the confederate, no change in the size of personal space was observed. Critically, ASD individuals failed to display changes of social distance in response to a brief social interaction, suggesting a marked inflexibility of personal space in this condition.

In the past few years, a distinction has arisen between flexibility and permeability of personal space. Permeability refers to the ease with which personal space is penetrated or intruded upon, irrespective of its current size or shape, while flexibility refers to situationally induced changes in the size and shape of personal space (Sommer, 1969; Little, 1965). Our data suggest that, in autistic children, personal space is altered both in permeability, since it is larger in ASD then in TD children, and in flexibility, since it is not reduced by a social interaction with the confederate. We propose that the impairment in flexibility and permeability of personal space in ASD children reflects overarousal and enhanced fear induced by others intruding their social space.

A previous lesion and neuroimaging study in humans suggested that the amygdala plays a key role in underpinning personal space regulation (Kennedy et al. 2009), either by triggering innate emotional reactions in response to personal space violations, or learning the association between close distance and aversive outcomes. Linking these previous results to the present findings, we suggest that reduced tolerance of physical closeness with a stranger and lack of flexibility of personal space in ASD children may result from impairment of an amygdala-based mechanism. This hypothesis is supported by several data. Recent studies indicate that the amygdala is enlarged in children with autism (Schumann et al. 2009) and could contribute to the abnormalities of fear and anxiety that appear to be a common feature of autism. An excessively functioning amygdala may account for the increased autonomic responses in autistic children (e.g., Hirstein et al. 2001; Amaral et al. 2003; Schulkin, 2006, Corbett et al. 2006, but see also Bernier et al. 2005; Ben Shalom et al. 2006; Bölte et al. 2008 for different results) leading to withdrawal from social interactions (Corbett et al. 2006). Moreover, functional imaging in older children and adults with autism provide evidence of an abnormal pattern of amygdala activation in response to social stimuli (Swartz et al 2011; Dalton et al. 2005; Kleinhans et al. 2009; Weng et al. 2011). This is further confirmed by findings in an animal model of autism, in which rats exposed to valproic acid exhibit autism-like symptoms associated with enhanced anxiety and fear processing in the amygdale (Markram et al. 2008). Finally, recent evidence indicates that oxytocin, a neuropeptide known to reduce activity in the amygdala, thereby resulting in decreased fear responses (Kirsch et al. 2005), can modulate social distance in interacting partners (Scheele et al. 2012), and improve social interactions in ASD individuals (Andari et al. 2010).

Several prior observations are in keeping with the present findings. Employing the naturalistic observation method, Rogers and Fine (Rogers, 1977) compared the personal distance behaviors of an autistic and asymbiotic psychotic child during play therapy. The autistic child maintained a greater personal distance from the therapist compared to the symbiotic child. Moreover, Parson and colleagues (Parsons et al. 2004) compared the ability to understand and use some virtual environments, such as a Virtual Cafè, in a social congruent way, in ASD participants of 13-18 years of age and in age-matched control participants. The results showed that the majority of autistic subjects seemed to have a basic understanding of the virtual environment as a representation of reality, but when participant's ability relative to some social norms was judged by naïve rates, autistics were more likely to be judged as bumping into, or walking between, other people in the virtual scene, compared to their paired matches. The authors suggested that understanding personal space is impaired in autism. More recently, Kennedy and colleagues (Kennedy et al. 2010), analyzing parent- and teacher-report questionnaire ratings, concluded that ASDs children are less aware of social distance than their unaffected siblings, showing significantly higher levels of interpersonal distance violations than controls. Overall, these previous findings are consistent with the present results, supporting the general conclusion that interpersonal distance regulation is impaired in autism. Still, results of increased violations of personal space in autistic individuals reported both by Parsons et al. (2004) and Kennedy et al. (2010) studies are not in accordance with behavioral patterns observed in the present study, in which ASD children exhibit large interpersonal distance preference. However, several methodological differences between previous studies and the present one may account for the seemingly discrepant results. For instance, Parson and colleagues (2004) study differed from ours in that they used virtual figures and scenes to probe personal space. It is possible that participants in the ASD group bumped into the people in the virtual environment because they have difficulty understanding the virtual environment as representations of reality. Likewise, Kennedy and colleagues (2010) analyzed questionnaire-based data and did not provide a direct and controlled assessment of personal space in ASD children. Thus, interpersonal distance measures and paradigms remain to be systematically compared in autism.

Two potential limitations of this study deserve mention. First, our suggestion that increased fear and hyperarousal following personal space violations would result in larger interpersonal boundaries in ASD compared to TD children remains speculative. Physiological reactions, such as skin conductance responses and heart rate, and subjective ratings of experience may provide potential measures of affect. While the present behavioural data support the claim that personal space regulation is impaired in autism, they cannot directly ascertain the role of affective processes in driving the difficulty with social space in ASD children. Second, as interpersonal distance in the present study was assessed in a controlled experimental setting, we should be cautious about generalizing the findings to other, more ecological settings. Discrepancy between the current and previous findings (Kennedy et al. 2010; Parson et al. 2004) may reflect differences across various settings.

To conclude, discomfort and fear of physical closeness with a social partner may be one of the most salient factors in regulating interpersonal distance during social interaction (Argyle et al. 1965). Here, we report that ASD children maintain a farther and rigid distance from unfamiliar others than do TD individuals, suggesting that they are less tolerant and more reactive to violations of personal space. We suggest that these effects could arise in part through enhanced, rather than reduced, amygdala functioning in childhood autism spectrum disorders. A better characterization of the mechanisms involved in abnormal personal space regulation in ASD children may lead to an improved understanding of how ASD develops and how to intervene to improve social functioning.

