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CODING ONE'S OWN BODY: AN INVESTIGATION OF NEURAL, COGNITIVE AND PERSONALITY DETERMINANTS OF SELF-RECOGNITION

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“If you have an apple and
I have an apple and we
exchange these apples
then you and I will still
each have one apple.

But if you have an idea
and I have an idea and
we exchange these ideas,
then each of us will have
two ideas.”

George Bernard Shaw

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Abstract

In the last decade, research on visual perception of the human body remarkably increased, especially following the discovery of the Extrastriate Body Area, an occipito-temporal region selectively involved in body-processing (Downing et al., 2001). However, an intriguing issue is to what extent a specific kind of body representation in the brain is devoted to the knowledge of the bodily self. Research on the visual recognition of the self-body, in particular, is still scarce, especially if compared to the extensive body of research devoted to the recognition of self-face. In the present thesis, a systematic investigation of unexplored aspects of self-body and self-face recognition is presented, with particular focus on the one side, on the possible neural correlates, and on the other, on the variables of personality that may play a role in these cognitive functions.

Recent work in neuroscience indicates a superiority in the visual processing of one's own than other people's body-parts (Frassinetti et al, 2008). Specifically, subjects show higher accuracy when asked to match pictures depicting their own compared to unfamiliar body-parts, the so-called "self advantage". It remains to be established, however, which cortical regions are involved in this phenomenon. To this aim, in experiments reported in Chapter 2 the causal role of cortical regions specifically involved in body-parts processing (i.e., the right Extrastriate Body Area) and in self-face recognition (i.e., the right Inferior Parietal Lobule) was investigated by means of Transcranial Magnetic Stimulation. The results did not allow definitive conclusions regarding the role of the cortical areas under investigation for self body-parts recognition; nonetheless, behavioural data seem to suggest that the self-recognition ability is not as universal as generally believed. In particular, the strength of the "self advantage" showed a large degree of variability across participants.

Therefore, the contribution presented in Chapter 3 was aimed at finding some possible determinants that modulate the self-body advantage. Namely, it was examined whether the self-body recognition ability is modulated by implicit and explicit self-esteem, relying upon studies linking the physical self and self-esteem. Two studies were conducted using paradigms assessing covert (Experiment 3) or overt (Experiment 4) self-body recognition (i.e., the matching-to-sample used in previous studies and a new-developed paradigm of overt recognition). Results revealed that the self-body recognition ability is qualified by individual differences in self-esteem, and especially implicit self-esteem, measured with the Implicit Association Test, a widely used procedure for measuring strengths of automatic associations between concepts (Greenwald et al., 1998). Moreover, considering the two studies together, only the implicit self-esteem showed incremental validity in predicting the ability to recognize self body-parts. The results are discussed in terms of the role of individual differences such as implicit self-esteem for cognitive functions such as self-body recognition.

Finally, a study (Experiment 5) was conducted to better address whether self-esteem and other personality traits with strong interpersonal value (i.e., empathy) also correlate with the strength and stability of self-representation. Self-face representation was recently found to be less stable than believed in the past (Tsakiris, 2008). Our findings reveal that higher level of implicit self-esteem correspond to lower susceptibility to the "enfacement" illusion, measured in terms of incorporation of other people's facial features in the self-face representation following synchronous visuo-tactile stimulation in a mirror-like setting. Moreover, the Perspective Taking component of empathy was found to correlate with the introspective experience of the illusion.

All in all, the present contribution bridges recent research in the cognitive neurosciences and social cognition and points toward a complex interplay among cognitive and personality factors in the domain of self-recognition.

Key-words: self-body recognition, TMS, self-esteem, Implicit Association Test, self-face recognition, visuo-tactile stimulation, "enfacement" illusion.

CHAPTER 1

INTRODUCTION

Self-body recognition is an important human ability that refers to the recognition of one's own body and depends on both the representation of one's own physical appearance and the ability to regard one's own identity as separate from that of other individuals. This cognitive ability is so fundamental that is commonly considered as an indicator of self-awareness (e.g., Gallup, 1970; Amsterdam, 1972).

The present work focuses on aspects of visual self-recognition that have been relatively neglected in the previous literature. In particular, the focus will be on the recognition of self body-parts other than the face. Since the face represents perhaps the most distinctive component of our identity, most work investigated the human ability of self-face visual recognition, whereas there is a lack of studies concerning self-body and body-parts. There is also a considerable difference in the way self-face and self-body visual recognition abilities are usually studied. In facts self-body-parts recognition is considered to rely upon motor and multisensory cues and therefore it is often investigated using videos and dynamic stimuli. This approach is motivated by the idea that corporeal clues other than the face become more important for recognition from distance (i.e., when facial features are less distinguishable). Differently, self-face recognition is thought to entail the retrieval of self-face representations stored in memory and based on visual-features, so that research is mainly based on the evaluation of static pictures. Only more rarely, self-body visual recognition is specifically investigated measuring the accuracy in discriminating static stimuli depicting one's own *versus* other people's body. Usually, results have shown that performance is not as accurate with bodies as with faces, thus revealing a higher degree of uncertainty in participants regarding the recognition of their own body-parts other than the face (e.g., Daury, Brooks, & Brédart, 2009).

Recently, Frassinetti and colleagues developed an interesting paradigm that allowed indirect testing of several aspects of self body-parts visual recognition (Frassinetti, Maini, Romualdi, Galante, & Avanzi, 2008). This new paradigm was devised to indirectly test the self-body processing mechanisms by asking participants to visually match pictures rather than directly recognizing whether pictures depicted their own or other people's body. The difference between the accuracy in response to self and to other pictures was considered an indirect measure of the self-recognition. Using their matching-to-sample paradigm, Frassinetti and collaborators (2008) demonstrated that the recognition of self body-parts is dissociated from the recognition of other people's body-parts since this ability can be selectively impaired following brain damage of the right hemisphere. Indeed, while healthy subjects and left brain damaged patients showed the so-called "self-advantage" (i.e., better accuracy in processing pictures depicting one's own compared to other people's body-parts), the self-advantage was lacking in right brain damaged patients. Moreover, in a further study initial evidence of a modular representation of the physical self was provided, in that a simple dissociation was revealed: brain-damaged patients were impaired in self-body but not self-face recognition, as indicated by the respective absence/presence of the self advantage (Frassinetti, Maini, Benassi, Avanzi, Cantagallo et al., 2010).

Therefore, first the matching-to-sample task can be considered as a valuable method for investigating the ability of self-body visual recognition, analogously to similar paradigms used in the field of the self-face processing (e.g., judging whether a face is tilted to the left or to the right; e.g., Sugiura, Kawashima, Nakamura, Okada, Kato et al., 2000; Ma & Han, 2010). Furthermore, self-body recognition proved to be a partially similar but independent ability with respect to the self-face recognition. Finally, self-body recognition likely engages specific brain areas within the right hemisphere, as revealed by the selective impairment showed by right brain damaged patients.

The predominant involvement of the right hemisphere in the processes related to self-body was already well known: for instance, patients with right frontoparietal damage often suffer from asomatognosia, the unawareness of ownership and lack of recognition of part of one's own body. Somatoparaphrenia, a disorder characterised by delusional beliefs concerning the contralesional side of the body, that may be misidentified as belonging to another person, often a relative of the patient, has been mainly reported following right hemisphere damage, with few exceptions (Vallar & Ronchi, 2009). Moreover, a predominantly right sided network of fronto-parietal cortical regions appears to be associated with the visual recognition of the self-face (see Devue and Brédart, 2010 for recent review).

For the body, however, precise data relative to the self-recognition ability are still extremely scarce. Indeed, despite a robust evidence exists regarding the Extrastriate Body Area (EBA), an occipito-temporal area selectively responsive to body and body-parts images (Downing, Jiang, Shuman, & Kanwisher, 2001), the interest towards self-body visual processing is recent among the neuroscientific community. Consequently, the debate is still rather hot, for instance regarding whether the EBA is responsive to both self and other body or instead it distinguishes between them (Hodzic, Muckli, Stirn, & Singer, 2009; Myers & Sowden, 2008).

In an attempt to cast light on this debate and to examine whether the right Inferior Parietal Lobule (IPL) is implied in the self-body processing to the same extent than in the self-face processing -as demonstrated by previous work (see Uddin, Molnar-Szakacs, Zaidel, & Iacoboni, 2006)- two Transcranial Magnetic Stimulation (TMS) studies were performed, with the aim of examining the causal role that these specific cortical areas within the right hemisphere may play in the processing of one's own compared to other people's body-parts. The studies will be presented in detail in Chapter 2, after a review of the recent literature relative to the self-face and self-body processing and recognition, particularly concerning the neural correlates.

The participants' right IPL and right EBA were stimulated with TMS before subjects completed the matching-to-sample task developed by Frassinetti and colleagues (2008). Critically, to our knowledge no study directly investigated the involvement of these two cortical regions in a task of self body-parts recognition. Indeed, the right IPL was found to be causally involved in self-face recognition (Uddin et al., 2006) but no direct tests on self-body recognition were conducted. As far as the EBA is concerned, Urgesi and colleagues demonstrated in a TMS study that this area is sensitive to the body-parts identity, but self stimuli were not present in that experimental sample (Urgesi, Candidi, Ionta, & Aglioti, 2007). Instead, the extrastriate body area seems to be related to the processing of non-self stimuli: data obtained by Chan and colleagues in their functional Magnetic Resonance Imaging (fMRI) study indirectly suggested that this cortical region is possibly tuned to the processing of others, since it is more responsive to pictures taken in allocentric than egocentric perspective (Chan, Peelen, & Downing, 2004).

Our hypothesis was that the self-advantage would be decreased depending on the causal involvement of the areas that were inhibited by the TMS. Therefore, we predicted a critical decrease of the self-advantage following the stimulation of the right IPL, while either a general worsening of subjects' performance (with both self and other stimuli) or a selective impairment with other people's body-parts was expected after TMS application over the right EBA.

Unexpectedly however, the self-advantage did not diminish following TMS administration. Since we could not exclude that the TMS protocol used was not effective in modulating subjects' performance, results did not allow us to draw conclusions regarding the role of the regions of interest in the ability under investigation.

Importantly, the matching-to-sample task proved to be a valid paradigm for investigating self-body recognition. However, we noticed that most but not all participants showed an advantage for images depicting self body-parts, and that self-body recognition turned out to be a rather variable ability across individuals. This variability became the focus of the second part of the present thesis. This subject is *per se* a novelty in the framework of cognitive neuroscience, that is usually tuned to the average performance of a group of individuals; nevertheless, analyzing the individual variability rather than the average performance can allow deeper understanding of the processes under investigation (e.g., Perugini, Richetin, & Zogmaister, 2010).

Starting from the assumption that the physical-self and the psychological-self are aspects of the self-concept, the contribution presented in Chapter 3 aimed at investigating whether self-body recognition ability is modulated by implicit and explicit self-esteem. Experiments 3 and 4 were based upon findings gathered in patients with Anorexia Nervosa (AN), Bulimia Nervosa (BN) and Body Dysmorphic Disorder (BDD), as well as preliminary data in healthy individuals, that linked physical self, self-recognition and self-esteem, broadly defined -according to Rosenberg (1965)- as a stable sense of personal worth or worthiness. In particular, the undue influence that shape and weight exert on self-esteem is a core characteristic of patients with AN and BN and it has become part of these eating disorders nosology. Rosen (1990) pointed out that the overestimation of the body shape and weight found in AN patients involves not only affective components but also perceptual deficits. Accordingly, two neuroimaging studies revealed that patients with eating disorders might have functional abnormalities in brain systems concerned with self body-image processing, while they did not show anomalies in the processing of non-self images (Uher, Murphy, Friederich, Dalgleish, Brammer et al., 2005; Sachdev, Mondraty, Wen, & Gulliford, 2008). Even more centrally to our concern, Ma and Han recently showed that the subjects' self-advantage measured in terms of latency in an implicit face-recognition task (i.e., discriminating head orientations of self *versus* familiar face) was mediated by implicit self-esteem (Ma & Han, 2010). However, to our knowledge no study so far investigated the role of explicit and implicit self-esteem in the recognition of the self-body.

The distinction between explicit and implicit self-esteem is relatively recent and follows the development of dual-process models (e.g., Strack & Deutsch, 2004). Implicit self-esteem can be defined as "evaluations that are cognitively associated with the self and activated in response to self-relevant stimuli, but which are not necessarily endorsed as valid reflections of how one feels about oneself" (Zeigler-Hill & Jordan, 2010). Implicit self-esteem demonstrated to have predictive validity for various kinds of behaviour and, critically, for self-face recognition (Ma & Han, 2010). Moreover, since the two forms of self-esteem often showed to have different predictive validity relatively to different behaviours, both were used in the series of experiments presented in Chapter 3 and 4. As a measure of implicit self-esteem, the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) was used, since it is the most widely used measure of implicit attitudes and possesses good psychometric properties.

Results of Experiment 3 confirmed that individuals' self-esteem partially determines their ability to recognize their own body-parts using the matching-to-sample paradigm. Therefore, the extent to which different tasks -that assess self-body recognition in indirect *versus* direct way- are equally efficient as measures of self-recognition and whether the influence of self-esteem can be generalized across tasks, was further addressed in Experiment 4. Overall, Experiments 3 and 4 seem to suggest that self body-parts recognition is not an ability that is universal across people, but it is qualified by individual differences in self-esteem, especially implicit. This finding expands previous literature by demonstrating that body-image and self-esteem are related not only in the psychopathological domain (e.g., Buhlmann, Teachman, Naumann, Fehlinger, & Rief, 2009; Cockerham, Stopa, Bell, & Gregg, 2009), but also in the healthy individuals. Moreover, data are discussed in parallel with those of Ma and Han (2010) relative to the self-face. Overall, the present work bridges recent research in the field of cognitive neurosciences and social cognition.

As mentioned above, recognition of one's own face and body are traditionally investigated in different ways. A recent work of Tsakiris (2008) questioned these separate approaches and investigated whether multisensory clues may have a role even in self-face perception and recognition. Capitalising on a now affirmed line of research, that of the Rubber Hand Illusion (RHI; Botvinick & Cohen, 1998), this author showed that the self-face representation is less stable than believed in the past. The rubber hand illusion refers to an experimental situation in which subjects view a rubber hand opportunely placed in front of them being stroked in synchrony with their own real hand, hidden from view. Participants may experience as if the dummy hand is their own real hand, and as if the touches they feel are coming from the rubber hand. Simulating a mirror-like situation in which a face (consisting in a 50% self - 50% other morphed face) was presented on the screen in front of the participant, Tsakiris showed that after being stimulated on their cheek while observing the face being stimulated in synchrony, participants assimilated features of the other's face in the mental representation of their own face (Tsakiris, 2008).

The illusion on the face was also replicated (e.g., Sforza, Bufalari, Haggard, & Aglioti, 2010) by a different research group. Nevertheless insights on this kind of illusion are scarce. In particular, the personality variables that might play an influence on the susceptibility to the illusory experience have not been investigated so far. This was the aim of the study presented in Chapter 4. In this experiment, the above described illusion was correlated with measures of implicit and explicit self-esteem, narcissism and empathy. These personality measures were assessed, since they, and in particular empathy, possess an interpersonal nature. If the self-face representation is not as stable as previously thought but rather malleable, then it is presumable that variability in characteristics known to play a role in self-face and self-body recognition (as evidenced by Ma & Han, 2010 and by the results obtained in Experiments 3 and 4 in the present thesis) may also affect the extent to which people are susceptible to this illusion (i.e., the degree to which they update their self-face representation following the synchronous visuo-tactile stimulation). Data are presented and discussed in Chapter 4.

To summarize, the self-body perception is an intriguing field of research for several reasons, not last that of being extremely important for our sense of identity and challenging to be studied, given that, as pointed out by Merleau-Ponty (1945), the body is an object that never leaves us. Our attempt was that of deepen the study of relatively scarcely investigated aspects of self recognition. In particular we focused upon self-body recognition using static images and on self-face recognition in a dynamic and multisensory approach. Furthermore, the aim of the present research was to understand the role of individual differences in self-esteem and psychological traits more tuned to a social dimension (i.e., empathy) for self-recognition. The peculiarity of the present work is that of joining insights from the cognitive neurosciences and social cognition, with the aim of contributing to the advance of both these scientific areas.

CHAPTER 2

Self body-parts visual recognition: two TMS studies

2.1 INTRODUCTION

In this chapter, results of two experiments will be presented. Experiments investigated the ability to visually recognize self body-parts in healthy adults and the effect of the transcranial magnetic stimulation applied to critical cortical regions on this ability. Though we used pictures of body-parts as stimuli in this research, in the initial part of the introduction data on self-face recognition will be summarized. In fact, due to the relative lack of studies that have investigated the self-body processing in healthy people using neuroimaging, electrophysiology or TMS, the choice of the critical sites and protocol of stimulation was mainly determined on the basis of work regarding self-face. Therefore, paragraph 2.1.2 will focus particularly on the neural substrates of self-face recognition, a topic that will be further discussed in the introduction to Chapter 4. Subsequently, another paragraph will be more specifically dedicated to the body, particularly to the perception of one's own body. Finally, a glance at TMS technique in general and at its specificity in this work will conclude the introductive part.

2.1.1 Faces: An overview of neural correlates

Faces represent undoubtedly a special category of objects for human beings and are of essential importance for human social life. They provide valuable information about the identity, age, health, gaze and expression of a person, and also about his/her emotions and intentions. Therefore, it is not surprising that faces are processed in a specialized cerebral extrastriate area in the fusiform gyrus, named Fusiform Face Area (FFA), as firstly shown by Kanwisher and colleagues (Kanwisher, McDermott, & Chun, 1997). Another face-selective area was subsequently found in the occipital cortex (the Occipital Face Area or OFA; Gauthier, Tarr, Moylan, Skudlarski, Gore et al., 2000). Recent face-processing models assume highly interconnected neural structures between different occipital, temporal and frontal brain areas with several feedback loops (see for example the model proposed by Haxby, Hoffman, & Gobbini in 2000, briefly presented in paragraph 2.1.4.2). As a result of this specialized network, humans are extremely efficient and fast at recognizing human faces.

Electrophysiological studies have shown that an Event Related Potential (ERP) component exists that is specifically related to the visual processing of faces: the N170 (Bentin, Allison, Puce, Pérez, & McCarthy, 1996), a negative component that peaks about 170 milliseconds (ms) after the stimulus presentation, with a maximum amplitude at occipito-temporal electrodes. Since N170 is insensitive to facial features such as gender, race and familiarity, it has been proposed as the correlate of late stages of structural coding of faces, in particular to the processing of facial features and their spatial relations. Tough the conclusion of a selectivity for faces in the N170 component has been questioned by some authors that controlled for inter-stimulus perceptual variance (Thierry, Martin, Downing, & Pegna, 2007), most neuroscientists remain convinced that N170 is critically related to face perception. Source localization indicates the fusiform gyrus as the source of very precocious processing and a more spread parieto-temporo-occipital network as correlate of the N170. Face recognition occurs 250 ms after stimulus presentation, as shown by another component -the P250- that originates in the ventral temporal cortex (e.g. Schweinberger, Pickering, Jentzsch, Burton, & Kauffmann, 2002) and is sensitive to familiarity.

A selective deficit that involves face recognition also exists. Prosopoagnosia is defined as an acquired or congenital deficit affecting visual recognition of faces in the presence of a relatively normal object recognition, and in the absence of primary deficits in visual perception or other cognitive functions, which usually follows occipito-temporal damage, often bilateral (Righart & de Gelder, 2007). Occasionally, also a selective deficit in mirror recognition of one's own face has been observed, for example -as a symptom of focal onset dementia- subjects may show the so called "mirror sign": they delusionally misidentify their own reflected image and insist that it is someone else's face (Breen, Caine, & Colthearth, 2001).

2.1.2 Self face: A special stimulus

One's own face can be regarded as a unique face among faces, at least given the fact that, since our eyes lay on it, we can only see our own face using a reflective surface. Self face recognition has appealed researchers from a long time: in fact, to operate effectively in the world, people must be able to distinguish "me" from "not me". During development, the ability to recognize oneself in front of a mirror typically emerged around the age of two years (Amsterdam, 1972). It has been suggested that recognition of self-face is an indicator of higher-order self-awareness and involves neural substrates beyond those involved in general face recognition (e.g., Keenan, Nelson, O'Connor, & Pascual-Leone, 2001).

Strong evidence for the effective processing of the self-face came from a study of Tong and Nakayama (1999). These authors used a visual search paradigm in which either one's own face or an unfamiliar target face were presented among distractors and showed that processing was consistently faster for self-face, irrespective of whether the face appeared in front, three quarter or profile view, upright or upside-down, with or without hair; moreover, the self-face was found as target or rejected as distractor more quickly than other faces, even after hundreds of trials, which allowed the non-self faces to become more and more familiar to the subjects. These authors claimed that self face is an highly overlearned stimulus, and they introduced the concept of "robust representation", that may: "(1) mediate rapid asymptotic visual processing; (2) require extensive visual experience to develop; (3) contain some abstract or view-invariant information; (4) facilitate a variety of visual and decisional processes across tasks and contexts; and (5) demand less attentional resources" (Tong & Nakayama, 1999). However, this study did not include highly familiar faces as control stimuli, so that whether robust representations are exclusive for self-face stimuli was not unequivocally assessed. Further analysis of this criticism was on the basis of a recent work by Devue and colleagues (Devue, Van der Stigchel, Brédart, & Theuwees, 2009). These authors included a familiar face as control stimulus and used eye-tracking to investigate in greater detail the participants' performance in a visual search task similar to that of Tong and Nakayama. These authors found that subjects did not detect their faces faster but they looked at them longer. Moreover, this behaviour was critically linked to familiarity more than to self identity, given that it was similar when searching for familiar non-self faces.

Despite the role played by familiarity, the possibility that self and other are processed in at least partially separate cerebral network remains likely. Therefore, in the last years neuroscientists have been more and more interested in investigating the neural correlates of self face recognition using modern techniques of neuroimaging and electrophysiology, besides behavioural studies. In this regard, although still controversial in the literature, growing amount of evidence shows that the self-face is predominantly processed in the right hemisphere. Data obtained through the study of split-brain individuals, and experiments conducted in healthy people using electrophysiological and functional neuroimaging techniques will be presented below, in order to give a general picture of the knowledge about self-face recognition. For the purpose of the present work, the focus of the introduction will be on studies investigating the visual modality, although data obtained using other sensory modalities are available (e.g., see Kitada, Johnsrude, Kochiyama, & Lederman, 2009 for haptic identification of human faces; Pietrini, Furey, Ricciardi, Gobbini, Wu et al., 2004).

2.1.2.1 Split-brains and connected studies

Nobel prize researcher Roger Sperry, while investigating two split-brain patients, demonstrated that the minor (right) hemisphere was able to recognize self-face when images were presented unexpectedly (Sperry, Zaidel, & Zaidel, 1979). Since then (but even before), other studies have examined split-brain patients. In the first neuropsychological investigations of self-recognition in humans, pioneer Preilowsky (1977) had found an increased galvanic skin response when self-face was presented to the right hemisphere in callosotomy patients; more recently other authors (Keenan, Wheeler, Platek, Lardi, & Lassonde, 2003) pushed beyond by claiming a right hemisphere advantage and higher sensitivity for the processing of self-face stimuli. In their study, patient M.L. was requested to respond to morphed pictures of his own face and Bill Clinton's face. M.L. made more mistakes when using his right hand compared to left hand. The authors interpreted this result as a clue for the superiority of the right hemisphere (controlling the left hand via crossed motor pathways) in the processing of self-face stimuli.

Nevertheless, opposite evidence suggesting a left hemispheric advantage in self-face processing are not lacking, the most famous study being the one of Turk and colleagues (Turk, Heatherton, Kelley, Funnell, Gazzaniga et al., 2002). They asked an epileptic individual, who underwent a callosotomy in order to minimize the spread of seizures activity, to recognize morphed facial stimuli as belonging either to himself or a familiar other. Stimuli were presented to each hemisphere separately and both hemispheres demonstrated to be able to perform the choice; however, the left hemisphere showed a recognition bias for self stimuli, while the right hemisphere a bias for familiar non-self stimuli. Authors strongly argued for superior self-recognition ability in the left hemisphere of split-brain individuals. Uddin and colleagues (Uddin, Rayman, & Zaidel, 2005b) recently provided a reconciliatory account by claiming that both hemispheres are capable of self-recognition. They tested a split-brain person with morphed pictures of his own or a highly familiar face with an unfamiliar face presented to each hemisphere tachistoscopically and found no difference when the performance was assessed using a signal detection method (Green & Swets, 1966). Despite the consideration that most of the few split-brain patients tested have demonstrated right or no hemisphere dominance for self-face, suggesting that the patient of Turk et al. (2002) may have been an exception, caution is necessary in general when studying patients. In particular, since split-brain patients are typically affected by clinically relevant forms of epilepsy that may correspond to an heterogeneously "dysfunctional" brain.

The group of Keenan also examined the performance of 5 neurologically unimpaired subjects by utilizing the Wada-sodium pentobarbital technique (Wada, 1949), that enables experimenters to “knock out” one hemisphere at a time (Keenan et al., 2001). When the left hemisphere was anesthetized, patients reported more often that the morphed (self-famous) face looked like themselves, while when the right hemisphere was anesthetized the response “other” was more likely. Similarly to Wada technique, that allows the anesthetization of a whole hemisphere, TMS permits to selectively inhibit a cerebral area of interest. To our knowledge, two studies have so far exploited this technique to investigate self-face recognition. In the work of Uddin and collaborators (Uddin, Molnar-Szakacs, Zaidel, & Iacoboni, 2006), that will be explained in details hereinafter, a parieto-frontal activation was found in the right hemisphere. The second study, carried by Théoret and colleagues (Théoret, Kobayashi, Merabet, Wagner, Tormos et al., 2004), confirmed a right hemisphere dominance in terms of cortico-spinal excitability: masked self images presented to the subjects activated the right hemisphere (as observed from larger Motor Evoked Potentials -MEP- registered from corresponding muscles when contralateral motor cortex was targeted with TMS) to a greater degree compared to the left hemisphere.

Overall, despite the fact that few patients and healthy subjects were examined and that studies greatly differ regarding stimulus presentation to each hemisphere (lateralized or central) and the response required, most studies seems to suggest a larger involvement of the right hemisphere in self-face processing.

2.1.2.2 Behavioural results

The first attempts to investigate the neural substrates involved in self-face recognition by means of behavioural experiments in healthy people were conducted by Keenan and colleagues (Keenan, McCutcheon, Freund, Gallup, Sanders et al., 1999; Keenan, Freund, Hamilton, Ganis, & Pascual-Leone, 2000). Both studies aimed to show lateralized hemispheric processing by measuring the Reaction Times (RT) of each hand at time, capitalizing on the notion of contralateral motor control. In the first experiment (Keenan et al., 1999), subjects were presented with pictures of self and others (i.e., friend, famous people, and stranger), in upright or inverted position. Analysis of RT confirmed the authors’ hypothesis: subjects responded significantly faster when using their left hand and responding to their own face, than in any other condition, which did not differ between each other. The finding was confirmed in a successive study in which videos showing one face gradually transforming into another face (each frames being obtained by morphing a famous face picture with either the participant’s own face or a personally familiar -co-worker- face picture) were shown (Keenan et al., 2000). When the sequence started with the participants’ own face, participants identified as the famous face a later frame when responding with their left hand as compared to the right hand.

Conversely, when the movies started with the image of the famous person and they were instructed to stop the sequence when a "self" frame appeared, subjects stopped earlier with left than right hand. The authors concluded that when the right hemisphere is preferentially accessed (and left hand used to respond) participants are more inclined to identify morphed images as their own face. A better performance with one hand was considered as an index of the dominance of the opposite hemisphere in that cognitive function.

A similar study conducted with Chinese participants (Ying, Jianli, & Jian, 2004) questioned Keenan and colleagues' strong conclusions, since it found similar right hemispheric preference with self and friend's faces under certain conditions. Another critical research was done by Brady, Campbell and Flaherty (2004) that suggested a left brain dominance for the recognition of the self and a right hemisphere more involved in others' recognition. This study was made with chimeric faces and required judgments regarding which of two images (one made from the left and one from the right halves of a photograph) looked more like the participant or his friend. Participants showed a bias for composite made from the half face lying in the right visual hemifield when looking themselves in the mirror in the case of judgments related to their own face, while the opposite bias was observed when the familiar face was the target: that is, for composite made from the half face lying in the left visual hemifield when facing the person. Finally, Keyes and Brady (2010) recently faced the issue from a different point of view. They shortly (150 ms) presented self, friend, and unknown faces both unilaterally or bilaterally during a recognition task. Reaction times analysis showed no differences depending on visual field (right *versus* left) with any of the stimuli presented, but a significant gain when pictures were presented bilaterally. Authors claimed for inter-hemispheric cooperation and suggested a redundant representation across hemispheres.

Overall, behavioural evidence provides quite varied results and the problem of the large assortment of tasks and control stimuli used persists, given that some studies analyzed differences in hand responses, while others opted for stimulus presentation to one hemisphere at a time.

2.1.2.3 Evidence from functional neuroimaging and electrophysiology

Differently from the behavioural studies or those testing split-brain patients reviewed above, that only give insight on the hemispheric dominance, researches presented in this section allow more precise conclusions regarding the neural correlates of the self-recognition ability. These studies mainly used fMRI, PET (Positron Emission Tomography) and ERPs obtained from electroencephalography recordings and were accurately reviewed by Platek and colleagues in a recent effect-location meta-analysis (Platek, Wathne, Tierney, & Thomson, 2008). Among the first fMRI studies, some came from Keenan's group (Platek, Keenan, Gallup, & Mohamed, 2004; Platek, Loughead, Gur, Busch, Ruparel et al., 2006). Platek and colleagues (2004) were interested in localizing the cerebral regions involved in self-face recognition and mental state attribution (i.e., inferentially modelling the mental experiences of others). According to the authors' hypothesis, the two high-order processes would share neural substrates in the right hemisphere. Subjects were requested to passively look at faces (self or familiar famous) and to think about the mental state of the person depicted in the picture (in the mind in the eyes - revisited test). Subtraction analysis between self-face and famous face conditions revealed a significant activation for the self-face recognition in the right frontal lobes. Moreover, researchers could partially confirm their hypothesis given that areas activated in the mind in the eyes task partially overlapped in the right frontal lobe. Two years later, the same research group run a second study, which was the first study to employ control faces rigorously matched for gender and familiarity with the self-face. Unfamiliar faces and the more stringent control of a personally familiar face were used in this experiment. The task required judgments about photograph identity, during an event-related fMRI scanning. Contrasting self-face with unfamiliar face-stimuli revealed right temporal activation. Critically, right superior frontal gyrus, inferior parietal and medial frontal lobes, and left middle temporal gyrus resulted specifically activated when the direct contrast between self and familiar face was carried out. Interestingly, analysis of behavioural performance showed that participants responded to unknown faces significantly faster and more accurately than to both self and familiar faces, which were not different between them.

The group of Sugiura was equally productive during the past decade in this field of research. In a first PET study (Sugiura, Kawashima, Nakamura, Okada, Kato et al., 2000), the authors were interested in finding differential activation patterns depending whether an active (A) or passive (P) face processing was performed. Subjects were required to click either a right or left button when the stimulus (the picture of an unfamiliar face) was tilted respectively to the right or to the left. This orientation task was common to the active, the passive and a control experiment. In the active task, there was a supplementary instruction: to press both response keys at the same time when the participant's own face was randomly presented among unfamiliar pictures. Participants' faces were also included in the passive task with no specific request given to the subjects; while in the control task only unfamiliar faces were shown. PET data revealed that the left fusiform gyrus and right supramarginal gyrus were activated during both active and passive recognition of the self face. Several cortical regions (e.g., right frontal cortex and pulvinar, left anterior insula) showed specific activation following A-P subtraction. However, the fact that no familiar faces were used as stimuli, made it impossible to conclude that these regions were selectively correlated to the processing of self-stimuli, instead of familiar faces in general. Better control stimuli were introduced in a successive event-related fMRI study (Sugiura, Watanabe, Maeda, Matsue, Fukuda et al., 2005). Here, three different faces were used as "other", besides the "self" face: an highly personally familiar face, a scarcely personally familiar face and the pre-learned face of an unfamiliar person. The results suggested a partial distinction of the brain mechanism involved in recognition of personally familiar faces and the one involved in recognition of one's own face. Cortical regions selectively activated during self-face processing were the occipito-temporo-parietal junction in the right hemisphere and the fusiform gyrus in the left hemisphere. Remarkably, both these areas appeared to be involved in the processing of one's own actions as well (e.g., Vaina, Solomon, Chowdhury, Sinha, & Belliveau, 2001). A very similar right hemispheric activity involving the inferior parietal lobule was shown by Uddin and collaborators (Uddin, Kaplan, Molnar-Szakacs, Zaidel, & Iacoboni, 2005a), using a task in which morphed faces were presented. Procedure and results of this study will be presented in detail in paragraph 2.1.7, since we used this study as starting point for our TMS experiments.

Conversely, bilateral activation was found in another study that used morphed pictures (Kircher, Senior, Phillips, Rabe-Hesketh, Benson et al., 2001). Kircher and colleagues presented subjects with varying levels of morphed images of themselves/their partner with an unknown face and found activation of right limbic, left prefrontal and superior temporal cortex when subjects viewed themselves. Only the right insula was selectively active when partner's face was presented. Nevertheless, critically these authors did not compare directly the self with the familiar partner and moreover only six subjects were recruited for the fMRI recording.

Finally, more recently Devue and colleagues (Devue, Collette, Balteau, Degueldre, Luxen et al., 2007) introduced an interesting paradigm: participants were required to indicate the real appearance of the picture of themselves and of a gender-matched close colleague among intact and altered pictures of faces and bodies. Data relative to bodies will be presented hereinafter. Behavioural results regarding face-stimuli showed shorter reaction times in response to self than to other pictures, while no differences were revealed by accuracy analysis. Consistently with previous works (Platek et al., 2004; 2006; Uddin et al., 2005a; Kircher et al., 2001), right inferior frontal gyrus and right insula were activated when contrasting intact participant's own face with the colleague's face. Nevertheless and contrary to some previous result (Kircher et al., 2001; Sugiura et al., 2000; 2005), no left-hemispheric activity was found.

According to the recent meta-analysis of Platek and collaborators (2008) we can conclude that evidences deriving from fMRI studies support the existence of a right-dominant, even if not strictly lateralized, network that subserves the ability of visual recognition of one's own face (see Figure 1).

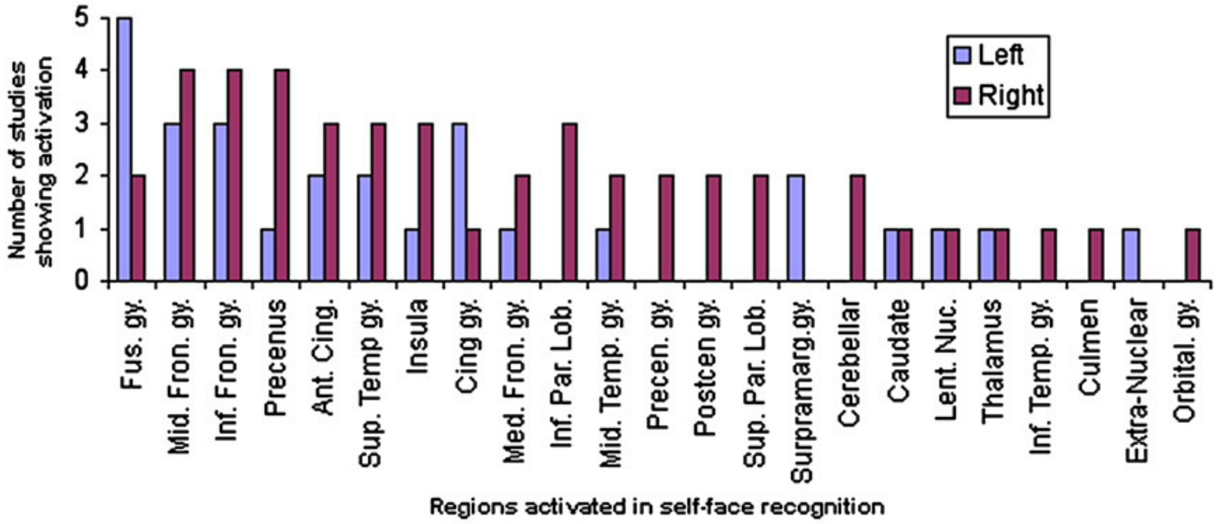

Figure 1. Number of studies showing activations to self-face recognition as a function of brain substrate and hemisphere (from Platek et al., 2008).

Finally, data coming from neurophysiological studies gave non-consistent results on the level of processing (early *versus* late) of self-face. At the first extreme of the debate there is for example the result of Keyes and Brady (2007). These authors believe that self-face may be differentiated from other faces processing as early as the N170 ERP component emerges. By contrast, data from Sui and colleagues (Sui, Zhu, & Han, 2006) only found later effects, i.e. an increased positivity in response to the self relative to familiar others over the frontocentral areas at 220-700 ms, but not before. Further studies are needed in order to reconcile these contrasting findings.

2.1.3 The Body

Human beings are highly social animals. From the time we are born, other humans capture our attention and elicit complex behavioural interactions. Even if the face is probably the most characteristic segment of the human figure, bodies are complex and interesting stimuli as well, and convey a large amount of relevant social information. Similar to faces, bodies are important for communication. Given that the body holds a complex brain representation, it is reasonable to consider it as a special stimulus among other objects (Berlucchi & Aglioti, 2010). Moreover, bodies can inform about gender, age, healthy state, attractiveness, emotions, actions, intentions of people around us, especially in situations in which information about the face is scarce (i.e., from great distance).

Although there has been relatively little research on visual perception of the human body, several similarities suggest that faces and bodies could be processed in a similar way. As many other highly familiar objects, faces and bodies appear to be coded trough a configural processing, defined as perception based on relations among the constituent parts, rather than visual processing of single segments (Minnebush & Daum, 2010). This claim has been mainly confirmed by evidence showing that the inversion effect (i.e., worst processing of highly familiar stimuli when presented upside-down compared to a canonical upright position) is present for both bodies and faces. For example, Reed and collaborators (Reed, Stone, Grubb, & McGoldrick, 2006) reported worst performance in healthy adults for decisions about inverted as compared to upright bodies, similarly to what happens when faces are presented. Moreover, an ERP study of Gliga and Dehaene-Lambertz (2005) found similar waveforms for static bodies and faces in both three-month-old infants and adults, suggesting that faces and bodies are processed in a similar manner at least to some extent. Indeed, although faces and bodies shapes are clearly very different, nonetheless differences between exemplars are metric rather than structural since both faces and bodies are made-up by critical elements, symmetrically disposed in a relatively fixed manner.

Nevertheless, results that questioned a common processing for faces and bodies are now the majority. Regarding the detection of bodies and faces, developmental data indicate that infants' expectations about typical human faces develop much earlier than the one regarding typical human bodies (Slaughter, Heron, & Sim, 2002). Indeed, infants younger than 18 months did not show any preference (measured in terms of fixation time) for typical or scrambled bodies, while they clearly prefer typical to scrambled faces. This result seems to suggest that there are differences in the basic perceptual detection of human faces and bodies, in seeming contrast with data from Gliga et al. (2005). However, disagreement about infants' age critical for the emergence of the preference for typical over scrambled bodies could arise from differences in the paradigms used and what remains certain is that knowledge about the canonical layout of the human body is present in infants, thus confirming a certain level of configural processing of bodies. Regarding the inversion effect, this doesn't appear as robust for bodies as for faces, showing that the two categories of stimuli are not strictly comparable, despite being similar. Moreover, very recent fMRI work showed that the body inversion effect (i.e., worse discrimination of inverted *vs.* upright bodies) disappeared for headless bodies, and suggested that brain areas selective for faces are critical in inversion effects (Morris, Pelphrey, & McCarthy, 2006). Finally and more importantly, fMRI studies recently demonstrated that detection of faces and bodies are subserved by separate brain regions (Kanwisher et al., 1997; Downing, Jiang, Shuman, & Kanwisher, 2001). Also at the recognition stage a dissociation between face and body recognition is suggested by the selectivity of prosopoagnosia, a neuropsychological deficit that impairs faces but not (in most cases; but see Righart & de Gelder, 2007 for different evidence) bodies recognition.

In sum, recent work shows that body and face perception presents similarity and differences and appears to involve both analytical and configural processing in a multistage process. While much research in cognitive neuroscience has been devoted to understanding of visual processing of faces, in recent times researchers have started to investigate the neural correlates of body perception with increasing interest. Some among fundamental works in this field are reviewed in the following section.

2.1.4 The body in the brain

In the last decade, a growing amount of researches has investigated the human ability to visually detect and recognize the body. The more detailed evidence probably comes from fMRI studies. In this section -however- also studies deriving from monkeys and brain damaged patients or performed using other techniques (i.e., ERPs, direct intracranial recordings etc.) will be reviewed.

2.1.4.1 Non-human primates

Analysis of single-cell responses (see for example Desimone, Albright, Gross, & Bruce, 1984) revealed that in the inferior temporal cortex of the macaque there are neurons selectively responding to monkeys' and humans' bodies and body-parts, but not faces. Temporal activation (superior temporal sulcus) -prevalent in the right hemisphere- was recently confirmed by two studies using fMRI, (Tsao, Freiwald, Knutsen, Mandeville, & Tootell, 2003; Pinsk, Desimone, Moore, Gross, & Kastner, 2005). Interestingly, the area in which these selective neurons were found neighbours the selective area for faces.

2.1.4.2 fMRI evidence

Functional MRI studies have provided perhaps the most striking evidence for selectivity in visual processing. A study done by Downing and colleagues offered the first direct evidence of the existence of visual brain regions selective for bodies in humans (Downing, Jiang, Shuman, & Kanwisher, 2001). The experiments involved 19 participants that were scanned while observing images of stimuli belonging to different categories. In all subjects a region was found in the occipitotemporal cortex that showed stronger response to photographs depicting bodies or parts of body, but not to faces or other non-biological objects. This greater activation generalized to silhouettes, stick figures and line drawings of the human body, suggesting the idea of an abstract representation of body shape. The authors provisionally named the discovered region extrastriate body area, a name that is still in use. Since 2001, the EBA attracted the interest and curiosity of several neuroscientists and it is now considered the counterpart for human bodies of the Fusyform Face Area (FFA; see Kanwisher et al., 1997) for human faces. The EBA is placed in the posterior inferior temporal sulcus/middle temporal gyrus, bilaterally. Anatomically, the EBA overlaps with the motion selective area and with the object-form selective area; nevertheless, Downing and co-workers (Downing, Wiggett, & Peelen, 2007) ruled out possible confusion by showing -using multi-voxel pattern analysis- that the form of a human body, visual motion, and object form elicited independent patterns of cortical activation.

A second brain region, anatomically distinct from EBA, was found more recently in the fusiform gyrus and was labelled Fusiform Body Area (FBA; Peelen & Downing, 2005). This region is adjacent and overlaps with the FFA (Gauthier et al., 2000) and responds more strongly to headless bodies than to objects, but equally to headless bodies and faces. Different neuroscientists independently replicated and strengthened the finding (e.g., Schwarzlose, Baker, & Kanwisher, 2005; Peelen, Glaser, Vuilleumier, & Eliez, 2009): using high resolution fMRI, a strong selectiveness was shown in distinct but adjacent regions in the fusiform gyrus for only faces in one region (the FFA) and only bodies in the other (the FBA).

Subsequently, Downing and co-workers tested whether an influential model proposed by Haxby and colleagues (2000) for faces could be applied in a similar way to body processing. Haxby's model is partially hierarchical: the occipital face area would analyze individual facial features, then superior temporal sulcus would process facial expressions and lip movements, finally the fusiform face area would be involved in analysis of invariant, identity-related aspects of the face. Following this idea, Taylor, Wiggett and Downing (2007) measured the activity elicited in EBA and FBA by different body parts, ranging from a single digit to the whole body without the head. The findings highlighted that while the EBA is strongly responsive primarily to body-parts, the FBA seems to prefer larger segments of the body or whole bodies, thus suggesting that only the second area is involved in the configural processing of the spatial relations among body parts (see Figure 2).