CHAPTER 10. GENERAL DISCUSSION

The main aim of the present dissertation was to study ecological and interpersonal aspects of self-awareness. Regarding the ecological self, I investigated the mechanism through which we distinguish between self and other people's body image. As far as the interpersonal self is concerned, I investigated the mechanism through which we regulate the permeability and flexibility of our own personal space.

In Chapter 6 7 and 8 the development and the degeneration of self body recognition during the life span was addressed. In Chapters 6 and 7 a matching-to sample task and a variation of the same where used to answer the question if the implicit recognition of own body image is different or similar in healthy and autistic children.

Specifically in Chapter 6 I have investigate whether the implicit self body-parts and self-face-parts recognition is present in autistic as well as in healthy children. Results show that autistic and healthy children's performance in the visual matching task was better with self than with others' body and face-parts, suggesting that they are able to implicitly distinguish self and others' stimuli and to take an advantage in processing self-compared to others' stimuli.

Subsequently, in Chapter 7, I used a variation of the visual-matching task , wit the aim of assessing whether the influence of emotional body postures on implicit bodily self-processing is similar or different in autistic and healthy children. Results showed that, both in healthy and autistic children, the self-advantage is modulated by emotional body postures when they are endogenously generated. For example, we better implicitly recognize our own bodily postures when we endogenously express happiness and neutral state than when we express fearful state. The different emotions have different roles for our survival and it is possible that for this reason they differently modulate the implicit self-other recognition.

Furthermore, the result of the experiments described in Chapter 6 and 7 support the theory that there are different ''levels'' of self and that not all of these levels are impaired in autism, being the bodily-self spared in (high functioning) autistic children. Thus, bodily self/other recognition and its modulations by emotional body postures are part of the low-level aspect of the self-awareness that seems preserved in subjects with autism spectrum disorders.

Considering that the implicit bodily self/other recognition and its modulations by emotional body postures are preserved in subjects with autism spectrum disorders, is possible that this kind of bodily recognition is a low-level aspect of the self-awareness with a crucial role for the survival of social species. Other components of the self-concept as for example the mental judgment (Williams, 2010) or the self referential understanding of emotions (Hobson. et al. 2006; Hill, Berthoz, & Frith, 2004) are considered mental or high level components of self-awareness and can be impaired in this pathological population. It is possible to hypothesize that the low and high level component of the self-awareness share some common cognitive mechanisms and linked cerebral networks. For this reason the use of preserved low level component of the self awareness could be adopted to rehabilitate the impaired high level component.

In Chapter 8 we tested the implicit and explicit self body and face parts recognition in patients with Parkinson’s disease. I asked if the motor and proprioceptive deficits of these patients affect the sensorimotor representation of one’s own body. As expected, in the implicit task patients with Parkinson’s disease were less accurate with self than with others’ face and body parts showing a self-disadvantage effect, whereas this effect wasn’t present in the explicit task. These data contribute to the current debate on the mechanisms of the implicit recognition of own body. In line with the behavioral and neuroimaging studies (Frassinetti etal., 2011; Ferri et al., 2011; Ferri et al., 2012) the results of the present experiments are a further proof that the implicit body self-advantage relies upon the integration of visual information with other modalities, having the sensorimotor body representation the crucial role.

A possible interpretation of the advantage in processing self compared to others’ bodily image in our implicit task is that this effect is due to an increased familiarity with self stimuli (relative to unfamiliar others). This interpretation can be excluded for at least two reasons. The first one is that healthy children did not show any facilitation in discriminating their mother’s body/face parts versus another woman’s stimuli (Frassinetti at al, 2012). Second, if the self-advantage is due to a mere visual–perceptual facilitation, it should be independent of the implicit or explicit request. Since, in the study described in Chapter 8, as well as in previous studies (Frassinetti et al. 2011; Ferri et al. 2012) the self-advantage was not found when an explicit recognition of one’s own body was required, I have excluded that the body self-advantage relies upon a mere visual representation of one’s own body. With the experiment described in Chapter 8 we have obtained a further proof of the hypothesis that the body self advantage is the expression of an implicit access to own body image, based mainly on the sensorimotor representation of one’s own body. ,The sensorimotor hypothesis is that when subjects observed stimuli depicting their own body image, the displayed stimulus perfectly matches with the observer’s body sensorimotor representation (Ferri et al., 2011) and the observer is advantaged in performing the task.

Taken togetherthe results of the experiments described in Chapter 6 ,7 and 8 showed that in autistic children but not in patients with Parkinson’s disease the implicit access to own body image and its underling sensorimotor representation are spared.

In the last part of my dissertation, ,I took in consideration another aspect of the self-concept, that is the interpersonal regulation of our spatial behavior. In Chapter 9 a stop-distance paradigm was used in healthy and autistic children to derive measures of their personal space before and after an interaction with an unknown person. The results showed that before the interaction autistic children are less tolerant of close proximity to an unfamiliar adult and prefer farther interpersonal distance compared to healthy children. Moreover autistic children failed to display changes of social distance in response to a brief social interaction. Thus, these results showed that the autistic personal space is less permeable and less flexible than that of healthy children.

These findings, contribute to the current debate about the autistic social deficit and their underlying cerebral networks, getting further light about an interpersonal aspect of the self, less studied in this pathological population.

The impairment of the personal space in autistic children is probably cause by increased fear and hyperarousal following personal space violations and by the underling dysfunctions of the cerebral system.

In conclusion the dissertation offers a journey from the development to the degeneration of the mechanisms mediating the recognition of own body image and the regulation of own personal space, passing through the investigation of implicit and explicit access to different aspect of the self-concept. The exposed results in the present dissertation contribute to advance the basic knowledge and provide new instruments to take advantage of the residual abilities to rehabilitate the deficits.

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