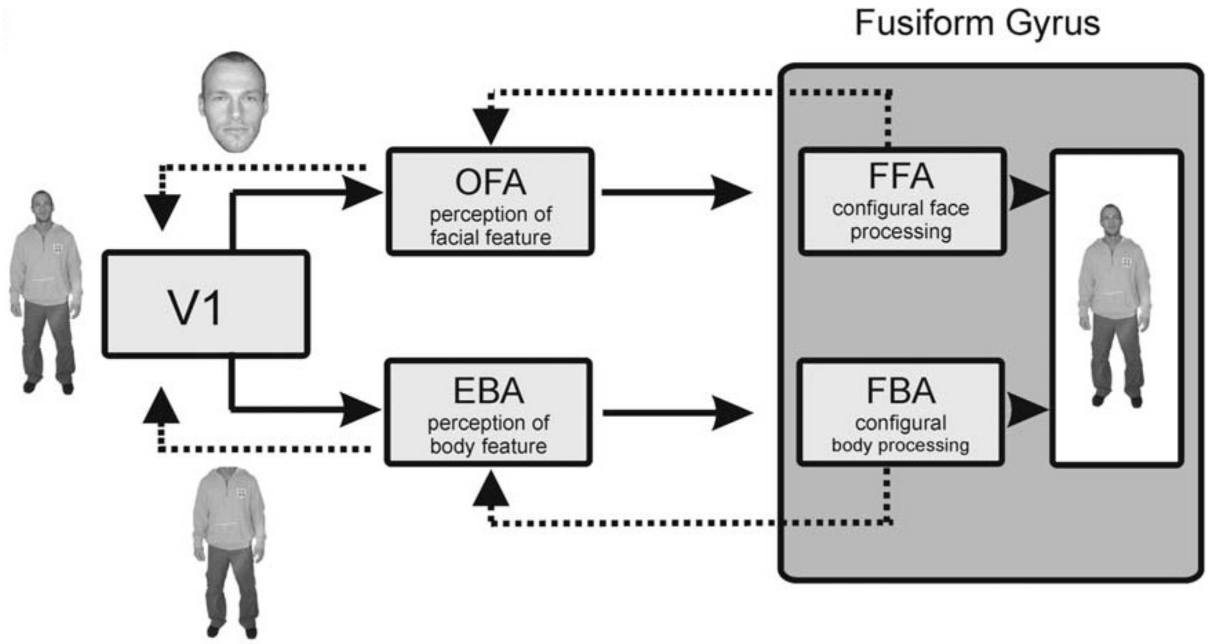

Figure 2. Parallel between face and body processing proposed by Taylor et al. (2007) on the basis of Haxby et al.'s (2000) model (from Minnebush et al., 2009).

Another interesting study revealed that EBA activation is modulated by the presence or absence of the face (Morris et al., 2006): activation may be diminished when bodies with head are presented, and this could reflect that faces capture attention *per se* when present, thus weakening the response in body-related areas.

Finally and importantly, Kitada and colleagues (2009) recently asked subjects to identity exemplars of faces, hands, feet, and non-biological control objects in visual and haptic modality at a time and identified two regions in the fusiform region by means of fMRI: the EBA and the haptic body region, thus suggesting that body selective regions seems to be partly modality-independent. The same was found for face-selective areas.

The widespread agreement regarding the existence of brain areas that are selectively sensitive to human bodies presented in visual modality encouraged neuroscientists towards a successive step: finding the proof of the causal involvement of EBA and FBA in these processes. Unfortunately, given that the fusiform face area lies on the ventral surface of the brain, TMS pulses cannot reach it. On the contrary, it is easily possible to stimulate the EBA, since it is located on the lateral surface of the temporal lobe. These studies will be presented in paragraph 2.1.4.4, after a brief look to electrophysiological evidence in the next paragraph.

2.1.4.3 A look into the time-course of body processing: ERPs and intracranial recordings

Given that event-related potential studies systematically revealed that faces elicit a typical component -the N170- and following the discovery of the EBA by Downing and collaborators (2001), researchers have become interested to investigate the ERPs related to body images as well. Thierry and colleagues studied whether a body-sensitive ERP waveform, analogous to N170 for faces, exists (Thierry, Pegna, Dodds, Roberts, Basan et al., 2006). These authors presented subjects with photographs of faces, bodies, scenes and objects and recorded electrical activity from the scalp: they found that the component elicited by bodies was close in amplitude to that elicited by faces, but peaked 20 milliseconds later (so that it was named N190), had a different topography and, interestingly, generalized to different kind of body images, as assessed by mixing together photographs, silhouettes and line drawings as stimuli. Unluckily, no strong conclusion about source localization could be made from this work, even if the right posterior extrastriate cortex was associated with the registered brain activity, more dorsal and anterior with respect to the locus of face perception and possibly corresponding to EBA or FBA.

Conversely, a very precise localization distinguishes a study carried in a patient prior to surgery for epilepsy (Pourtois, Peelen, Spinelli, Seeck, & Vuilleumier, 2007). The authors provided the first direct electrophysiological evidence for an early visual processing stage specialized for human body shapes and furnished a precise time-course of this selective response, thus overcoming the main limit of fMRI, that is an indirect measure with limited temporal resolution. In this study, a 27-year-old right-handed male patient had an electrode grid placed over the extrastriate cortex, comprising the EBA location. Intracranial local field potential were recorded while he categorized different stimuli (static images of faces, human bodies, mammals and tools) by means of four buttons. One electrode showed a very selective response to bodies compared to other stimuli: critically, Talairach coordinates were 39, -77, -2 (Talairach & Tournoux, 1988), that is the electrode felt within the range of EBA coordinates reported in a previous work (48±5, -50±5, 1±6; see Peelen, Wiggett, & Downing, 2006). The peak of activation started at 190 ms and was maximum at 260 ms after the stimulus onset, suggesting a role of the EBA in initial perceptual analysis of human body shape. Similarly, a pioneer study had reported a negative visually evoked potential at several posterior recording sites that peaked at about 230 ms and was responsive to human hands (McCarthy, Puce, Belger, & Allison, 1999), but in this case the localization was much less accurate.

In order to disambiguate whether the N1 for bodies originates from the EBA or the FBA, Taylor and collaborators recently used functional criteria to distinguish among the neural sources of ERP markers (Taylor, Roberts, Downing, & Thierry, 2010), combining fMRI and ERP methodologies. To test the hypothesis that the response in the N1 reflects the BOLD (Blood Oxygenation Level Dependent) signal selectivity of either EBA or FBA, stimuli depicting whole bodies and body-parts (fingers, hands and arms) and matched control stimuli (whole trees and tree-parts) were shown to healthy participants that performed a one-back repetition task while their electrical cerebral activity was registered from the scalp. Authors interpreted their findings as evidence that EBA (and not FBA) is the generator of the N190, that strictly corresponded to the N190 firstly found in the work by Thierry and colleagues (2006).

In sum, the analysis of the literature related to the brain electrical activity in response to human body visual stimuli seems to confirm fMRI data: the extrastriate body area plays a fundamental role in this process.

2.1.4.4 TMS and lesional data

As already mentioned, TMS can only be applied to the EBA, while FBA is out of reach by TMS effects, being situated in the medial surface of the visual cortex. Utilizing this technique, Urgesi and colleagues were the first to demonstrate that functional interference with EBA functioning selectively impairs the visual processing of body-parts (Urgesi, Berlucchi, & Aglioti, 2004). Inhibitory TMS pulses were administered in couple at 150 and 250 ms after stimulus presentation either to the right EBA or to the right primary visual cortex (BA17) in order to control for non-specific TMS effects on visual processing. Notably, TMS pulses were delivered according to the temporal window resulting from intracranial and scalp electrophysiological recordings (Thierry et al., 2006; Pourtois et al., 2007). Participants were engaged in a delayed matching-to-sample task in which body parts as well as face parts and motorcycle parts were used as stimuli. Results showed that TMS over EBA but not BA17 selectively impaired subjects' performance when stimuli depicted body parts, while the responses did not exhibit changes with faces or motorcycles.

While in the study mentioned above the impairment consisted in increased reaction times, a subsequent work revealed a decrease in accuracy as measured by d' (Pitcher, Charles, Devlin, Walsh, & Duchaine, 2009). These authors run three experiments: faces, whole bodies without head and objects were briefly (200 ms) presented as stimuli in a discrimination task (one-back repetition detection) while three adjacent areas of the extrastriate visual cortex were targeted with TMS pulses. Repetitive TMS protocol consisted in 10 Hz pulses delivered for 500 ms starting from the target onset at 60% of maximum stimulator output. Targeted areas were the right OFA, the right EBA and the right Lateral Occipital area (rLO). Results strongly supported a modular account of different visual stimuli processing: in fact, TMS over rOFA impaired discrimination of faces but not objects or bodies; TMS over rEBA impaired discrimination of bodies but not faces or objects; finally, TMS over rLO impaired discrimination of objects but not faces or bodies. Curiously, TMS did not show to affect reaction times.

A further experiment by Urgesi and collaborators in which EBA was stimulated by rTMS (Urgesi, Candidi, Ionta, & Aglioti, 2007) found a double dissociation between performance in a body form (or identity; selectively impaired after TMS over EBA) and a body action (selectively impaired after TMS over Ventral Pre-Motor Cortex, vPMC) task of matching of figures. Remarkably, a lesion study conceived by Moro and colleagues further supported the claim for a double dissociation between identity and motor aspects of body recognition (Moro, Urgesi, Pernigo, Lanteri, Pazzaglia et al., 2008). The authors mapped the lesions of 28 brain damaged individuals and showed that posterior lesions involving an occipitotemporal area corresponding to EBA coincided with a selective deficit with stimuli representing human bodies, while more extended lesions of the right ventromedial temporal cortex were associated with deficit in visual discrimination of both faces and bodies. Moreover, body form and body action recognition deficit were double dissociated, the first being linked to damage of the EBA and the second of the vPMC, compatibly with the results obtained from Urgesi and co-workers (2004; 2007).

2.1.5 One's own body

As Merleau-Ponty (1945) noticed, the body is an object that never leaves us. The body is not only something that the brain owns and regulates, but also the source of many information that concern the body itself and the world around. Among the many sources through which the human brain receives information about the human body there is vision. Through this channel we also receive information about our own body. However, this information is surely biased by obvious anatomical constraints. In fact, even if we can see most of our own body directly, with no need of a mirror (in contrast, for example with the face), we typically observe our own bodies from above, in a kind of upside-down way (Gregory, 2001), although we have now more and more occasions to see our own bodies in a third person's perspective, through photographs and videos. As Gillihan and Farah (2005) pointed out in their review of the literature regarding the self as a special stimulus, there is a lack of studies concerning self-body and body-parts visual recognition. In fact, most works have focused on specific aspects as agency or ownership[1], and

[1] The sense of agency refers to the recognition of being the cause of an action. It relies on both a recognition of one's body as one's own and of the actions as caused by oneself, or in the words of Jeannerod and colleagues (Jeannerod, Farrer, Franck, Fourneret, Posada et al., 2003), "ownership" and "authorship". Body-ownership refers to the feeling that "my body" belongs to me, and is ever present in my mental life (Gallagher, 2000).

not many have considered the visual recognition of one's own body shape. Today, a few years later these authors' review, a few more data are available, as discussed below.

2.1.5.1 Behavioural data

Within experimental psychology, the typical way to investigate the self body visual recognition is to merely measure the accuracy in discriminating pictures (or videos) of one's own *versus* other people's body-parts. In this kind of task participants often showed surprisingly poor performance (e.g., Wolff, 1932; reported in Gillihan & Farah, 2005). Collins (1981) tested the ability of adolescents to correctly identify their own bodies, also in order to assess which body parts were more important for self identification. The author photographed adolescents' whole bodies from three different views and one month later presented arrays of pictures of bodies and body-parts to each participant with the request to choose those that depicted his/her own body. In general, females performed better than males, who however responded faster; females made the most accurate judgments with their breasts, while males with genitals. Critically, no effect of viewpoint was reported.

More recently, a more rigorous experiment was projected ad run by Daury and colleagues (Daury et al., 2009). The aim of the study was to assess whether people's memory for their own and familiar body shape reaches a degree of precision comparable to that reported in previous studies involving faces (Ge, Luo, Nishimua, & Lee, 2003; Brédart & Devue, 2006). Pictures of each participant, a very personally familiar person and unknown people were used and were presented both in the original shape and after graphic distortion consisting of an increase or decrease of the waist-to-hip ratio (at various degrees from 2% up to 10% of change). In one task participants performed same/different discriminations on two simultaneously presented pictures, while in another they judged, following stimulus presentation, whether the pictures were normal or altered. Performance was overall similar in the task involving retrieval from memory and in the perceptual discrimination task. Critically, however, in judgments based on memory, pictures with higher amplitude of distortion were considered as normal, revealing a certain degree of uncertainty in participants regarding their body-image.

Evidence from behavioural data described above seems to suggest, unsurprisingly, that perceptual memory for self and familiar bodies may be not as accurate as memory for faces. Moreover, apparently there would be no marked differences in the ability to recognize one's own or personally familiar people's body.

2.1.5.2 Evidence from patients

Historically, self-body-recognition-related disorders have been noticed in psychiatric population (see for example Jeannerod et al., 2003). Within clinical neurology, there are several disorders of bodily sensation, action and awareness. Among them, somatoparaphrenia deserves a mention here given that it seems to involve a distinction between knowledge about self and others. Somatoparaphrenia is a term suggested by Gerstman (1942) to denote “illusions or distortions concerning the perception of and confabulations or delusions referring to the affected limbs or side”. Vallar and Ronchi (2009) wrote in their recent review that somatoparaphrenia is characterized by a delusion of disownership of -more often- left-sided body-parts, following right-sided brain lesions. Instead, no problems are shown with other people’s body. Nevertheless, deficit of proprioception may play a relevant role in this condition.

Evidence of a selective impairment in self-body processing in the visual modality was almost completely lacking until very recently, when Frassinetti and colleagues (Frassinetti, Maini, Romualdi, Galante, & Avanzi, 2008) developed a new visual matching-to-sample paradigm to indirectly test self body-parts recognition in brain damaged patients and healthy people. The task involves the simultaneous presentation of three pictures, representing either self or non-self stimuli. Participants are requested to match the central target with the corresponding upper or lower stimulus. Performance with “self” targets *versus* “other” targets is compared in order to assess whether a “self advantage” is present. By using this and a similar paradigm including moving body parts besides pictures, Frassinetti and colleagues tested healthy people and left and right brain damaged patients in three successive experiments (Frassinetti et al., 2008; Frassinetti, Pavani, Zamagni, Fusaroli, Vescovi et al., 2009; Frassinetti, Maini, Benassi, Avanzi, Cantagallo et al., 2010) that suggest the following general conclusions. First, recognition of self body-parts is independent from the recognition of other people’s body-parts, given that it can be selectively impaired after brain lesion. This deficit affects right brain damaged patients more often than left brain damaged patients, suggesting a right hemisphere prevalence in this ability. It is a selective deficit that cannot be explained in terms of a general recognition deficit, since patients did not show pathological performance when parts of objects were used. More importantly, a simple dissociation was found whereby patients impaired in the processing of self-body parts (as assessed by means of the matching-to-sample task) showed a preserved self-advantage when selfface parts were presented, providing preliminary evidence of a modular representation of the corporeal self (Frassinetti et al., 2010). Finally, according to the hypothesis of Sugiura and colleagues (Sugiura, Sassa, Jeong, Miura, Akitsuki et al., 2006; see the next section 2.1.5.3), it was shown that the deficit for static pictures of self body-parts did not generalize to self body-parts in motion (Frassinetti et al., 2009). Unfortunately, given to the relative scarce number of patients who were recruited for these studies, authors could not drive strong conclusions regarding the neural substrates of the dissociations they found. Nevertheless, patients' lesions analysis seems to indicate that self-body processing mainly involves frontal and parietal areas in the right hemisphere.

2.1.5.3 fMRI studies

Research relative to the neural substrates that are linked to visual self-body recognition has begun only very recently, often starting from the results of self-face recognition studies. For example, Sugiura and colleagues (2006) used fMRI to test the hypothesis that the left fusiform gyrus processes self-face as a symbol, while a right parieto-frontal network is involved in the visual processing of self stimuli in a motion-action contingency. To this aim, participants were required to express a judgment of familiarity/unfamiliarity when presented with different stimuli: pictures *vs.* movies representing faces *vs.* whole bodies belonging to their own *vs.* a friend *vs.* an unfamiliar person. Results partially supported the hypothesis: indeed, self *versus* friend pattern of activation (collapsed across the four conditions) revealed the implication of a bilateral ventral occipito-temporal region extending over the fusiform gyrus and the right parietal and frontal cortices; moreover, according to the authors' hypothesis, ventral occipito-temporal cortex of the left hemisphere was more highly activated by face than body, only with static pictures. Nonetheless, right parieto-frontal regions did not show to be preferentially sensitive to movies representing whole bodies. Overall, this work confirmed previous evidences of multiple cortical networks for visual self-recognition (see Gillihan & Farah, 2005 for review).

While the study presented above used only veridical pictures, two works used veridical as well as artificially modified body photographs. The group of Kurosaki was specifically interested to look for gender differences in brain activation elicited by the view of distorted images of one's own body (i.e., a "fat" version and a "slim" version created starting from real photographs; Kurosaki, Shirao, Yamashita, Okamoto, & Yamawaki, 2006). They used an original task named "body image task" in which pairs of images (fat-real, slim-real, real-real) were presented in a block-designed fMRI protocol. Subjects were instructed to select the more unpleasant image from the pair in which one real and one distorted images were mixed, or alternatively to select the real image showing a red cross in the case of real-real pairs. Despite authors themselves noted a few limitations in their experiment (e.g., control task was quite dissimilar from the body image task), the results showed that in women but not in men the area of the amygdala was activated during the critical task. Given the role played by the amygdala in relation to fearful/unpleasant stimuli (see Sergerie, Chocol, & Armony, 2008 for review)- the authors suggested that women may perceive distorted images of their own bodies via complex cognitive and emotional cerebral circuits. Interestingly, these results are strongly linked with other studies in anorexic patients (e.g., Sachdev, Mondraty, Wen, & Gulliford, 2008). Further discussion of this topic will be provided in Chapter 3.

A further fMRI study is that by Devue et al. (2007) already mentioned above. These authors asked participants to identify the real appearance of their own face or body, or that of a close colleague. Authentic pictures were presented together with distorted versions of the same face- or body-stimulus. Behavioural analysis showed that participants were faster to respond to faces than bodies, to self than other and to altered than intact stimuli. Imaging data relative to the subtraction of intact-colleague body from intact-own body revealed an extended activation encompassing the right superior frontal sulcus, right cingulate cortex, left inferior frontal gyrus and anterior insula bilaterally.

All in all, despite the studies presented started to investigate the neural correlates of self-body recognition and their results -pointing toward a right hemispheric predominance- are interesting and encouraging, data are fragmentary and their amount is still insufficient to draw definitive conclusions.

2.1.5.4 fMRI studies of the Extrastriate Body Area

Following the discovery and localization of the EBA (Downing et al., 2001), further research addressed the issue of the ability of this area to recognize one's own body and body-parts with respect to others' bodies. Yet, the is no complete agreement about the answer, even if most work suggests that self-recognition does not necessarily involve the EBA.

First, two studies investigated the effect of viewpoint and perspective on body representation, a topic strongly connected to body ownership. A first attempt to examine whether the EBA can differentiate egocentric and allocentric views of the body was made by Chan and colleagues (Chan, Peelen, & Downing, 2004) using a one-back-repetition-detection task (i.e., to report whenever two identical images appeared consecutively). Stimuli were pictures of the participant's and four familiar persons' body-parts, each photographed from both egocentric (i.e., first person view) and allocentric perspective (i.e., third person view). Results showed that the right but not the left EBA responded stronger to images taken from allocentric perspective, irrespective to the identity. The opposite pattern (higher activation with egocentric perspectives) was found in the left superior parietal cortex. Unfortunately for the sake of the present project, authors reported areas that were more active with "other" pictures (e.g., bilateral superior temporal sulcus, right medial anterior occipital cortex, cuneus/precuneus, cerebellum), but no with "self". Overall, EBA did not seem to be particularly sensitive to the body identity, even if the greater activation for allocentric views suggests that this cortical region is possibly tuned to the processing of others. Similar conclusions have been reached by Saxe, Jamal and Powell (2006) that used the same task but showing hands, arms, legs and feet of a model unknown to the participants, photographed from egocentric and allocentric views. Once again, the right EBA was sensitive to pictures in allocentric perspective.

Hodzic's group of research performed a series of fMRI experiments testing a total of 26 subjects in tasks that required either direct self-recognition or a one-back-repetition-detection (Hodzic, Muckli, Singer, & Strin, 2009a; Hodzic, Kaas, Muckli, Stirn, & Singer, 2009b). None experiment revealed a sensitivity of EBA to stimuli depicting self body-parts. Authors firmly concluded that distinct cortical networks exist for the detection and identification of human body. According to their model (see Figure 3), body detection involves the EBA bilaterally and the FBA and IPL in the right hemisphere, while body identification is subserved by a right parieto-frontal network. Thus, the two networks partially overlap at parietal level. Nevertheless, they are clearly segregated in extrastriate cortices and in frontal areas.

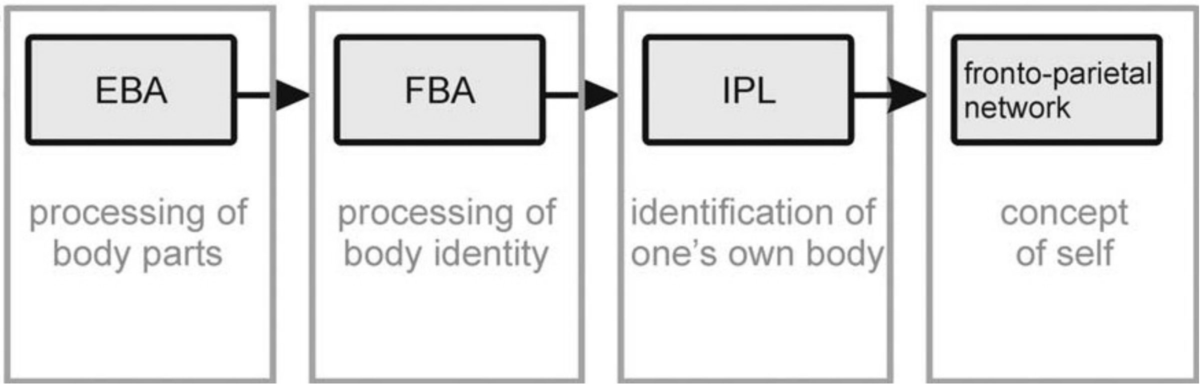

Figure 3. Hodzic et al.'s (2009a; 2009b) model (from Minnebush et al., 2009).

Very interestingly, when the recognition of one's own body was contrasted to the identification of familiar bodies, differential activation was revealed in the right inferior parietal lobule (consistently with the findings of Uddin et al., 2006) and inferior parietal sulcus, and in the left posterior orbital gyrus and lateral occipital gyrus.

Finally, it has to be mentioned that results from a recent study of Myers and Sowden (2008) strongly challenged the conclusion relative to the "blindness" of EBA to self-identity. Using fMRI adaptation, these authors showed evidence of two separate neural sub-populations in the right EBA, selectively responsive to images of one's own or other people's body-parts.

2.1.6 Transcranial Magnetic Stimulation: A unique tool for neuroscience

The transcranial magnetic stimulation is a technique for non-invasive stimulation of the human brain. A few decades ago, Barker and colleagues (Barker, Jalinous, & Freeston, 1985) demonstrated that it is possible to directly stimulate the brain using magnetic stimulation with little or no pain. Since then, the only possibility was the painful Transcranial Electric Stimulation (TES) developed by Merton and Morton (1980). The TMS operates on Faraday principle of electromagnetic induction: a magnetic field induces an electric field in an electrically conducting medium placed in it. In the case of the TMS the conductor is the brain. A brief, high-current pulse is produced in a coil of electric wire, the magnetic coil. The coil is usually placed tangentially to the scalp and the flux of the magnetic field passes perpendicularly to the plane of the coil; as a result, the electric field generated in the brain is parallel to the coil and opposite to the original electric current.

The magnetic field can reach up to about 2 Tesla and typically lasts for about 100 μs (microsecond). If the magnetic field changes rapidly enough, the produced electric field can depolarize the underlying neurons with consequent interference with the cerebral activity for a few milliseconds. The interference derives from the fact that the TMS-induced electrical activity is random with respect to the goal-state of the stimulated area, thus disrupting cognitive performance. In other words, a certain amount of "noise" is introduced into normal neural processing, in order to investigate whether a given area is functionally involved in the cognitive function under investigation.

TMS is now a well established tool in neurosciences. Most experimental studies use a figure-of-eight shaped coil, which is more focal than the traditional circular coils. The spatial resolution of TMS varies depending on the size and shape of the stimulating coil, and can be on the order of a few millimetres of cortical surface (Ro, Cheifet, Ingle, Shoup, & Rafal, 1999).

Several different types of TMS are currently used, named on the basis of the number of pulses delivered:

- *single pulse TMS* when single pulses are administered and the shorter distance between pulses is 3 seconds;
- *paired pulse TMS* if two pulses are delivered at different locations in order to assess the functional interplay between different cortical areas. The Inter Stimulus Interval (ISI) is variable and determines the excitatory or inhibitory effect of the stimulation;
- *repetitive TMS* that refers to a rhythmic train of pulses delivered at regular intervals. The frequency can vary from less than 1 to about 50 Hz (that is from 1 to 50 pulses per

second): rTMS at slow rates (0.2-1 Hz) causes a decrease in brain excitability (Chen, Classen, Gerloff, Celnik, Wassermann et al., 1997), while rTMS at higher rates (5 Hz or faster) increases the brain excitability (Pascual-Leone, Valls-Solé, Wassermann, & Hallett, 1994). Other parameters that can vary in rTMS are intensity of the stimulation, inter-stimulus interval, number of pulses delivered and length of the period of stimulation;

- *theta burst TMS* that is a recently developed protocol, in which short burst of high-frequency (50 Hz) rTMS are repeated at a rate in the theta range (5 Hz), administered in continuous or intermittent train with either inhibitory or excitatory effects (Huang, Edwards, Rounis, Bhatia, & Rothwell, 2005).

In general, higher frequency and intensity of stimulation cause greater cortical interference.

Depending on the type of stimulation, the effect of TMS is assessed on-line or off-line. In the on-line approach, the pulse or train of pulses is delivered during the task (event-related TMS) and high-frequency repetitive stimulation can be employed. Instead, in off-line paradigms repetitive TMS is delivered for some minutes before starting the task. This is possible because, using certain parameters of stimulation, TMS shows the power to slightly change cerebral activity beyond the period of stimulation itself. For example, it was shown that low-frequency, 1 Hz rTMS for 15 minutes reduces the cortical excitability and produces inhibitory effects that last for more than 15 minutes post-stimulation (Chen et al., 1997). So, low-frequency repetitive TMS is largely used to induce relatively long lasting suppression of neural activity.

TMS is a very safe technique. However, given the interference with the electrical brain activity and the presence of a magnetic field, safety guidelines must be followed and TMS avoided in people suffering from epilepsy, neurological diseases, or holding metallic biomedic implants (Wassermann, 1998; Rossi, Hallett, Rossini, & Pascual-Leone, 2009). All in all, TMS is a very safe technique if one carefully respects safety guidelines.

Summarizing, TMS is a unique tool for neuroscientists since it allows to establish causal relationships between the area in which the interference is produced and the effects generated in a certain cognitive function. This adds critical knowledge to that available through functional magnetic resonance imaging, electroencephalography and event-related potentials that can only assess correlational links. In that sense, the "lesional" TMS approach (prolonged interference with brain activity through repetitive stimulation) is similar to the classic neuropsychological approach but with the advantage of being very focal and reversible, as compared to post-stroke or traumatic brain injuries.

2.1.7 TMS as a tool for investigating self (body) recognition

In the present research we used low-frequency repetitive TMS in order to investigate the causal involvement of the right inferior parietal lobule and the right extrastriate body area in self body-parts processing and self-recognition.

The right IPL has long been linked with self-body perception. First, it is well known that lesions in this area can cause deficits in corporeal awareness, such as anosognosia (Vallar & Ronchi, 2006). Moreover, the direct cortical stimulation of the inferior parietal lobule in the right hemisphere is associate with the phenomenon of out-of-body experience, a sensation in which a person's consciousness seems to become temporarily detached from the body and take a remote viewing perspective on the body itself (Blanke, Ortigue, Landis, & Saeck, 2002). Furthermore, this cortical region was indicated in several fMRI studies as the possible neural correlate of the ability to recognize one's own face and body (e.g. Sugiura et al., 2005; Platek et al., 2006; Hodzic et al., 2009a; 2009b; Verosky & Todorov, 2010).

More specifically, our study is based upon the findings of Uddin and collaborators (Uddin et al., 2005a; 2006). These authors have investigated the self-face processing in two consequential studies. Firstly, they have found that a frontoparietal network was activated by images of one's own face. Subjects were presented with pictures of faces, each obtained by morphing to a varying extent (0%, 20%, 40%, 60%, 80%, 100%) pictures of the subjects' own face and the face of a gender-matched highly familiar other. The highly personally familiar other represents a suitable control for the over-learned and highly familiar self-face. Moreover, differently from the often used famous familiar others, it calls for social and emotional attachment (Gobbini, Leinbenluft, Santiago, & Haxby, 2004). The task was to decide whether the image presented looked like "self" or "other". When the activation elicited by the presentation of morphed pictures containing higher percentages of self than other was subtracted from the activation occurring with pictures containing more other than self, an activation of the inferior parietal lobule (BA 40), the inferior frontal gyrus (BA 44), the inferior occipital gyrus (BA 19) and the superior parietal lobule (BA 7) emerged in the right hemisphere (Uddin et al., 2005a). In sum, these authors found that the right IPL activity correlated with increasing "self" component in the stimuli. Subsequently, the same authors went into more depth with their investigations and showed that the right IPL activity is not only correlated but rather causally involved in self-face perception (Uddin et al., 2006). Critically, these authors showed a significant decrease in sensitivity to detect the self-face after rTMS applied to the right but not left IPL.

2.2 RATIONALE OF THE EXPERIMENTS

Recent work in neuroscience indicates a superiority in the processing of self relative to others' body-parts that can be selectively impaired following right parietal damage (Frassinetti et al., 2008; 2010). Based upon these evidences and the above described results from Uddin and co-workers (2006), we applied low-frequency (1 Hz) repetitive TMS for 15 minutes at the MNI (Montreal Neurological Institute) coordinates reported in Uddin et al. (2005a): 64, -24, 50, in order to obtain the inhibition of the right IPL and test whether this area is causally involved in the self body-parts processing and more specifically in self-recognition. It must be noticed that we could not use personally familiar stimuli as "other" given that it is at least unlikely that friends' or relatives' body parts (hands, feet, arms and legs) could become familiar to an individual to the extent that friends' and relatives faces do. Our prevision was that the "self advantage" (i.e., the better performance achieved by subjects in the matching-to-sample task when matching self as compared to other people's body parts; see Frassinetti et al., 2008; 2010) would be reduced following the rTMS over the right IPL if this neural substrate subserves visual recognition of self-body in addition to self-face.

Differently from Uddin and colleagues (2006), that used the left IPL as a control site, we planned to use a baseline condition without TMS in a control experimental session. This decision was mainly due to our need for further evidences of the "self advantage": indeed the matching-to-sample was (at the time of our experiments) a relatively new paradigm that had been successfully used mainly with brain damaged people (Frassinetti et al., 2008). Anyway, we planned to stimulate also the left hemisphere in a different sample of participants whenever convenient to explain any interesting pattern of results obtained in the first experiment.

In a third session, we planned to stimulate the right EBA (from Downing et al., 2001: MNI coordinates: 52, -72, 3). Our choice was linked to the consideration that, to the best of our knowledge, no study had so far investigated the processing of self body-parts in this cortical region, at least using TMS. Moreover, this area is certainly linked to the processing of body stimuli (see Peelen & Downing, 2007 for review). None but one of the fMRI studies that used both participants' own and unfamiliar bodies or body-parts pictures (Chan et al., 2004; Hodzic et al., 2009a; 2009b) revealed that the EBA was sensitive to stimulus identity (but see Myers et al., 2008 for different opinion). Chan and colleagues (2004) found that the right EBA was chiefly activated by stimuli presented in allocentric but not egocentric viewpoint, but still was substantially "blind" to identity. Saxe and colleagues (Saxe et al., 2006) reached the same conclusion with an fMRI study that confirms the EBA sensitivity to allocentric perspective; however, participants' own pictures were not used in this work. Hodzic at al. (2009a) claimed that extrastriate areas are only involved in the detection of body-related visual information, but not in the assignment of body identity, a function that involves parieto-frontal areas.

Critically, the only available evidence showing that event-related rTMS over the extrastriate body area selectively disrupts the visual processing of body identity (Urgesi et al., 2007) did not use participants' own body parts pictures as stimuli.

Given the above evidence, we foreshadowed a general worsening in subjects' performance regardless of body-parts identity following right EBA stimulation. In general, the pattern of results of the whole experiment would enable us to shed light on the involvement of the right IPL and the right EBA in the visual processing of one's own and other people's body-parts.

2.3 EXPERIMENT 1

2.3.1 Method

2.3.1.1 Participants

Nine healthy current students at the University of Milano-Bicocca (5 females, 4 males; mean age = 26.9 years, standard deviation = 9.1) took part in this experiment, obtaining course credits for their participation. Participants were right-handed and had normal or corrected-to-normal visual acuity. None of them reported signs or history of neurological or psychiatric disease or other counter-indications to TMS (Wasserman, 1998). Written informed consent was obtained from each subject prior to participating. The study was approved by the local ethical committee and the protocol was carried out in accordance with the ethical standards of the Declaration of Helsinki (BMJ 1991; 302:1194). All the participants were naïve to the purpose of the experiment and information about the experimental hypothesis were provided only after the completion of all sessions.

2.3.1.2 Stimuli and Procedure

In a preliminary session prior to the experiment, digital pictures of the participants' own right hand, left foot, right leg and left arm were taken with a digital camera Canon Power Shot A720IS in a standard environment. Pictures were then modified by means of Adobe Photoshop software in order to use them as stimuli: pictures were converted to gray scale and resized at the standard height of 220 pixels, maintaining the proportions between height and width. The luminance, contrast and brightness were slightly adjusted in order to make them equal across pictures. All body parts were photographed from above, against a white background in an artificially illuminated environment. Each body-part was depicted in three different postures:

natural vertical posture, rotated of 30° clockwise and rotated of 30° anticlockwise. Pictures of the body parts of six models (three females and three males) were used as distracters. The participants were not familiar with the models so that they never saw the body-parts used as "other" stimuli before participating to the experiment. Therefore, each participant was exposed to a different set of stimuli comprising his/her own 12 stimuli (3 pictures of the hand, 3 of the foot, 3 of the leg and 3 of the arm) and 36 distracters belonging to three gender-matched unfamiliar models (3 pictures of the hand, 3 of the foot, 3 of the leg and 3 of the arm of each model).

In each trial, three stimuli of the same category were simultaneously presented, vertically aligned on a uniform white background (see Figure 4).

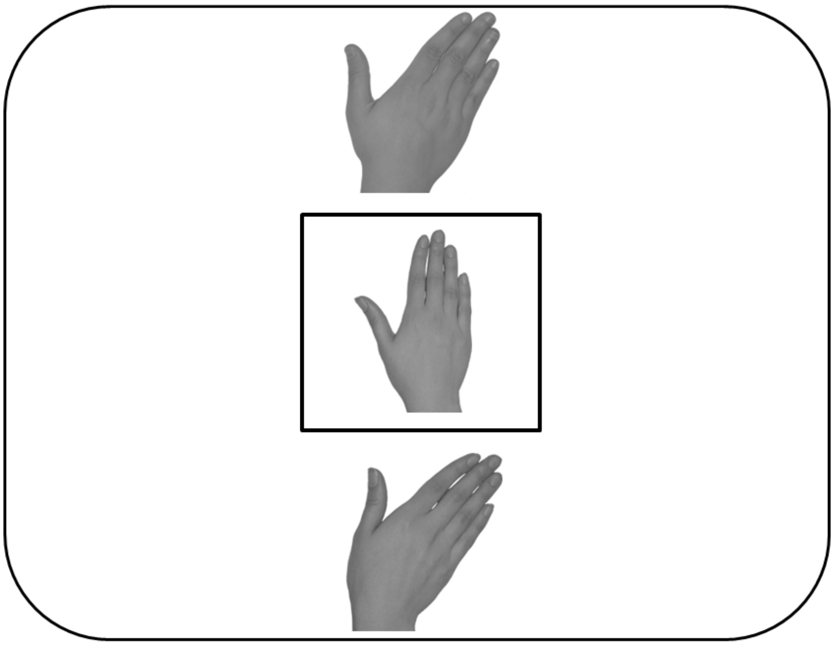

Figure 4. Example of trial presented in Experiments 1, 2 and 3.

The central stimulus represented the body-part depicted in vertical up-right posture, in a black frame, and constituted the target stimulus. The upper and the lower stimuli represented the 30° tilted body-parts, in order to minimize any superficial judgement based upon a low-level visual analysis of the stimulus features. Ninety-six trials were presented to the subject in a random order, in two blocks of 48 trials. A short rest was allowed between the two blocks, if needed. Stimulus presentation and randomization were controlled using E-Prime software (Psychology Software Tools, Pittsburgh, PA) running on a PC Amilo Pro V3515 Fujitsu Siemens. Stimuli were shown in a 15 inches monitor, with resolution 1280 x 800 pixels, so that they subtended a visual angle of 5.5° (height), from a distance of about 57 cm. Forty-eight trials contained the participant's own body-parts and forty-eight trials contained other people's (models') body-parts.

Participants were requested to decide which of the two images (the upper or the lower) matched the central target stimulus by pressing one of two keys on the computer keyboard with their dominant right hand. The participant sat in front of the PC screen at a distance of about 57 cm in a darkened room and completed the task in about 10-12 minutes. Trial duration was not limited and images remained on the screen until a response was given. At odds with Frassinetti et al. (2008), we exerted time pressure on subjects' performance, giving them the instruction to respond as quickly (and accurately) as possible. We introduced this difference in the forced-choice paradigm for two reasons: firstly, in order to better investigate eventual effects of the rTMS on the reaction times, besides the accuracy. Secondarily, because our participants were young healthy adults instead of the brain damaged patients and the older adults tested by Frassinetti and colleagues (2008; 2010). Reaction times and response accuracy were registered for offline analyses.

Each subject performed the task three times, in sessions occurring on separate days to avoid residual effects of TMS (the inter-sessions interval was at least 24 hours). In the baseline session no TMS was applied to the subjects, while in the remaining two sessions the task was completed immediately afterwards a 15 minutes exposure to low-frequency (1 Hz) rTMS (see details in the following paragraph). Each experimental session started after participants were presented with some examples of the stimuli used and performed some trials of practice. The order of sessions was counterbalanced across participants.

2.3.1.3 TMS protocol

In two separate sessions, we stimulated the right inferior parietal lobule (MNI coordinates: 64, -24, 50) and the right extrastriate body area (MNI coordinates: 52, -72, 3). The choice of these stimulation sites was based upon previous fMRI and TMS work (Uddin et al., 2005a; 2006; Downing et al., 2001; Urgesi et al., 2007). SofTaxic Evolution navigator system (Version 1.0, http://www.emsmedical.net) was used to accurately localize the stimulation sites on participants' scalps. Participants wore a tightly fitting swimming cap. Nasion, inion, and two preauricular points corresponded to the main skull landmarks and, together with about 50 points that were carefully marked by the experimenter on the cap, and digitally recorded by the navigator (3D Fastrack Polhemus digitizer), provided a uniform representation of the subject's scalp. The SofTaxic navigator was used to automatically estimate the coordinates of each digitalized point in Talairach space (Talairach et al., 1988) using an MRI-constructed stereotaxic template. This procedure allows to reconstruct the cerebral cortex in Talairach coordinates on the basis of the digitalized skull landmarks, with an accuracy of ~1 cm. Following this reconstruction, an estimation of each individual's cerebral volume is obtained by "Point-based Warping" to an MRI template and areas of interest can be localized on the 3D virtual reconstruction. Scalp locations which matched at best the IPL and the EBA coordinates were identified and marked on the bathing cap. These same points were then targeted with the TMS. A Magstim Super Rapid magnetic stimulator (Magstim, Whitland, UK) and a figure-of-eight coil (70 mm diameter) were used to deliver low-frequency (1 Hz) rTMS. The coil was positioned on the correct site in each session and held tangentially to the scalp, with the handle pointing backward. It was supported by a mechanical device and its position was continuously controlled by the experimenter. TMS stimuli were delivered at the fixed intensity of 65% of the maximal output of the stimulator (2 Tesla for 1 ms), compatible with the intensity used in the TMS study by Uddin and colleagues (2006)[2].

2.3.2 Results

Individual mean percentages of correct responses and RTs for each Stimulus Category (hands, feet, arms and legs) and Stimulus Identity (self and other) were separately calculated for the three sessions (baseline, TMS over EBA and TMS over IPL). Only RTs for correct trials were considered; moreover, we removed values that fell below or above two standard deviations from each individual mean. Analysis was performed on the arcsin transformation of accuracy percentages, as in Frassinetti and colleagues' (2008) study.

A preliminary analysis was run to assess whether subjects' performed differently in the baseline condition depending on which body-parts was presented, taking into account also the Stimulus Identity. A two-way repeated-measures ANOVA was performed on accuracy, with Stimulus Category and Stimulus Identity as main factors. No significant main effects or interactions were found (all *p*s > .05) so that we collapsed data relative to different body-parts.

Then, a second two-way repeated-measures ANOVA was performed with Stimulus Identity and Stimulation Site (no stimulation, EBA and IPL) as factors (see Figure 5). The effects of the two main factors did not reach significance, while the interaction was significant: $F(2,16) = 4.18$, $p < .05$. Post-hoc analysis was conducted using the Bonferroni correction and revealed a

[2] These authors determined the resting Motor Threshold (MT) for each of their eight subjects individually, using the standard procedure: minimal stimulator output that induces motor-evoked potentials (MEPs) of at least 50 μV in five out of ten trials (Rossini, Barker, Berardelli, Caramia, Caruso et al., 1994). The average MT for the subjects was 61.6% maximal stimulator output and all subjects were stimulated at 100% of their MT. So, the value we choose is in line with this previous work and it is also compatible with the inhibitory aim of the present study.

significant worsening of subjects' performance in response to other stimuli after stimulation of the EBA as compared to the baseline condition ($p < .05$).

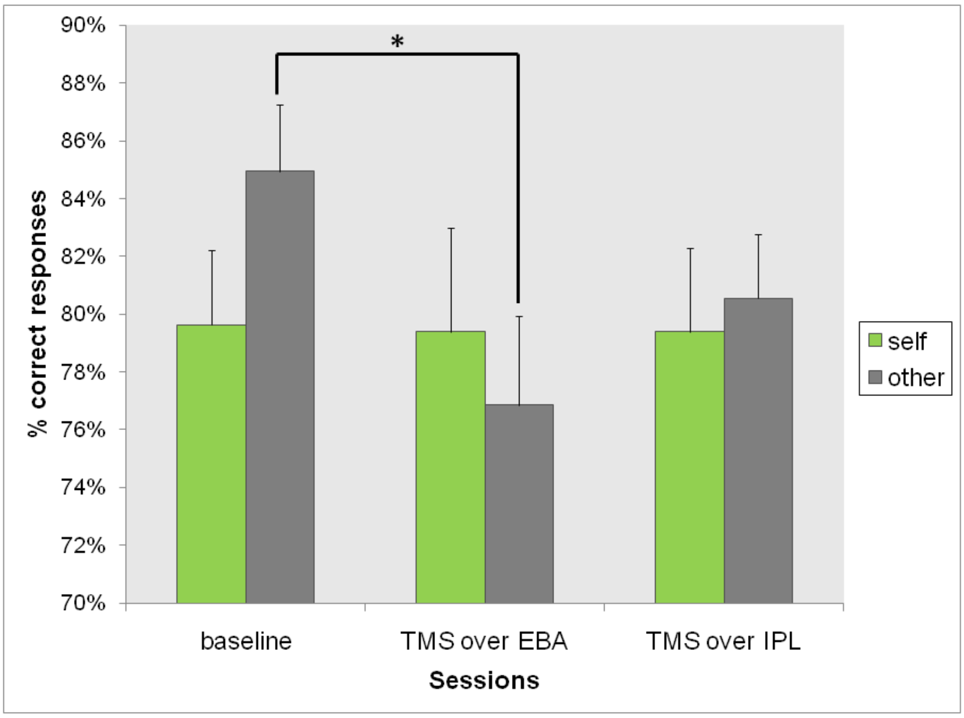

Figure 5. Mean percentages of correct responses (± standard error) as a function of session and Stimulus Identity in Experiment 1.

Despite reaction times were very high on average (range: 1742 – 2548 ms), a similar two-way repeated-measures ANOVA was performed on these values using Stimulus Identity (self, other) and Stimulation Site (no stimulation, EBA, IPL) as main factors. No main effects or interaction were found (all *ps* > .05).

2.3.3 Discussion

The results of Experiment 1 were surprising to some extent. In fact, we failed to replicate the results of Frassinetti and colleagues (2008; 2010) as we did not find any "self advantage" in terms of accuracy: in our sample there was even an opposite trend, with the mean accuracy in the baseline session being 79.6% for one's own body parts and 85.0% for other people's body parts, even if the difference did not reach the statistical significance.

The lack of the previously reported "self effect" in the baseline condition may have affected the possibility of finding a specific TMS modulation. Nevertheless, a significant difference emerged: indeed, the mean accuracy percentage was significantly diminished in response to "other" targets by the rTMS over the right EBA. This result fits with those of Urgesi and collaborators (2007) that showed that rTMS over the right EBA selectively impairs subjects' performance in a form (identity) but not in an action matching-to-sample task. More interestingly, our findings seem to further specify the sensitivity of the EBA, that appears to be not specifically involved in self-related processing but nevertheless able to differentiate between self and others body images. Notably, the present data appear to confirm the results of Myers and colleagues' (2008) study, that showed, using fMRI adaptation, that different parts of the right EBA may perform an important sorting of body part images by identity (including self-recognition). Finally, our results agree with the claim made by Chan et al. (2004): these authors concluded from their fMRI data that the greater activation shown by the right extrastriate body area in response to pictures taken in allocentric views compared to egocentric perspectives might suggest that this cortical region is possibly tuned to the processing of others.

A further aspect of our results that is worth mentioning is that we did not find any modulatory effect after TMS over the right IPL. One could posit that this lack of modulation might be due to the fact that this region was not causally involved in visual recognition of one's own body (at least in our indirect paradigm) to the same extent that it subserves self-face recognition (see Uddin et al., 2005a; 2006). However, several aspects can be remarked that differentiate our study from that of Uddin and colleagues (2006). First, we used body-parts instead of faces. For these stimuli, the differential activation induced by self *versus* non-self stimuli may be smaller, and therefore any evident modulation of the relative neural substrate could be more difficult to obtain. Furthermore, the task used in the present experiment did not require an overt distinction between self and non-self visual stimuli while this was explicitly addressed in the experiment by Uddin et al. (2006). It is possible that these differences might have had a role in the lack of TMS modulatory effects.

Since we failed to replicate previous results, we firstly tried to improve the experimental procedure. First, also following several suggestions coming from our participants, we decided to improve the quality of the stimuli used as distractors. This is always an issue to consider when planning a self-recognition research. For example, when stimuli are faces, one must carefully check stimuli for familiarity (see Gobbini et al., 2004), when photographs depict whole bodies people might dress standard clothes (e.g., Devue et al., 2007). Since we used pictures of body-parts, we simply selected three female and three male models that were unfamiliar to the participants. Probably this was not enough, and moreover some of the female models' body-parts turned out to be very different from those of other models and most of participants so that they were very easily detected, as reported from several participants. The excessive ease in matching some of the models' stimuli might indeed have prevented the "self advantage" to emerge. Therefore, we paid even greater attention to accurately chose very "average" stimuli as distractors, matching them in terms of shape, size, colour, brightness etc. Finally we opted to go back to the exact original task developed by Frassinetti and colleagues (2008). In particular we avoided to give any response speed pressure to the participants, since this proved not to be effective in producing reasonably fast response times, while at the same time it may have reduced the "self advantage" in the accuracy. These methodological changes are described in detail in the following paragraph.

2.4 EXPERIMENT 2

Experiment 2 was conceived with the same rationale of Experiment 1, that is to test whether the right inferior parietal lobule and the right extrastriate body area play a critical role in distinguishing between self and other bodily stimuli and in visual recognition of one's own body-parts. We used the same paradigm developed by Frassinetti and collaborators (2008) and utilized in Experiment 1, with some methodological changes.

First, we improved the stimuli used as other by choosing three new female models, as explained above. We replaced these pictures taking into account the shape of each body parts: all stimuli depicted very "average" body parts lacking of peculiar characteristics and did not differ in any of their distinctive shape features, nor in colour, brightness or size.

More importantly, two differences were introduced in the task and in the rTMS protocol. Differently from our first study but similarly to Frassinetti et al.'s (2008) research, we totally avoid to exert time pressure on subjects' performance, for the reasons discussed above. Therefore, in this second experiment there was no time restriction to produce the response. Given that this change in the instruction would have probably prolonged the duration of the behavioural task itself, we decided to extend the phase of rTMS from 15 to 20 minutes in order to have an effect lasting for at least 15-20 minutes after the stimulation.

2.4.1 Method

2.4.1.1 Participants

Sixteen right-handed healthy students (8 females, 8 males; mean age = 23.1 years, standard deviation = 3.4) were recruited to take part in the experiment. They received course credits for their participation. All students had normal or corrected-to-normal vision and were naïve to the purposes of the research. All participants signed a written informed consent before their participation and were screened to rule out history of neurological or psychiatric disorders, medication use, or other serious medical conditions or counter-indications for TMS

(Wasserman, 1998). The study was conform to the Declaration of Helsinki and it was approved by the ethics committee of the University of Milano-Bicocca.

2.4.1.2 Stimuli and Procedure

Procedure was the same as in Experiment 1, with the only difference that no time pressure was given for the response. Accordingly, only response accuracy, but not speed, was recorded and stored for analysis.

2.4.1.3 TMS protocol

Again the procedure was as in Experiment 1, with the exception that the stimulation duration was prolonged to 20 minutes.

2.4.2 Results

As shown in Figure 6, in this second experiment we found the "self advantage" firstly demonstrated by Frassinetti and collaborators (2008; 2010). A preliminary analysis was run to assess whether subjects performed differently in terms of accuracy in the baseline condition depending on which body parts or whether self or non-self stimuli were presented. A two-way repeated-measures ANOVA was performed on accuracy, taking Stimulus Category (hands, feet, arms, legs) and Stimulus Identity (self, other) as main factors. Both main effects were significant: $F(3,45) = 6.27$, $p < .005$ for Stimulus Category and $F(1,15) = 4.99$, $p < .05$ for Stimulus Identity. The difference related to Stimulus Identity was clearly due to better accuracy in response to self than to other stimuli. Paired t-tests were performed in order to know which body-part differed from which other body-part. Given that a pattern composed by hands and feet *versus* arms and legs emerged from t-tests[3], subsequent analyses were conducted separately for each cluster of stimuli.

Furthermore, two separate ANOVAs were performed with Stimulus Identity and Stimulation Site (no stimulation, IPL, EBA) as main factors. Analysis relative to hands and feet showed a main effect of Stimulus Identity ($F(1,15) = 13.92$, $p < .005$) due to better performance when participants' own compared to other people's pictures were presented; no main effect of Stimulation Site or interaction were found. Although no interaction was found, it was decided to run a direct comparison between self and other in the baseline condition in order to specifically

[3] Percentage of correct responses to hands differed from that to arms ($t = 3.55$, $p < .005$) and to legs ($t = 2.46$, $p < .05$), but not to feet ($t < 1$, $p > .6$). Percentage of correct responses to feet differed from that to arms ($t = 4.03$, $p < .005$) and to legs ($t = 2.62$, $p < .05$). Finally, percentages of correct responses to arms and legs were not significantly different ($t < 1$, $p > .7$).

assess whether the "self advantage" was present or not. We found a significant difference ($t(15) = 3.77$, $p < .005$), thus replicating previous results (Frassinetti et al., 2008; 2010).

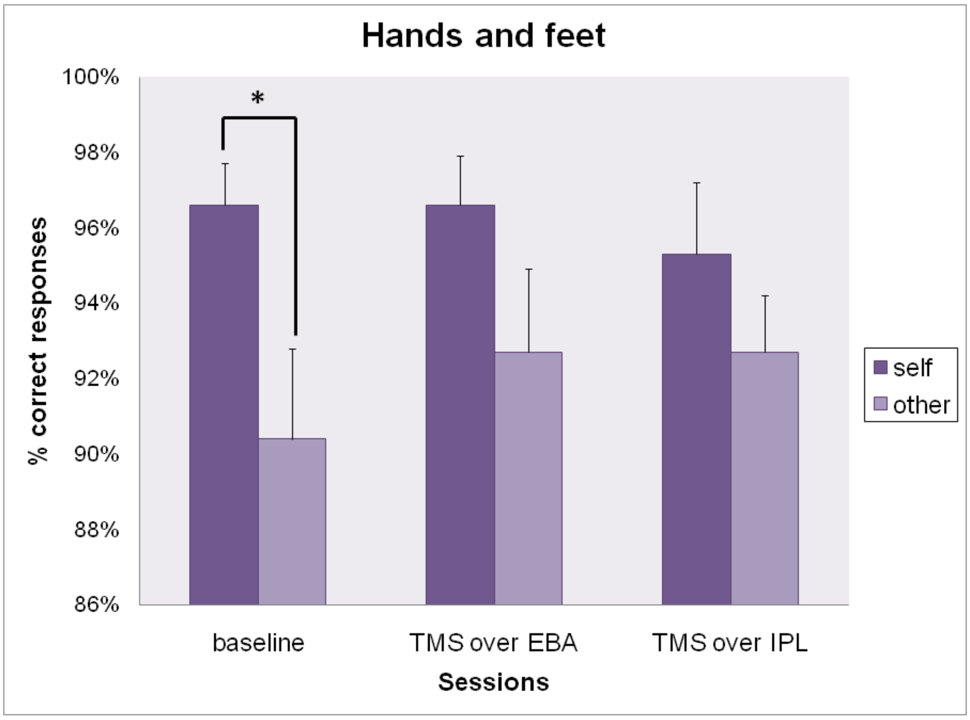

Figure 6. Mean percentages of correct responses (± standard error) as a function of session and Stimulus Identity in Experiment 2. Data are relative to hands and feet.

Results of the ANOVA relative to arms and legs did not show significant differences (all *ps* > .05), even if there was a trend in the expected direction, i.e. higher accuracy for self than for non-self stimuli (see Figure 7).

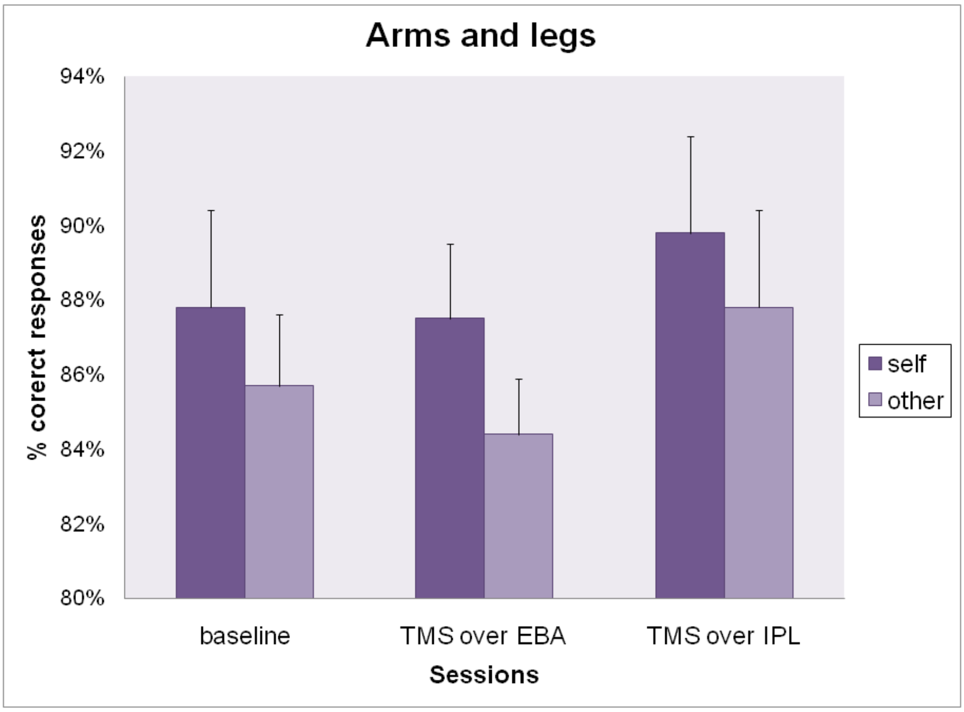

Figure 7. Mean percentages of correct responses (± standard error) as a function of session and Stimulus Identity in Experiment 2. Data are relative to arms and legs.

2.4.3 Discussion

In Experiment 2, after improving the stimuli and using the original paradigm with no request of maximal velocity, we replicated the results from Frassinetti and colleagues (2008; 2010). Specifically, a significant "self advantage" in terms of matching-to-sample accuracy was revealed when considering hands and feet stimuli, while it was lacking in the case of arms or legs, even if there was a trend in the expected direction. The difference that emerged between different body parts has never been investigated or incidentally found in previous works at best of our knowledge (e.g., Myers et al., 2008). We believe that the pattern of results found in the present work might be due to the larger visual exposure that we typically have to limb extremities as compared to limbs themselves, and also to the greater characterization of these anatomical structures that, although not as peculiar as faces, show several distinguishing anatomical and functional features.

As far as the critical aim of the present study, we failed to find any modulation in the response to self *versus* other visual stimuli following TMS stimulation. In fact, even if we increased the duration of stimulation from 15 to 20 minutes in order to increase the post-stimulation inhibitory effect, the present results suggest that rTMS applied as in the present protocol was not active in reducing the accuracy to any stimulus condition.

2.5 GENERAL DISCUSSION AND CONCLUSIONS

Considering the results of Experiments 1 and 2, two main conclusions can be drawn. First, the findings of Frassinetti and colleagues were replicated (2008; 2010), with a general advantage for self as compared to non-self stimuli at least when considering data relative to hands and feet. In particular, a better performance in the matching-to-sample task when one's own stimuli were presented, compared to unfamiliar stimuli, was found in the baseline condition of Experiment 2, in which the experimental procedure matched as close as possible that of previous work by Frassinetti. This is *per se* an important result, given that evidence for a specific ability in self body-parts recognition in humans are still scarce. To our knowledge, all experiments that reported behavioural data used pictures of whole bodies and there is no consistency among them regarding whether or not self body-related stimuli hold a special *status* in visual processing. For instance, Devue and colleagues (2007) showed that the processing of self-relevant stimuli was faster than that of stimuli depicting a colleague, although there was no effect of stimulus identity on accuracy. Moreover, original and manipulated photographs of the participants' hips were used as stimuli and only females were tested in this study, and these aspects -given the emotional importance that women usually give to their body appearance (see for example Kurosaki et al., 2006)- cannot be considered as neutral. In general, previous work rather showed that our memory and ability to visually recognize our own bodies and body-parts is far from being perfect (Wolff, 1932; Daury et al., 2009), especially if compared to the excellent performance we usually obtain with faces. Also the study of Sugiura and colleagues (2006) did not show differences in accuracy and reaction times in response to one's own *versus* a friend's whole body-image (in a task that required a familiarity judgement with stimuli depicting self and friend *versus* unfamiliar bodies and faces). Analogously, no differences were reported in the control behavioural experiment in the study of Hodzic et al. (2009a). By contrast, the analysis of the behavioural measures relative to another fMRI experiment by the same research group, which used very similar stimuli and task (Hodzic et al., 2009b) showed more accurate responses to the self than to a familiar other, but -intriguingly- no difference between self and unfamiliar others.

Overall, the fact that the majority of our subjects showed the "self advantage" seems to suggest that individuals hold an accurate representation of their own body-parts. Such a specific representation may elicit automatic forms of visual recognition even when the body identity is not overtly taken into account. Intriguingly, the advantage for self body-parts was obtained only for the limb extremities and not for leg and arm stimuli. This suggests the interesting conclusion that any advantage for the self-body processing may be relative to body segments that hold higher functional motor properties, and/or a deeper brain representation based on visual experience. Functional properties and visual experience would be particularly important for body segments other than the face, since they surely hold less peculiar and personal anatomical landmarks and features as compared to the face, which is the main determinant of people's identity.

As far as the results of the TMS on self-body recognition, these do not allow us to draw conclusions about the causal involvement of the right EBA or IPL in the processing of self body-parts. Furthermore, the evidence gathered in Experiment 1 for a selective worsening in participants' performance in response to stimuli belonging to unfamiliar people after right EBA stimulation, although interesting, was not confirmed in Experiment 2. A possible explanation for it is that a significant decrease in performance accuracy may only be detected when fast responses are required (as in Experiment 1 and in Urgesi et al., 2007). In addition, rTMS did not affect performance when applied to the right IPL. On the one side one could consider that the absence of an effect on self-recognition following EBA stimulation could be somewhat attended, given previous results showing that this area does not seem to activate for first-person view of bodily stimuli more than for third-person views, as it would be expected given a functional specialization in self-body processing (Chan et al., 2004). On the other, an effect of interference over the IPL could be expected on the basis of previous work, for example that showing the link between right parietal lobe damage and disorders of body-awareness such as anosognosia and somatoparafrenia, characterized by a delusion of disownership of left-sided body-parts (Vallar et al., 2009). Or, more specifically, the results of several fMRI studies that found right parietal activity in response to self-stimuli (Hodzic et al., 2009a; 2009b; Uddin et al., 2005a; 2006). Of course, the absence of evidence cannot be taken as an evidence for absence of a specific involvement of parietal cortex in self-recognition; some hypotheses may be advanced for this negative result. We may hypothesize some methodological reasons. It is possible, for instance, that our TMS protocol did not produce any effective cortical inhibition or that inhibition, if present, was not strong enough to interfere with the targeted, high-level cognitive function. Moreover, from further analyses we conducted on our data, it was found that TMS did not impair subjects' performance even when only the first half of trials post-stimulation were considered. This seems to suggest that the inhibition of the right IPL was probably not effective overall, i.e. even immediately at the end of the TMS stimulation. This in spite of using the same parameters of TMS stimulation and IPL coordinates than Uddin and colleagues (2006), although stimuli and task were not the same. In this respect, a strategy to increase the probability of finding cognitive effects may be linked to the TMS protocol. In particular, one could stimulate areas of interest using high frequency stimulus parameters. For example, adopting a rTMS protocol more similar to the one used by Urgesi and colleagues in their studies (2004; 2007), consisting of couples of 10 Hz pulses that were delivered over EBA shortly after each trial onset, in an on-line paradigm, might be more effective. Indeed, this kind of stimulation is known to produce higher, although short lasting, cortical interference (Pascual-Leone & Walsh, 2002).

One intriguing and interesting aspect of our experiments is that, even if the majority of participants showed some advantage for self than non-self body-parts, not all participants showed this effect. This kind of trend is generally overlooked in cognitive behavioural experiments where the average performance of a group of participants is taken into account and analyzed. However, there is an increasing interest into the individual differences in the cognitive processes that play a role in a given task (e.g., Spalding & Hardin, 1999; Perugini, Richetin, & Zogmaister, 2010). This may be very relevant when assessing fundamental human abilities such as self-recognition. In particular it may be the case that an advantage for self body-parts in a visual task may be stronger for people holding certain psychological or personality factors. This variability may be very high among participants (Schröder-Abé, Rudolph, & Schütz, 2007) and may determine the inconsistency in the processing of self body-parts found in different studies, as discussed above.

For these reasons we decided to investigate how personality factors may bias the basic "self advantage" in body recognition tasks similar to the one used so far. This topic will be the subject of Chapter 3.

CHAPTER 3

Self-body recognition: The role of self-esteem

3.1 INTRODUCTION

In the present work, we aimed at examining the human ability of self-body recognition, joining insights derived from implicit social cognition. Physical self and self-esteem are both parts of the self-concept (Epstein, 1973; Klein & Gangi, 2010). Moreover, self-worth is heavily linked to body perception in individuals with pathology (e.g., eating disorders and body dysmorphic disorders; see Sachdev, Mondraty, Wen, & Gulliford, 2008; Buhlmann, Teachman, Gerbershagen, Kikul, & Rief, 2008) as well as healthy people. In this context, the first aim of this contribution was to investigate whether the self body-recognition ability in healthy people is modulated by implicit and explicit self-esteem. Although implicit self-esteem has been recently shown to play a role in face-recognition (Ma & Han, 2010), to our knowledge no studies so far examined the relationship between both implicit and explicit self-esteem in the recognition of body-parts other than the face. More precisely, we tested whether recognition of self body-parts (i.e., hands and feet) was significantly affected by one's own self-esteem, especially implicit. Second, we were interested to investigate the extent to which different tasks (i.e., indirect/covert *versus* direct/overt body recognition) are equally efficient as measures of self-recognition and whether these tasks are differentially affected by implicit and explicit self-esteem.

In the following paragraphs, relevant issues will be presented in order to clarify the theoretical background of the present research, with particular emphasis on measures of implicit self-esteem. We believe that investigating the role of individual differences in cognitive functions, that are usually considered universal, may allow a better understanding of human cognition. Moreover, this method of investigation is innovative since it may bring to fruitful results that are relevant for research in social cognition and cognitive neurosciences.

3.1.1 The physical self as part of the self-concept

As noted by Allport: "Who is the I that knows the bodily me, who has an image of myself and a sense of identity over time, who knows that I have propriate strivings? I know all these things, and what is more, I know that I know them. But who is it who has this perspective grasp? ... It is much easier to feel the self than to define the self." (Allport, 1961). The self, as many other fundamental psychological concepts, is doubtless difficult to define. In the words of Pinker (1997, *p. 564*), "The I is not a combination of body parts or brain states or bits of information, but a unity of selfness over time, a single locus that is nowhere in particular". However, self-concept may effectively be considered as the totality of perceptions that individuals have of themselves, and this self identity plays an important role in the psychological functioning of everyone.

Despite the fact that each one of us has the experience of a unitary self, starting from the end of the 19th century philosophers and psychologists have investigated the possible variations of this concept. More than one century ago, William James (1890) theorized the physical self, the mental self, the spiritual self and the ego. Besides, neuropsychological findings have contributed to support the idea that the self is not a single and unitary entity. It rather seems to be a multiplicity of interrelated and interacting, although functionally independent and separable, systems. Selective neuropsychological disorders relative to the self may help researchers to identify otherwise (i.e., when operating under healthy conditions) hardly isolable systems. In a non-exhaustive list, Klein and Gangi (2010) have reported:

- episodic memories of one's life events;
- semantic knowledge of facts about one's life;
- experience of continuity trough time;
- semantic summary representations of one's personality traits;
- the ability to self-reflect;
- a sense of personal agency and ownership, that refers to the beliefs and experiences that each individual is the cause of his own thoughts and actions;
- the physical self, namely the ability to represent and recognize (e.g., in mirrors, photographs, videos) one's own body.

Much work (see also Marsh, 1990) has contributed, over time, to establish the current view of the self as a multidimensional concept, confining the feeling of a unitary self in the subjective domain. In 1973, while reviewing all the characteristics attributed to the self Epstein noted that, like many other "empirical selves", the physical self is part of the self-concept. Accordingly, Gillihan and Farah (2005) have proposed a useful distinction between physical and psychological aspects of the self. Physical aspects have been usually examined in studies of whole body or body-parts perception, whereas psychological aspects have often been addressed with researches encompassing general self-knowledge, autobiographical memory, personality, feelings of self-worth and first-person perspective, that is the subjective perspective from which people view the world. Notably, the physical dimension is commonly considered as a fundamental component of the general self-concept (James, 1980; Epstein, 1973; Marsh, 1990; Gillihan & Farah, 2005).

Indeed, our physical self is the centre of our subjective experience and therefore awareness of our own bodies represents perhaps the most fundamental aspect of self-awareness. Remarkably, we are not only aware to have a body, we are also intriguingly able to recognize our own body-images. In this regard, it is noticeable that the ability of recognizing one's own image in a mirror has been demonstrated in a restricted number of species (e.g., Gallup, 1970) and in infants starting from their second year of life and has been therefore considered as an important marker of self-awareness (see Chapter 4 for further discussion). Specifically, according to Epstein, the development of a physical self starts with the child learning that his/her own body is just one among all human bodies and also that his/her own body is uniquely his/her own (Epstein, 1973).

Therefore, it appears at least likely that the physical self and the psychological self are strictly related to each other, both being fundamental for building up the general self-concept and the strong feeling of unity that each of us experiences relative to oneself in normal conditions. In particular, several findings deriving from various topics of normal and abnormal psychology (e.g., eating disorders, adolescence etc.; see Meijboom, Jansen, Kampman, & Schouten, 1999; Cockernham, Stopa, Bell, & Gregg, 2009) seem to evidence close links between the physical self and the feeling of self-worth.

Given the above considerations, the aim of the present work was to investigate the relationship between self-esteem (in the general meaning of an evaluation of oneself; Rosenberg, 1965) and self body-parts recognition (starting from works by Frassinetti et al., 2008; Frassinetti et al., 2010; and from the studies presented in Chapter 2 of the present thesis).

In the next sections some relevant concepts relative to the self-concept will be introduced with the purpose to introduce the experimental design and aims. In particular, paragraph 3.1.2 will focus on the interplay between physical self and self-esteem which is critical for the experiments presented in the present chapter.

3.1.2 Physical self, body image and self-esteem

In a different psychological tradition, what was named physical self in the previous paragraph is usually referred to as "body image". Body image, according to Gallagher's definition, is a system of perceptions, attitudes and beliefs about one's own body that is involved in the sense of ownership and self-consciousness (Gallagher, 2000). Notably, typical definitions highlight the affective nature of body image. As a consequence, a strict connection might link body image and feelings of self-worth.

Despite the clinical impression that self-esteem is generally low in specific clinical samples particularly concerned about body shape and weight, only recently psychological research has started to investigate the issue more systematically. Notably, overvalued ideas about body, weight, and shape and their undue influence on self-esteem characterize patients with eating disorders (e.g., Cooper & Fairburn, 1993). Specifically, the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association [APA], 1994) defines the undue influence of body weight and shape on self-evaluation as one diagnostic criterion of Bulimia Nervosa (BN)[4] and a possible marker of altered body image in Anorexia Nervosa (AN)[5]. Cognitive-behavioural models of bulimia nervosa emphasize the importance of an excessive concern about one's own body shape in the aetiology and maintenance of bulimic symptoms. Furthermore, these models suggest that low self-esteem represents a risk factor for developing overvalued ideas about body shape and appearance (Meijboom et al., 1999). Meijboom and co-workers (1999) demonstrated experimentally that the accessibility of subliminally presented verbal stimuli related to body shape and weight (measured with a lexical decision task: words *vs.* non-words) was increased in restrained eaters following a low self-esteem priming procedure (i.e., retrieving a memory of an event in which the subjects had the feeling they had failed).

To the best of our knowledge, only few studies have so far investigated experimentally the link between self-esteem and body concern in patients with eating disorders. In particular, in two papers the self-esteem Implicit Association Test (IAT; Greenwald & Farnham, 2000) was used to this purpouse. This test will be presented in details in section 3.1.6. In short, the IAT assesses the implicit self-esteem by comparing the strength of associations between the self-concept and positive *versus* negative attributes. Cockernham and colleagues recently compared a group of 20 female individuals with BN or binge eating disorder to an healthy control group (Cockernham et al., 2009). The patients showed lower explicit self-esteem (measured using the Rosenberg Self-Esteem Scale or RSES; Rosenberg, 1965), thus partially confirming the authors' hypothesis. However, they also manifested a more positive implicit self-esteem than healthy controls, suggesting that the focal point rather consisted in the incongruence between explicit and implicit values. In another experiment, Hoffmeister, Teige-Mocigemba, Blechert, Klauer and

[4] Critical BN criterion from DSM-IV: ***D.*** Self-evaluation is unduly influenced by body shape and weight.

[5] Critical AN criterion from DSM-IV: ***C.*** Disturbance in the way in which one's body weight or shape is experienced, undue influence of body weight or shape on self-evaluation, or denial of the seriousness of the current low body weight.

Tuschen-Caffier (2010) showed that implicit self-esteem, assessed through the IAT, can be modulated following the experimental manipulation of the participants' awareness about their body shape and weight. In particular, implicit self-esteem increased in unrestrained eaters, but decreased in restrained eaters. This result suggests that the initial level of body (dis)satisfaction might determine whether the activation of the body schema leads to an increased or decreased implicit self-esteem.

Equally important to our concern are two studies in which Buhlmann and colleagues (Buhlmann et al., 2008; Buhlmann, Teachman, Naumann, Fehlinger, & Rief, 2009) investigated the self-esteem biases in individuals diagnosed with Body Dysmorphic Disorders (BDD)[6]. The hallmark of BDD is an over-concern about a slight or imagined "defect" in the body appearance, frequently related to the face, skin, or hair. Individuals with BDD misperceive the "defect" as hideous and repulsive, although this is usually irrelevant or even not noticeable to other people. The results showed significantly lower implicit (and explicit) self-esteem in the clinical sample (total N = 36) with respect to both healthy people and subclinical population with intermediate scores between the other two groups (Buhlmann et al., 2008; 2009). In addition, the self-esteem IAT was a significant predictor of BDD symptoms severity and distress and avoidance behaviour shown during mirror-exposure (i.e., the deliberate, planned and systematic exposure to body image). Therefore, the results of Buhlmann and colleagues (2008; 2009) seem to suggest that beliefs relative to body appearance are the outcome of an evaluative bias linked to poor self-esteem. Critically, cognitive-behavioural models propose that individuals with BDD misinterpret visual input from normal aesthetic features or minor appearance flaws and the misinterpretation leads to excessive anxiety, shame and worrying (e.g., Wilhelm, 2006). Moreover, these subjects have maladaptive beliefs about the importance of attractiveness. Given these premises, these individuals think they are ugly, evaluate themselves negatively and have low self-esteem. Although it is still unclear whether poor self-esteem predisposes to BDD and/or it is a consequence of the disorder, overall the experiments discussed above provide further evidence that self-esteem and problems related to the body image perception and evaluation (body concern and dissatisfaction) are linked to each other.

The fact that individuals with BDD show misperceptions relative to their bodies is reminiscent of the behaviour of patients with anorexia nervosa. More specifically, in these patients a disturbance in self body weight and shape experience (usually a systematic

[6] BDD criteria from DSM-IV: ***A.*** Preoccupation with an imagined defect in appearance. If a slight physical anomaly is present, the person's concern is markedly excessive. ***B.*** The preoccupation causes clinically significant distress or impairment in social, occupational, or other important areas of functioning. ***C.*** The preoccupation is not better accounted for by another mental disorder (e.g., dissatisfaction with body shape and size in Anorexia Nervosa).

overestimation) is likely to involve both perceptual and affective components. Indeed, it has been found that individuals with eating disorders might have functional abnormalities in brain systems concerned with body-image processing. Uher and colleagues (Uher, Murphy, Friederich, Dalgleish, Brammer et al., 2005) conducted an fMRI study and found that parts of the distributed neural network that processes body image were hypoactive in women with eating disorders (especially AN). This hypoactivity may underlie the failure to represent and evaluate one's own body in a realistic way. Subsequently, further studies confirmed and specified these claims. Sachdev and colleagues (2008), in a neuroimaging study, revealed that patients suffering from anorexia nervosa did not show the same pattern of activation of non-AN subjects when presented with self-stimuli (pictures of their own bodies), while they showed no difference in the processing of non-self images. So, AN patients are characterized by a distorted self-body perception and damaged self-esteem, therefore linking body image, self-esteem and body recognition. Rosen (1990) suggested that there are two components of the body image distortion in AN: a perceptual disturbance that generally leads to overestimation or distortion of body size and shape and a cognitive and affective dissatisfaction with one's own body.

Several authors also noticed as the link between self-esteem and the physical self (or body-image) is tight even in the non-pathological population (Furnham, Badmin, & Sneade, 2002; Hoffmeister et al., 2010). Indeed, the physical self is becoming an increasingly important correlate of global self-concept and Fox proposed that the perception of one's own physical self is related to the global self-concept (Fox, 1998). Therefore individuals with a negative sense of self, living in a society obsessed with body perfection, would reflect their feelings of worthlessness in the way they perceive themselves (thus acquiring the feeling of a distorted body image; see Furnham et al., 2002). Finally, as reported above, in the recent work by Hoffmeister and colleagues (2010) unrestrained eaters' implicit self-esteem did not remain stable after the body mirror exposure manipulation, suggesting that the association between self-esteem, body image and shape/weight concern might represent a connection that is not limited to individuals with eating disorders.

To summarize, a growing amount of evidence recently pointed out that physical self, body image and self-esteem are highly connected concepts not only in psychopathology, but in healthy people as well. In this view, we planned our studies with the aim of investigating the role of individuals' self-esteem in the perceptual processing of their own body, as assessed through self body-parts recognition tasks.

Before proceeding to the experimental part, in the next section an overview of self-esteem and its measurement methods will be presented.

3.1.3 Self-esteem: An introduction

In the theoretical frame of implicit social cognition, the self-concept can be defined as an associative network containing associations between the self and attribute concepts (Greenwald, Banaji, Rudman, Farnham, Nosek et al., 2002). Greenwald and Pratkanis (1984) proposed a theoretical model in which four hierarchically organized aspects of the representation of the self are described, each differentially contributing to self-evaluation and self-esteem: diffuse, public, private and collective self. The authors consider the diffuse self as an implicit self aimed at satisfying basic needs, whereas hierarchically higher aspects of the self are assimilated to an explicit self, concerned at gaining public, private or collective acceptance. In this view, achieving given targets increases self-esteem, while missing targets decrease it.

In the idea of Greenwald and Pratkanis's (1984) self-esteem represents the affective part of the self-concept, the association of the self with valence (Greenwald, Banaji, Rudman, Farnham, Nosek et al., 2002). Given its relevance for people's well-being, self-esteem is one of the most widely investigated topics in modern psychology and the subject of thousands of scientific publications in the last decades. Indeed, self-esteem is a central component of individuals' daily experience, since it refers to the way people feel about themselves, which reflects and affects their ongoing relationships with other people and the environment. Overall, self-esteem is considered to be a core concept in psychology given, for example, that moderate or high self-esteem seems to be a prerequisite for healthy human functioning.

According to Rosenberg's (1965) definition, self-esteem is an evaluation of oneself, a "favourable or unfavourable attitude toward the self". Rosenberg defined the self-concept as "an organisation of parts, pieces and components ... hierarchically organised and interrelated in complex ways ... with self-esteem being the totality of the individual's thoughts and feelings having reference to himself as an object". Therefore, self-esteem is considered a judgement about the self as a whole, although the self is regarded as hierarchical. According to Zeigler-Hill and Jordan (2010), self-esteem represents the evaluative aspect of self-knowledge that reflects how much people like themselves. In particular, explicit self-esteem is presumably based upon conscious beliefs about the self.

Direct measurement of self-esteem has a long history and is generally referred to as explicit, being based on self-reports made by individuals that introspectively reflect upon how they feel about themselves. Among the explicit measures of global self-esteem most widely used in psychological research, there is the Rosenberg Self-Esteem Scale (Rosenberg, 1965). The majority of people in non-pathological population obtain medium to high self-esteem scores in the Rosenberg Scale, while only a small minority is characterized by having low self-esteem.

Individuals with high self-esteem like, value and accept themselves, including their own imperfections; nonetheless, as Rosenberg himself pointed out, they usually do not feel superior, but rather on an equal plane with others.

In general, explicit measures of self-esteem offer a number of advantages, not last that of being quickly, cheaply and easily administered. Moreover, they possess strong and well-ascertained psychometric properties (i.e., high reliability and validity, in particular a good predictive validity). Above all, directly asking participants about their feelings about themselves makes a lot of sense considering that self-esteem is a subjective evaluation of the self. However, explicit measures of self-esteem are based upon two assumptions that are not always true: (1) individuals respond to direct measures of self-esteem accurately reflecting their feeling of self-worth and (2) individuals have introspective access to all aspects of their self-esteem. In most authors' opinion, people are not aware of all aspects of their attitudes, neither in general nor toward themselves. Moreover, reports concerning introspection are not always sincere, but rather they might be altered by social desirability. In other words, there might be more about ourselves than we can tell or want to tell.

Starting from the above considerations and a renewed scientific interest for many aspects of the self that cannot be introspectively accessed, a great number of implicit methods for measuring implicit self-esteem were recently developed.

3.1.4 Implicit self-esteem

Greenwald and Banaji (1995) suggested that there are implicit aspects of self-esteem besides the explicit ones. In their definition, implicit self-esteem refers to "introspectively unidentified (or inaccurately identified) effect of the self-attitude on evaluation of self-associated and self-dissociated objects" (Greenwald & Banaji, 1995, *p. 11*). Put more simply, implicit self-esteem is an "implicit attitude toward the self" (Dijksterhuis, 2004, *p. 353*). Researchers consider implicit self-esteem as an individual's overlearned, automatic and unconscious self-evaluation. The findings of a research conducted by Koole and co-workers support the notion that implicit self-esteem is driven by automatically activated self-evaluations without any conscious self-reflection (Koole, Dijksterhuis, & van Knippenberg, 2001). In fact, implicit self-evaluations were found to correspond with explicit self-evaluations to a greater extent in the case they were measured under time pressure or cognitive load, i.e. constraints that are thought to limit the possibility of adopting explicit cognitive strategies.

The distinction between explicit and implicit self-esteem relies on dual process models, recently developed as a consequence of the renewed interest for the unconscious side of psychological experiences. Banse and Greenwald (2007) have illustrated the history of psychology as a theoretical pendulum that moved from psychoanalytic views toward cognitive paradigms in the second half of the 20th century and is now swinging again toward the unconscious pole. In fact, beliefs about the dominance of conscious control over behaviour have gradually eroded since 1980 and automaticity has been acknowledged as one of the most important determinants of human behaviour (Hassin, Uleman, & Bargh, 2005). Therefore, during the last decades there has been a renaissance of interest in processes that are believed to operate outside of awareness, especially in the field of implicit social cognition[7] (see Greenwald & Banaji, 1995).

Recently, besides unitary models (e.g., Fazio's (1990) Motivation and Opportunity as Determinants model or MODE), dual-process models have been proposed that assume two classes of psychological processes at the basis of different aspects of implicit social cognition (e.g., attitudes, stereotypes and cognitions relating to the self-concept such as self-esteem; Greenwald et al., 1995; 2002). Among these models, the Reflective-Impulsive Model (RIM; Strack & Deutsch, 2004 see Figure 8) has gained a large consensus.

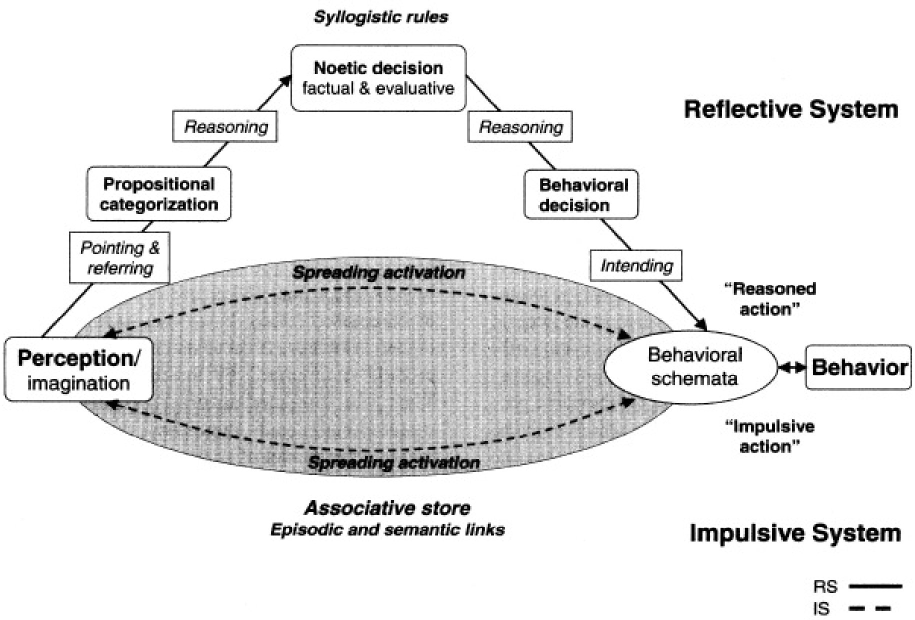

Figure 8: The Reflective-Impulsive model (from Strack and Deutsch, 2004).

The model proposes that behaviour is the result of the parallel and sometimes interactive influence of two separate systems of information processing, the Reflective system (slow,

[7] The general view about the mechanisms of implicit cognition is that traces of past experience affect performance, even if the experience itself is not available to self-report or introspection.

onerous in terms of cognitive and attentive resources, intentional, accessible to introspection) and the Impulsive system (rapid, economic in terms of cognitive and attentive resources, unintentional, not accessible to introspection). While behaviour deriving from the Reflective system is the outcome of a decision process, behaviour originates from the Impulsive system through a "spreading of activation" of associative nets. Spreading of activation operates on concepts represented as nodes in a semantic network; the activation of one concept can spread through associations that connect similar concepts, thus facilitating their subsequent processing.

Therefore, it appears that -as conceptualized by dual-process models- while explicit self-esteem refers to the Reflective cognitive system, implicit self-esteem is the product of an automatic, intuitive processing (in the Impulsive system). As a consequence, given that the two forms of self-esteem reflect and are influenced by different processes, asymmetric changes may intervene, leading to discrepancies between explicit and implicit self-esteem. The last two issues, that of the intuitive nature of implicit self-esteem and that relative to possible discrepancies, are well illustrated and combined in a study by Jordan and colleagues (Jordan, Withfield, & Zeigler-Hill, 2007). These researchers showed that individuals that viewed their intuitions as valid –as expressed in spontaneous conditions or following an experimental manipulation- also exhibited more consistent implicit and explicit (measured as self-evaluations made under time pressure) self-esteem.

Implicit self-esteem is thought to have at least some roots in early childhood experience, particularly in social interactions in early life, as suggested by a work that has revealed a relation between students' implicit self-esteem and reports of their interactions with their parents during childhood, separately reported by themselves and their mothers (DeHart, Pelham, & Tennen, 2006). Previous evidence suggesting a certain stability of implicit self-esteem came from Hetts and colleagues (Hetts, Sakuma, & Pelham, 1999). These authors, starting from previous demonstration that East Asians have more modest self-views compared to North Americans (see Heine, Lehman, Markus, & Kitayama, 1999), evidenced an interesting pattern in people recently emigrated from Asia to North America: while the explicit self-esteem was comparable to that of native people, the implicit self-esteem was significantly lower, thus suggesting that this second form of self-esteem is slower to adapt to a new environment. Nonetheless, recent findings seem to indicate that implicit self-esteem may also change quickly, to the extent that context elicits different patterns of activation in the associative network (see for example Dijksterhuis et al., 2004; Rydell & Gawronski, 2009).

Several implicit measures of self-esteem have been developed during recent years, as result of the parallel progress on both theories relative to implicit and explicit self-esteem and dual-process models of cognition on the one hand and implicit measurement theory on the other hand. In general, these measures are conceived to reveal people's attitudes toward themselves from their reactions to self-related stimuli. The main conceptual structure on which these methods are based is association and they usually consist of very simple tasks such as categorization. The strong point of implicit measures of self-esteem is that they are not obvious, in the sense that it is not always evident to the subjects what is being measured and it is very difficult to pilot the response in order to achieve a desired result. Overall, these measures are suitable to reliably tap aspects of self-esteem of which individuals are little aware.

3.1.5 Measures of implicit self-esteem

Today, the term implicit "has come to be applied to measurement methods that avoid requiring introspective access, decrease the mental control available to produce the response, reduce the role of conscious intention, and reduce the role of self-reflective, deliberative processes" (Nosek et al., 2007). According to the RIM (Strack & Deutsch, 2004), while explicit measures tap into the Reflective system and reflect individuals' knowledge and beliefs, implicit measures are the expression of the associative structures that characterize the Impulsive system.

Despite the large agreement that implicit measures are a valuable tool of investigation, they show poorer psychometric properties as compared to explicit measures of self-esteem. Bosson and co-workers' meta-analysis (Bosson, Swann, & Pennebaker, 2000) emphasized the poor reliability of implicit measures of self-esteem and their low correlation with explicit measures. This scarce correspondence could either represent the evidence of good discriminant validity (that is, the two measures do capture something different) or instead simply reflect their poor reliability. Anyway, this last possibility seems unlikely given that implicit measures of self-esteem correlate with other constructs in meaningful ways: for example, both high implicit and high explicit self-esteem help people cope with negative experiences and stressors (Zeigler-Hill & Jordan, 2010). Furthermore, they may predict different responses. Spalding and Hardin (1999) conducted the first study that documented a relationship between implicit self-esteem and social behaviour. Participants' implicit and explicit self-esteem were measured before they sustained an interview regarding either their own or a friend's healthy state. It was found that implicit self-esteem affected apparent, nonverbal anxiety during the interview (when self-referred) as evaluated by the interviewer, while explicit self-esteem affected self-reported anxiety. Notably, the results suggested a double dissociation pattern (i.e., explicit self-esteem predicted self-ratings of anxiety but implicit self-esteem did not, whereas conversely implicit self-esteem predicted nonverbal indicators but explicit self-esteem did not), thus indicating that the behavioural effects of explicit and implicit self-esteem may be dissociated. In addition, according to Jordan and collaborators (2007), the fact that measures of implicit and explicit self-esteem generally do not correlate simply reflects the fact that they are related in different ways in different people (depending for example on the extent to which people trust or not their intuitions).

Interestingly, Bosson, Swann and Pennebaker themselves admitted that a valuable exception -showing acceptable values in both reliability (test-retest after one month: $r = .69$; see Bosson et al., 2000) and validity tests- is represented by the IAT. Recently, a further study aimed at investigating psychometric properties of measures of implicit self-esteem confirmed that the standard self-esteem IAT displays the best internal consistency and temporal stability (Krause, Back, Egloff, & Schmukle, 2010). Furthermore, Rudolph and colleagues have recently ruled out the low reliability of the measures adopted, with particular reference to the IAT, as a cause for low correlation between measures of implicit and explicit self-esteem (Rudolph, Schröder-Abé, Schütz, Gregg, & Sedikides, 2008). Therefore, given that the relative independence between implicit and explicit scores could not be attributed to poor measurement reliability, the authors claimed that their results further confirmed the good fit of dual-process models of cognition applied to self-esteem.

To summarize, following the renaissance of the interest regarding aspects of the self-concept that are not completely accessible to introspection and the development of dual-process models and implicit measurement methods, the existence of an implicit component of self-esteem has been theorized. Most authors agree that implicit measures of implicit self-esteem are worth in that they measure something distinct but related to explicit self-esteem. Moreover, the relationship (correspondence vs. discrepancy) between implicit and explicit self-esteem contributes to define unique psychological states of individuals, that would be not completely defined by each of these two measures separately. Indeed, implicit measures may predict behaviour over and above explicit ones (e.g., Spalding et al., 1999; Jordan, Spencer, Zanna, Hoshino-Browne, & Correll, 2003; Schröder-Abé, Rudolph, & Schütz, 2007). Among implicit measures, the self-esteem IAT has been confirmed by a large amount of research to hold good psychometric qualities (e.g., Bosson et al., 2000; Krause et al., 2010), so that it is now largely used in psychological research.

In the following paragraph we will focus more in depth on the IAT measure of implicit self-esteem, as functional to the experimental part presented in this chapter, with particular attention to the relationship between implicit and explicit self esteem in the definition of specific personality traits.

3.1.6 The self-esteem IAT

Among implicit measures that have been proposed and used to assess self-esteem, the Implicit Association Test (Greenwald, McGhee, & Schwartz, 1998) is one of the most popular. In general, the IAT is thought to assess the difference in the strength of associations between two concepts and a bipolar attribute, comparing response latencies. Typically, four categories of stimuli are used and the task requires to categorise exemplars using just two response keys, each assigned to two of the four categories. The rationale is that if two concepts are strongly associated, categorisation will result easier (and reaction times faster) when they share the same key of response (compatible situation) compared to when they require different responses (incompatible situation). This procedure has good psychometric properties: high internal consistency, moderate -even if not outstanding- test-retest reliability and satisfactory predictive validity. For this reason and also due to its ease of administration, the IAT is having considerable success and represents the most widely used method of implicit measurement in psychology.

Therefore, following consistent theorization about implicit aspects of self-esteem, the IAT procedure was readily adapted to assess the strength of associations between the self-concept and positive/pleasant attributes. In 2000, Greenwald and Farnham published the first study that used the IAT to capture implicit self-esteem (Greenwald & Farnham, 2000).

3.1.6.1 Design of the self-esteem IAT

The critical materials of a IAT are four categories defined by category labels and stimulus items that adequately represent each category. At the begin of the experiment, the general instruction to respond as quickly and accurately as possible is given to the participant. Subsequently, category labels assigned to the left and right response keys are displayed on the screen in the corresponding corner throughout all phases (see Figure 9 for examples). Stimuli are presented at the centre of the screen one at a time, with an inter-trial interval that is typically around 250 ms (range 150-750 ms).

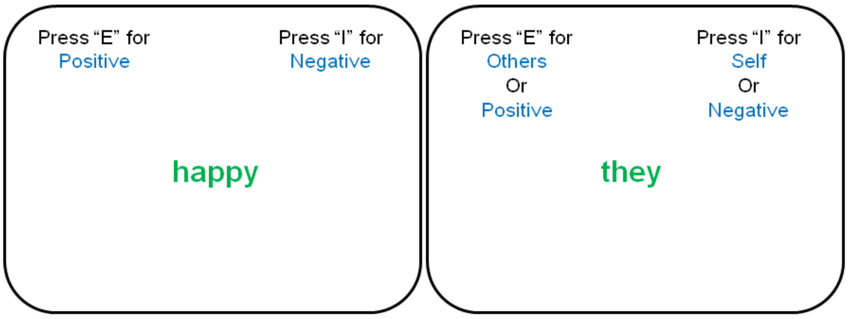

Figure 9: Examples of trials of the IAT. On the left, attribute categorization is requested (i.e., block 2); on the right, double incompatible categorization is requested (i.e., block 5).

Table 1 represents schematically the structure of a typical IAT that measures association strengths between concepts "me" and "others" and "positive" and "negative" attributes.

BLOCK	DESCRIPTION	INSTRUCTION	NUMBER OF STIMULI
1: Practice	Concept categorization	ME *vs.* OTHERS	20
2: Practice	Attribute categorization	POSITIVE *vs.* NEGATIVE	20
3: First critical phase	Double compatible categorization	ME+POS *vs.* OTHERS+NEG	40 - 80
4: Practice	Inverse concept categorization	OTHERS *vs.* ME	20
5: Second critical phase	Double incompatible categorization	OTHERS+POS *vs.* ME+NEG	40 - 80

Table 1: Structure of the IAT.

The IAT is composed of five blocks, some of which are of practice (blocks 1, 2 and 4) and are proposed in order to make the participants familiar with the stimuli and the procedure. Either concept exemplars (concept categorization) or attribute exemplars (attribute categorization) are presented in practice blocks and subjects are required to classify them according to their category membership. In the first block, subjects practise the categorization of target concepts "me" *versus* "others", using alternatively one left or one right key. In the following attribute categorization participants discriminate attribute-items on the basis of their valence, i.e., "positive" or "negative". Critically, a double-categorization task by means of just two keys is required in block 3: concepts and attributes are combined on the basis of previous practice blocks (e.g., me and positive share one key, while others and negative share the other). In the fourth block, concept categorization is required but keys are inverted with respect to block 1. Finally, in the second critical phase (block 5) double-categorization is requested on the basis of the newly assigned key, that is others with positive on one side and me with negative on the other side.

The association between concepts and attributes that share a response-key is inferred to be stronger the faster the subject performs the task. The difference in performance between the first combined block (block 3) and the reversed combined block (block 5) represents the IAT effect and is taken to reveal the relative association strengths between concepts and attributes. In practice, the self-esteem IAT measures how much easier is for individuals to categorize self items with the pleasant as compared to the unpleasant attributes. The more participants have positive associations with the self-concept, the more the IAT scores will be positive, thus meaning higher implicit self-esteem.

It is worth noticing that the IAT is a measure of the strength of associations among nominal categories more than among the exemplars used to represent those categories. Nevertheless, stimuli must be chosen carefully in order to be representative for their respective superordinate category, taking into account also basic properties such as length and frequency (in the case of words) or colour and other visual features (in the case images are used). In most cases, each category is represented by four to six items. Typically, practice phases 1, 2 and 4 include 20 trials, while 40 to 80 trials are presented in the critical blocks 3 and 5.

3.1.6.2 Scoring procedure

The D algorithm has been indicated by Greenwald and colleagues (2003) as the score that offers the best psychometric properties. Therefore, it will be presented in the methodological section, since it was used in the present work.

It is important to know and remember that IAT scores always have to be interpreted in a relative manner, since the target concept of interest is compared with an alternative (often opposite) concept. For instance, a positive score in a IAT regarding flowers cannot tell whether a person evaluates flowers positively or not, but rather whether the evaluation of flowers is more or less positive than that of the control category (e.g., insects). Moreover, a IAT score of zero does not necessarily mean absence of preference or a neutral attitude. Consequently and importantly, individual subjects' scores can only be interpreted relatively to each other, not in absolute.

3.1.6.3 Psychometric properties

Reliability - As already mentioned, the great success of the IAT is at least partially due to the fact that it exhibits satisfactory internal consistency. Two recent meta-analyses reported split-half correlation and Cronbach's alpha scores ranging from .70 to .90 (Nosek, Greenwald, & Banaji, 2007; Greenwald, Poehlman, Uhlmann, & Banaji, 2009). Test-retest reliability has usually proved to be less satisfactory, with mean estimates of about .50 (Lane, Banaji, Nosek, & Greenwald, 2007), suggesting to some authors that IAT might measure states rather than traits (see Gawronski & Bodenhausen, 2006 for review; Schmukle & Egloff, 2004) or that learning effects may occur.

Validity - In most cases, IAT validity has been investigated in terms of correlation with explicit or other implicit measures, and in terms of predictive validity for behavioural measures. A recent meta-analysis by Hofmann and collaborators has revealed low correlation (~.24) of the IAT with explicit measures (Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005). Depending on their theoretical framework, authors have either considered this correlation as an index of discriminant or convergent validity (see Payne, Burkley, & Stokes, 2008 for discussion). Correlations between IAT and other implicit measures are usually found to be weak (e.g., Scherman, Presson, Chassin, Rose, & Koch, 2003; Rudolph et al., 2008). However, low correlation has been attributed to the unacceptable reliability of the other implicit measures more than to the invalidity of the IAT. In fact, reliability of a measure sets the upper limit on its possible correlation with other measures. More in general then, weak correlation might reflect structural differences among implicit measures or heterogeneity of the cognitive processes involved. Interestingly, the IAT shows good predictive validity, being able to predict behaviour over and above explicit measures (see Greenwald et al., 2009 for a recent meta-analysis). In particular, Perugini and co-workers (Perugini, 2005; Perugini, Richetin, & Zogmaister, 2010) have proposed several predictive validity patterns involving implicit and/or explicit measures: simple association, moderation, additive, interactive or multiplicative models, double dissociation, partial dissociation and double additive model.

3.1.6.4 IAT: Pros and cons

As it emerges from the literature and what reported above, the IAT is a valuable method of investigation in several psychological fields such as attitudes, stereotyping, prejudices, brand and political preferences and self-concept. Indeed, besides the general advantages that implicit measures offer compared to explicit measures (see also paragraph 3.1.5), an ever-growing amount of research has recently demonstrated the IAT good psychometric qualities (Greenwald et al., 2009). In two recent meta-analyses (Hofmann et al., 2005; Greenwald et al., 2009), IAT measures have been shown to own both discriminant and incremental predictive validity with respect to explicit measures. Importantly, an implicit measure used in personality research is often as good as its validity in predicting behaviour. This may be linked to the fact that IAT is less affected by social desirability and response controllability variations and operates in a more automatic (fast, unintentional, uncontrollable, efficient, and perhaps unconscious; see Moors & De Houwer, 2006) fashion. Consequently, the IAT is hardly falsifiable, unless one is told how to do or has a long practice with the IAT. Additionally, its relative ease of implementation and administration allows researchers to use large and very representative samples, also through the web.

Although a number of criticisms still persists (for instance, general cognitive abilities, overall speed of processing and task-switching abilities might play a role; see Hummert, Garstka, O'Brien, Greenwald, & Mellott, 2002), the IAT represents today a very useful implicit method for understanding human experiences and behaviour.

3.1.7 Explicit and implicit self-esteem: Convergent and divergent findings

In Greenwald and Farnham's study (2000), two confirmatory factor analyses stated implicit and explicit self-esteem as two distinct constructs, positively but weakly correlated, thus indicating discriminant validity of the self-esteem IAT. Moreover, the self-esteem IAT was found to have good validity in predicting cognitive reactions to success and failure. Lower implicit self-esteem was associated with worst cognitive protection against the effect of failure -explicit self-esteem being equal- possibly because, when explicit positive self-views are challenged, the normally less conscious implicit self-esteem may enter awareness, causing the experience of inconsistency within the self to individual with negative implicit self-esteem (Zeigler-Hill & Jordan, 2010).

A still increasing amount of research that assesses implicit self-esteem by means of the IAT procedure further confirmed its validity in predicting behaviour over and above explicit measures. Moreover, discrepancies have been revealed between implicit and explicit self-esteem, that appear largely independent from each other: therefore, knowing about one's explicit self-esteem does not necessarily predict the level of implicit self-esteem and viceversa (see the model of Wilson, Lindsey, & Schooler, 2000). This evidence brought about a number of theorizations. Jordan and colleagues' work (2003) started from converging evidence that some individuals with high self-esteem are more defensive than others. For example, Kernis (2003) claimed that people with high but unstable self-esteem (named "fragile" self-esteem by the author) behave more defensively than people with high and stable self-esteem ("secure" self-esteem). Jordan and collaborators hypothesized that this difference might depend from the fact that some individuals, besides conscious high self-esteem, hold a relatively negative feeling about themselves at a less conscious, implicit level. These researchers tested their hypothesis by studying subjects with both explicit measures and the self-esteem IAT, and confirmed that individuals with incongruent explicit and implicit self-esteem hold highest levels of narcissism, thought to be an indicator of defensiveness (Jordan et al., 2003). Interestingly, the discrepancy between the two forms of self-esteem predicted as well defensive behaviours such as in-group bias (self-enhancement). The authors concluded that individuals with consistent high explicit and implicit self-esteem possess a "secure" high self-esteem, while subjects with discrepant levels of self-esteem (i.e., high explicit and low implicit) possess a "defensive" self-esteem. Jordan and co-workers investigated the issue in more depth in a subsequent work (Jordan, Spencer, & Zanna, 2005), capitalizing on a premise of Tajfel and Turner's (1979) social identity theory, stating that people tend to value more in-group over out-group members in order to enhance self-worth, especially in the case of threatening situations.

Notably, the usefulness of implicit self-esteem assessment to further qualify individuals' self-worth was recently shown in individuals with both high and low explicit self-esteem. After showing that defensive behaviours may occur in subjects with both forms of discrepant self-esteem, Schröder-Abé and co-workers' (2007) investigated, at a more general level, how discrepancies between explicit and implicit self-esteem relate to mental and physical health. Results demonstrated that both individuals with "fragile" self-esteem (high explicit/low implicit) and individuals with the so-called "damaged" self-esteem (low explicit/high implicit) had lower scores on measures of mental and psychological health, and higher levels of anger suppression, depressive attributional style, nervousness and frequency of days off work due to health problems. The authors concluded that discrepancies in either direction are maladaptive, since they represent deficient integration of self-representations and can potentially lead to psychological conflict. Moreover, this seems to suggest that having high implicit self-esteem is not necessarily advantageous, but rather it must be evaluated in comparison to the level of explicit self-esteem.

Overall, studies including self-esteem IAT seem to indicate that implicit self-esteem is an independent construct -separated from explicit self-esteem- that may further qualify the personality of individuals, their behaviours, and cognitive performances. Consequently, when planning a research, it is essential to consider the interplay of, and discrepancies between, implicit and explicit self-esteem, given that both enhance our understanding of how self-esteem affects judgements and behaviours.

3.2 RATIONALE OF THE EXPERIMENTS

The previous research work reported above seems to suggest the existence of a link between individuals' self-esteem and the way people perceive their own body. This has been especially studied in the field of eating and body dysmorphic disorders, in which poor self-esteem is often associate to body dissatisfaction (e.g., Cockernham et al., 2009; Buhlmann et al., 2008; 2009). However, as preliminary suggested by some valuable research (Meijboom et al., 1999), it is likely that a similar link might be also present in healthy people. Moreover, although there is a growing amount of evidence about the mechanisms of self-recognition (e.g., Devue, Collette, Balteau, Degueldre, Luxen et al., 2007; Frassinetti et al., 2008; 2010), some intriguing aspects are still to be explored.

The present studies aimed at linking aspects of self-body recognition, typically investigated in neuroscience, to the measure of implicit self-esteem, typically addressed by research in social cognition. In particular, the relationship between the level of explicit and implicit self-esteem (that are separate but clearly related processes, see for example Jordan et al., 2007), and the ability to process self *versus* other body-parts, was investigated. Moreover, we investigated whether covert and overt body recognition tasks are equally efficient as measures of self-recognition and whether subjects' performances in these tasks are differentially affected by implicit and explicit self-esteem. Despite a previous attempt to link self-face recognition and schizotypal personality traits was done by Platek and colleagues (Platek & Gallup, 2002) leading to some interesting results, only very recently Ma and Han (2010) showed that the "self-advantage" demonstrated by participants in an implicit face-recognition task (i.e., to discriminate the orientation of self *versus* familiar face-stimuli) was mediated by an implicit positive association with self, as assessed by the IAT. However, to our knowledge, no study so far investigated this issue using non-face bodily stimuli. The present work may shed light in the cognitive function of self-recognition and also in the interplay between this cognitive function and personality traits.

3.3 EXPERIMENT 3

This study tested whether implicit and explicit measures of self-esteem can predict the ability to recognize one's own body-parts. Frassinetti's matching-to-sample paradigm (see Frassinetti et al., 2008; 2010) was adopted to assess covert self body-parts recognition.

3.3.1 Method

3.3.1.1 Participants

Forty-four healthy students (21 females, 23 males; mean age = 23.4 years, standard deviation = 2.6) took part in Experiment 3. Participants had normal or corrected-to-normal visual acuity and were all naïve to the purpose of the experiment. Information about the experimental hypothesis were provided only after the completion of the tasks, and participants received course credits for their participation. The data of three participants were removed because of a high percentage of errors in the IAT (superior to 25%) leaving a total of 41 participants.

3.3.1.2 Procedure

All participants completed, in the following fixed order, a self-esteem IAT, a measure of explicit self-esteem, and finally the matching-to-sample task developed by Frassinetti and colleagues (2008) and already used in our Experiments 1 and 2. Participants always completed the IAT before the explicit measure, given that using explicit measures before implicit ones can artificially increase the correlation between the two measures (Bosson et al., 2000). Matching-to-sample represents an indirect way to investigate the self-body recognition, in that participants are never required to focus on the ownership relative to body-parts. All measures were administered with Inquisit 3.0.2 on a Dell D610 14.1 inches laptop, in a single session. IAT self-esteem was introduced as a categorization task; instructions emphasized both accuracy and speed.

3.3.1.3 Materials

Self-Esteem IAT. The IAT was planned following previous work (Greenwald, McGhee, & Schwartz, 1998; Greenwald & Farnham, 2000). Participants were instructed to classify words as quickly and accurately as possible using two keys (i.e., 'E' and 'I') with the index finger of their left and right hand, respectively. Items were presented individually and in a random order in the middle of the screen; trial were separated by a 500-ms interval. The target concept was "me" and its contrast was "others", whereas the attribute categories were "positive" and "negative".

For each category, five stimuli were used (see Table I in the Appendix for the full list of the Italian stimuli). The task was divided in five blocks as follows:

1) Practice block: me *versus* others
2) Practice block: positive *versus* negative
3) Compatible critical block: me + positive *versus* others + negative
4) Practice block: others *versus* me
5) Incompatible critical block: others + positive *versus* me + negative

The order of the compatible and incompatible association was kept fixed for all participants, with the combination me and positive being presented first. This decision, as well as the one relative to the fixed order of different tasks in the experimental session, was taken considering that "if establishing predictive validity is the main goal of a given study, when one of the two blocks is thought to be normatively compatible, a simple solution to the problem is to administer the task to all participants in the same order starting with the compatible block first" (Perugini et al., 2010; *p. 268*). So, given that our study had a predictive nature and it is well established that people usually possess a positive self bias, we kept the order fixed in order to control for the eventual influence of the block administered first on the second block (see Klauer & Mierke, 2005). All practice blocks consisted of 20 trials and each critical block consisted of 81 trials (including one initial dummy trial that was discarded from analysis). Each item was presented an equal number of times. A red X appeared in the middle of the screen for 200 ms if the participant did not answer correctly; there was no built-in penalty, so that subjects were not required to correct incorrect responses before proceeding to the following trial. The appropriate category labels stayed on the top part of the screen through all experimental blocks.

Explicit self-esteem. The Rosenberg Self-Esteem Scale (Rosenberg, 1965), a self-report inventory consisting of ten items, was used. The scale is composed by five positively and five negatively phrased sentences composed exclusively of first person evaluative statements about the self (e.g., "On the whole, I am satisfied with myself", "At times, I think I am no good at all"). Participants rated the extent to which they agree with each statements on a 4-point Likert scale (from 1 = "strongly disagree" to 4 = "strongly agree"). The scores of negatively phrased items need to be opportunely recoded before the calculation of the total score. Total scores range from 10 to 40, with higher scores representing more positive self-esteem. RSES items were designed to optimize unidimensionality, ease of administration and scoring, and economy of time. The scale has good internal consistency, test-retest reliability (see Blascovich & Tomaka, 1991) and validity (both convergent and discriminant). We used the Italian version validated by Prezza and colleagues (Prezza, Trombaccia, & Armento, 1997; see the Appendix, II for the complete Italian version of the scale).

Indirect Body Recognition Task. The task has been built following Frassinetti and colleagues' (2008; 2010) procedure. Participants were simultaneously presented with three images, vertically aligned on the centre of the computer screen. They were required to decide which of the upper or the lower one matched the central target stimulus, by pressing one of two keys as fast and accurately as possible. Stimuli represented gray scale pictures of body-parts. Just before the experiment was completed, six flash photographs of each participant's right hand and left foot were taken with a digital camera Fuji FinePix A820 positioned 50 cm away, in an environment with constant illumination. Each body-part was depicted in three postures: upright and rotated by 30 degrees on the right and on the left, following a grid. Then participants were asked to wait about 20 minutes, while their pictures were post-processed using Adobe Photoshop software. Pictures length was fixed at 220 pixels, while maintaining the internal proportions. In order to prevent low-level dissimilarities the color, contrast and brightness of the pictures were slightly adjusted. The same stimuli used in our previous Experiment 2, three gender-matched models' body-parts pictures, were used as distractors. The target stimulus was presented upright, in a black frame, at the centre of the screen while the distractors were presented above and below the central target. To minimize any automatic matching between target and distractors, the upper and lower distractor depicted stimuli tilted by 30 degrees to the left or to the right (see Figure 4 in Chapter 2). The stimuli remained on the screen until the participants responded and were immediately followed by the successive trial. The task consisted of 96 trials: 24 trials depicted the subject's own body-parts as target stimulus and 72 trials other people's body-parts. Response time and accuracy were recorded for offline analysis.

3.3.2 Results

3.3.2.1 Data transformation

Following Greenwald and colleagues' advice for the calculation of self-esteem IAT scores (Greenwald, Nosek, & Banaji, 2003), all 80 trials of the critical blocks (block 3 and block 5) were considered. Since there was no built-in penalties, error trials were replaced with the block mean and an automatic penalty of 600 ms applied. A difference score was calculated between the mean scores on the two critical blocks; this value was then divided by the standard deviation of the trials across both blocks 3 and 5, obtaining the final D score. Higher D scores indicate a higher implicit self-esteem (α = .84). For the explicit self-esteem measure, a single score was calculated by aggregating the scores for each item (after appropriate recoding of the five negative items) with a positive score reflecting a positive explicit self-esteem (α = .84). Finally, six scores were considered for the indirect body recognition task. Mean reaction times and frequencies of correct responses depending on the target (self *versus* others), and the difference between self and others were calculated. The reaction times were log-transformed for the analyses and the frequencies of correct responses were arc-sine transformed for self and others. Both transformations were performed in order to normalize data distributions. For clarity, the means reported in Table 2 are the raw values.

3.3.2.2 Indirect body recognition task

A t-test for paired samples was performed on the frequency of correct responses depending on the target (i.e., self *versus* others). There was a significant effect of the type of target on the frequency of correct responses: $t(40) = -4.28$, $p < .001$.

A similar t-test was performed on main reaction times. A significant main effect of type of target was found: $t(40) = 3.58$, $p < .005$.

In short, results showed that participants made less errors and responded faster when confronted to their own body-parts than when confronted to other people's body-parts, confirming and extending previous results (Frassinetti et al., 2008).

3.3.2.3 Correlations

The self-esteem IAT was positively correlated with the difference in mean latencies between other and self targets and with the frequency of correct responses for self targets. The explicit self-esteem was also positively correlated with the frequency of correct responses for self targets. Explicit self-esteem was positively correlated with self-esteem IAT. Mean values, standard deviations and correlations are shown in Table 2.

Table 2: Mean values (M), standard deviations (SD) and correlations relative to Experiment 3.

	M	*SD*	1	2	3	4	5	6	7	8
1. IAT self-esteem	.78	.37	1							
2. Explicit self-esteem	3.67	.52	**.33***	1						
3. Mean latency for "other"	2090	649	.13	.31	1					
4. Mean latency for "self"	1940	698	-.17	.15	.83**	1				
5. Mean latency for "other - self"	150	399	**.38***	.21	.13	-.40**	1			
6. Correct responses for "other"	.86	.08	.06	.21	.42**	.32*	.10	1		
7. Correct responses for "self"	.92	.07	**.35***	**.41****	.30	.06	.33*	.28	1	
8. Correct responses for "self - other"	.06	.09	.15	.16	-.18	-.26	.14	-.68**	.44**	1

*Note: ** p < .01, * p < .05*

3.3.2.4 Incremental validity

The incremental validity of both self-esteems (implicit *versus* explicit) was tested with a regression analysis in which both measures were entered to predict the arc-sine values of the frequency of correct responses for self targets. The full model explained 22% of variance. The self-esteem IAT was not a significant predictor although showing a tendency toward significance (β = .24, p = .124), while the explicit self-esteem was significant (β = .33, p = .034). In terms of incremental validity, the explicit measure showed predictive validity of self body-parts recognition ability as assessed in the present matching-to-sample task over and above the implicit measure, although the self-esteem IAT was not far from being significant.

3.3.2.5 Moderation effects

In order to investigate whether individual differences in explicit self-esteem moderates the validity of the self-esteem IAT in predicting the ability to recognize one owns' body parts, a series of linear multiple regressions was performed on the transformed values of frequency of correct responses and reaction times. Variables were centered before calculating the appropriate interaction term to reduce multicollinearity (Aiken & West, 1991). No significant effects were found (all *ps* for interaction terms > .212).

3.3.3 Discussion

The results of Experiment 3 corroborated previous results obtained by Frassinetti and colleagues (2008; 2010) and those of Experiment 2 in the present thesis. In particular, not only participants showed a "self advantage" in terms of accuracy (i.e., more correct responses when stimuli depicting one's own body-parts were presented as targets with respect to other people's body-parts), but they were also faster. Therefore, the matching-to-sample task proved to be a valuable method to indirectly test the ability of self-body recognition.

More central to our concern, implicit self-esteem was positively correlated with the percentage of accuracy in response to self targets, demonstrating the ability of self-esteem IAT to predict the recognition of self body-parts. Also explicit self-esteem was positively correlated with the accuracy for self targets. When considering the incremental validity, only the measure of explicit self-esteem confirmed to be a predictor of accuracy in response to self stimuli. Nevertheless, implicit self-esteem was not far from significance.

Notably, a positive correlation between explicit and implicit self-esteem was found. This is a rather uncommon result, even if previous similar findings are not lacking (see Zeigler-Hill & Jordan, 2010 for a recent review).

Overall, the results of this first study show that self-esteem qualifies and partially determines the ability to recognize one's own body-parts as assessed with the present matching-to-sample covert paradigm.

In order to gain a better comprehension of the influence of self-esteem on this cognitive ability, a second experiment was conducted, in order to assess the influence of self-esteem when people are engaged in an overt recognition of their own *versus* non-self body-parts. It is possible that explicit and implicit self-esteem might play a different role in dealing with one's own bodily stimuli when self-recognition is assessed by using a direct, and probably more automatic paradigm (see Spalding & Hardin, 1999).

3.4 EXPERIMENT 4

This second study was aimed to replicate and extend the findings of Experiment 3 by testing whether implicit and explicit self-esteem can also moderate the recognition of self body-parts as measured with a more overt paradigm. Accordingly, now participants were directly asked to decide whether a given stimulus represented their own or other people's body parts.

3.4.1 Method

3.4.1.1 Participants

Thirty-seven new healthy participants (12 females, 25 males; mean age = 26.5 years, standard deviation = 3.2) participated in the study. They all had normal or corrected-to-normal visual acuity, were naïve to the purpose of the experiment and received course-credit for their participation. The data of two participants were discarded because their error rate was over 25% in the Implicit Association Test.

3.4.1.2 Procedure

The order of the tasks was kept fixed for all participants: in a single experimental session they first performed a self-esteem IAT, then they completed a measure of explicit self-esteem, and finally they were required to categorize items depicting body-parts on the basis of ownership (i.e., self *versus* other). This was an original task used in order to directly investigate the people's ability in overt self body-parts recognition. All measures were administered with Inquisit 3.0.2 on a Dell D610 laptop with a 14.1 inches monitor.

3.4.1.3 Materials

Self-Esteem IAT. The IAT was identical to the one used in Experiment 3.

Explicit self-esteem. The Rosenberg Self-Esteem Scale (1965) was used. Due to an error in programming, participants rated their agreement to the items on a 6-point Likert scale from 1 ("strongly disagree") to 6 ("strongly agree").

Indirect Body Recognition Task. Participants' hand and foot were photographed following the same protocol as in Experiment 3; nevertheless, this time pictures were collected in a previous session occurring a few days before the real experiment. The same three gender-matched models' pictures were presented as distractors. Each stimulus was resized to 450 pixels of height, maintaining the proportional width. The pictures were presented randomly in black and white while participants were instructed to classify them according to whether the depicted body-part belonged to their own body or to someone else. They were required to respond as fast and accurately as possible by pressing one of two keys, labelled "self" and "other". Trials were separated by a 500-ms inter-trial interval. The experimental session comprised 24 trials: six trials with participant's hand and foot presented upright, tilted by 30° to the left and tilted by 30° to the right, and eighteen trials with three distractors of the same gender, again presented in three different postures. Given the simplicity of the task (binary response to a single stimulus) compared to covert paradigm, the number of trials was kept small in order to avoid learning effects, that could have confounded the overt recognition results. On each trial the stimulus stayed on the screen until the participant responded. Reaction time and accuracy were registered.

3.4.2 Results

3.4.2.1 Data transformation

As in Experiment 3, for the self-esteem IAT, a D score was calculated by considering all 80 trials of the two critical blocks, taking the difference in reaction times between phase three and five and transforming it (D algorithm with 600 ms penalty for errors; Greenwald et al., 2003). Larger positive scores thus reflected higher levels of implicit self-esteem (α = .91). For the explicit self-esteem measure, a single score was calculated by aggregating the scores for each item (after appropriately reversing the scores relative to five negatively phrased items) with a positive score reflecting a positive explicit self-esteem (α = .80). Finally, as it has been done in the previous study, for the direct body recognition task, we considered the mean reaction times and the frequency of correct responses depending on the target (self *versus* others) and the difference between self and others. The reaction times were log transformed for the analysis and the frequency of correct responses were arc-sine transformed for self and others respectively. In addition, considering the nature of the task, a d' score was obtained by subtracting the proportion of false alarms from the proportion of hits[8]. Higher positive scores indicated better recognition of one's own body. As before, for descriptive purposes untransformed data are reported in Table 3.

3.4.2.2 Direct body recognition task

Separate t-test for paired samples were performed on the mean latency and the frequency of correct responses with stimulus-target (i.e., self *versus* others) as factor.

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[8] Calculation of d-prime (d') proceeded according to the approach defined by Green and Swets (1966). Empty cells (i.e., no false alarms or misses) present a problem for calculation of sensitivity effects and require a correction. We applied the approach recommended by Banaji and Greenwald (1995), resulting in a correction of 0.35, divided by the number of trials, to empty cells and probit. In signal detection, sensitivity is calculated with the following algorithm: (1) the proportion of hits (correct response for signal items) and false alarms (incorrect response for noise items) are each converted to z-scores; (2) a difference between the z-score values for hits and false alarms is d'. D-prime values of 0 or below indicate that subjects were either unable to discriminate any signal from noise or were not performing the task as instructed. As such, blocks with sensitivity scores of 0 or below (0 is chance responding) were removed from the analysis.

Consistently to the previous findings, there was a significant effect of the type of target on the mean latencies, with $t(34) = -2.09$, $p < .05$, while there was no significant difference on the frequency of correct responses, $t(34) = .50$, $p = .620$. Participants responded faster when looking at their own body parts.

3.4.2.3 Correlations

Self-esteem IAT was positively correlated with the accuracy for self targets, with the difference in accuracy between self and others targets and with the d' score. Explicit self-esteem did not correlate with other variables. Finally, implicit and explicit self-esteem were not correlated ($r = -.09$). See Table 3 for values relative to means, standard deviations and correlations.

Table 3: Mean values (M), standard deviations (SD) and correlations relative to Experiment 4.

	M	*SD*	1	2	3	4	5	6	7	8	9
1. IAT self-esteem	.90	.44	1								
2. Explicit self-esteem	4.53	.74	-.09	1							
3. Mean latency for "other"	2318	2302	.16	.12	1						
4. Mean latency for "self"	1705	1593	.04	.23	.88**	1					
5. Mean latency for "other - self"	612	2228	.22	-.25	.07	-.42*	1				
6. Correct responses for "other"	.82	.13	.10	.07	-.25	-.21	-.05	1			
7. Correct responses for "self"	.73	.29	**.38***	-.16	.16	.05	.20	-.10	1		
8. Correct responses for "self - other"	-.07	.24	**.35***	-.20	.17	.06	.21	-.41*	.91**	1	
9. d prime	1.72	1.03	**.40***	-.13	-.02	-.09	.15	.49**	.79**	.58**	1

*Note: ** p* < .01, * *p* < .05

3.4.2.4 Incremental validity

Implicit and explicit measures of self-esteem were simultaneously considered for the prediction of the accuracy for self targets and the d' score. For the frequency of correct responses to self targets, the full model explained 15.8% of variance. The self-esteem IAT was a significant predictor ($\beta = .37$, $p = .031$) whereas the explicit self-esteem was not ($\beta = -.12$, $p = .447$). For the d' score, the full model explained 17% of variance. The self-esteem IAT was again a significant predictor ($\beta = .39$, $p = .021$) whereas the explicit self-esteem was not ($\beta = -.09$, $p =$

.575). These results suggest that implicit self-esteem predicts participants' ability of overtly recognize their own body-parts over and above the explicit self-esteem.

3.4.2.5 Moderation effects

In order to investigate whether individual differences in explicit self-esteem moderates the validity of the self-esteem IAT in predicting the ability to recognize one's own body-parts, a series of linear multiple regressions was performed on the transformed values of accuracy (frequency of correct responses), reaction times and d' scores. Again, variables were centered before calculating the appropriate interaction term to reduce multicollinearity (Aiken & West, 1991). No significant effects were found with the exception of a tendency towards a moderation effect of explicit self-esteem on the validity of self-esteem IAT for predicting the d' scores in the direct body recognition task. The full model explained 25.1% of variance. The explicit self-esteem was not a significant predictor of the d' score (β = -.05, p = .775), whereas self-esteem IAT was (β = .49, p = .006) and the interaction showed a tendency toward significance (β = .30, p = .076). A simple slope analysis (see Figure 10) revealed that the self-esteem IAT predicted the d' in participants with high (+ 1 SD) and medium scores on explicit self-esteem (β = .75, p = .005, and β = .50, p = .009, respectively), whereas it did not in participants with low scores (- 1 SD; β = .25, p = .179).

So, it appears that for people that obtain high and medium scores in explicit self-esteem, the self-esteem IAT is a valid predictor of the ability of self body recognition. It is worth noting that the congruence between implicit and explicit self-esteem (high scores in both) is defined in the relevant literature as "secure" self-esteem and has attracted a number of works (see Kernis, 2003; Jordan et al., 2003) during the last years.

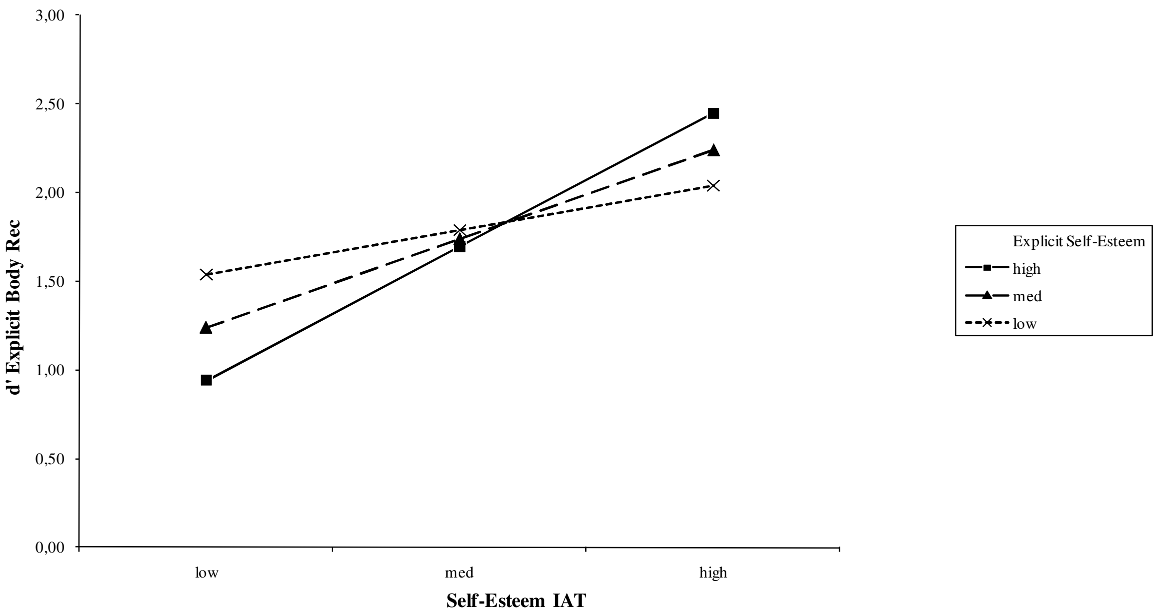

Figure 10: Moderation effect of explicit self-esteem on the validity of self-esteem IAT for predicting the d' score of the direct body recognition task.

3.4.3 Discussion

Findings relative to the overt body recognition task demonstrated that it is possible to reveal a "self advantage" using a more direct paradigm, in which subjects' attention is actively focused on the ownership. In fact, despite the fact that participants did not show higher level of accuracy in response to self than to others pictures, they performed the task significantly faster with self body-parts. To our knowledge, this was the first time that a "self advantage" was found using a direct task that involved recognition of body-parts other than face or waist/hips (e.g., Devue et al., 2007).

Even more interestingly, the positive correlation between the percentage of correct responses to self stimuli and the implicit self-esteem was confirmed in this second study. On the contrary, no significant correlation of explicit self-esteem with other variables was found. Furthermore, no significant correlation between explicit and implicit self-esteem was found, a result that is in line with the majority of previous findings (see Bosson et al., 2000 for review). Moreover, unlike what was obtained in the previous study, the self-esteem IAT predicted the frequency of correct responses to self target over and above the explicit self-esteem.

A moderation effect of explicit self-esteem on the validity of self-esteem IAT for predicting the d' score of the direct body recognition task was marginally significant (p = .076). In other words, IAT self-esteem predicted the explicit self-recognition ability in the case participants also showed high or medium explicit self-esteem, whereas it did not in the case of low explicit self-esteem. It is interesting to note from the graph in Figure 10 that individuals with congruent high explicit and implicit self esteem ("secure" self-esteem) showed the best performance, compared to subjects with congruently low self-esteems, with "fragile" self-esteem (high explicit, low implicit) and with "damaged" self-esteem (low explicit, high implicit; see Schröder-Abé et al., 2007). Future studies might further investigate the issue of self-esteem incongruence relatively to body recognition, in particular whether and why having "fragile" self-esteem corresponds to a very poor performance in explicit self-body recognition and whether this could have clinical relevance by explaining patients' behaviour in pathological conditions such as eating disorders.

3.5 JOINT ANALYSIS

In order to better understand the robustness of the effects of self-esteem in body recognition, we finally conducted a joint analysis in order to compare indirect and direct self-body recognition tasks (see Table 4).

Table 4: Correlations relative to Experiments 3 and 4 (joint analysis).

	1	2	3	4	5	6	7	8
1. IAT self-esteem	1							
2. Explicit self-esteem	.07	1						
3. Mean latency for "other"	.03	**.50****	1					
4. Mean latency for "self"	-.10	**.37****	.88**	1				
5. Mean latency for "other - self"	**.26***	**.30****	.30**	-.18	1			
6. Correct responses for "other"	.06	.16	.06	.03	.06	1		
7. Correct responses for "self"	**.28***	**.32****	.36**	.20	.35**	.04	1	
8. Correct responses for "self - other"	.22	.20	.27*	.14	.29*	-.37**	.86**	1

Note: ** $p < .01$, * $p < .05$

To test the incremental validity of both implicit and explicit self-esteem[9] in predicting the accuracy and the latency for self targets, a series of regression analyses was run, in which the type of paradigm (indirect *vs.* direct) and the two measures of self-esteem (implicit *vs.* explicit) were entered. For the accuracy, the full model explained 24.2 % of variance. The type of study was a significant predictor (β = .32, p = .011) indicating that the indirect self-body recognition task was easier than the direct one, the implicit self-esteem was also a significant predictor (β = .31, p = .004), whereas the explicit self-esteem was not (β = .14, p = .250). For the mean latencies, the full model explained 22.4 % of variance. The type of study was a significant predictor (β = .32, p = .011) indicating that participants were quicker in the indirect than in the direct self-body recognition task, the implicit self-esteem was not a significant predictor (β = -.07, p = .517) whereas the explicit self-esteem showed a tendency toward significance (β = .21, p = .087).

A series of linear multiple regressions was performed to test moderation effects. No significant interaction effects were found.

3.6 GENERAL DISCUSSION AND CONCLUSIONS

The main aim of these experiments was to investigate the eventual role of individual differences (i.e., general feelings of self-worth) over the ability to process bodily stimuli belonging to oneself. The idea originated, on the one hand, from the evidence that self-recognition ability is very variable across individuals (see Experiments 1 and 2 in Chapter 2) and, on the other hand, from a growing amount of research that relates body image and self-esteem in patients and healthy people (Meijboom et al., 1999; Buhlmann et al., 2008; 2009; Cockernham et al., 2009). Furthermore, we were interested to compare different kinds of self-recognition tasks, namely overt and covert, regarding both their efficiency and their link with self-esteem.

In order to obtain a more complete picture of the issue, both explicit and implicit measures of self-esteem were used. For their large diffusion in modern research on psychology and the good psychometric properties they offer, the Rosenberg Self-Esteem Scale (Rosenberg, 1965) and the self-esteem Implicit Association Test developed by Greenwald and colleagues (1998; 2000) were chosen.

Both measures confirmed their good reliability (all α were > .80) and -more importantly- revealed their validity in predicting people's ability to recognize self body-parts. In particular, whereas explicit self-esteem showed incremental validity in predicting self recognition as

[9] The Rosenberg Scale scores in the second study were recoded in a 4-point scale in order to be comparable to those relative to Experiment 3.

assessed using the covert paradigm, in the second study implicit self-esteem predicted participants' performance over and above explicit self-esteem.

As a first consideration, this result adds to a growing body of research in the field of implicit social cognition that supports the value of implicit methods in predicting behaviour (e.g., Greenwald et al., 2009 for a meta-analysis; Perugini et al., 2010). More importantly, the results relative to positive correlations between explicit and implicit self-esteem and self-recognition seem to suggest that this cognitive ability is not universal but it is qualified by individual differences in self-esteem, and especially implicit self-esteem. Notably, for the first time it is shown that self-esteem qualifies the extent to which people are able to recognize their own body-parts (see Ma & Han, 2010 for similar findings about face-recognition). This result may be relevant not only for the understanding of the influence of personality factors in self-body representation in humans, but could have important implications for the study of people with damaged body image, such as patients with eating disorders.

Regarding the apparent inconsistency of the results (i.e., self-recognition predicted by explicit self-esteem in Experiment 3 and by implicit self-esteem in Experiment 4 in terms of incremental validity) we believe this might be considered in the light of recent evidence showing that implicit and explicit self-esteem predict different behaviours. According to dual-process models (e.g., the RIM of Strack & Deutsch, 2004), implicit self-esteem taps into processes that have associative nature and it would better predict spontaneous and affectively driven behaviours (Bosson, et al., 2000), that are also more usual and automatic. Therefore, it might be that in our research implicit self-esteem resulted more predictive in the case of more automatic task involving self body-parts. It is likely -indeed- that in everyday life people directly and automatically recognize their own body-parts rather than covertly compare stimuli in order to match them, as it is the case in Frassinetti and colleagues' (2008) matching-to-sample paradigm. Moreover and decisively, joint analysis demonstrated that the self-esteem IAT was a significant predictor of the general ability to recognize one's own body-parts, regardless of the nature of the task (covert or overt).

In the literature, low or absent correlation between explicit and implicit self-esteem, together with their unequal power in predicting different kinds of behaviour, classically point to their distinct nature (Greenwald et al., 2000; Rudolph et al., 2008). In our first study, however, we found a significant positive correlation between scores in the RSES and in the self-esteem IAT, that was instead absent in the successive experiment. However, variations in the correlation between measures of implicit and explicit self-esteem are not uncommon in the literature (e.g., Olson, Fazio, & Hermann, 2007; Zeigler-Hill et al., 2010). Therefore, deeper insights can be gained not by asking whether there is a relation between implicit and explicit attitudes, but rather by asking when or under which conditions the two measures agree. For example, Pelham and colleagues (Pelham, Koole, Hardin, Hetts, Seah et al., 2005) found greater implicit-explicit self-esteem correspondence in females than males, and the authors hypothesized that this happens because women trust their intuitive feelings more than men, although Riketta (2005) found the opposite pattern. So, it might be that our results were partially driven by the fact that females were more numerous in the first than in the second sample. More interestingly, latency in responding to the items of the RSES (used as an index of the accessibility to self-attitudes) was recently found to moderate the relation between explicit and implicit self-esteem (Lebel, 2010): more specifically, self-esteem IAT scores significantly and positively predicted RSES scores for fast responders, whereas no relation emerged for slow responders. We did not registered our participants' latencies in RSES items so that a direct test of this possible explanation relative to our results is not possible. However, we believe that the accessibility-based explanation of Lebel might be considered in future research, even because it is consistent with research by Koole and colleagues (2001), who found that responses on a direct measure of self-attitude made under time pressure correlated more strongly with the IAT scores.

Furthermore, a more recent study by Koole and co-workers (Koole, Gocorun, Cheng, & Gallucci, 2009) suggested that meditation can lead to greater congruency between implicit and explicit self-esteem. This might be relevant here: in fact, in the case of Experiment 3, but not 4, people were photographed and asked to wait around 30 minutes before participating to the experiment. The possibility to have time to reflect on themselves and also about the fact they were taking part to a psychological study could have increased the correlation between implicit and explicit self-esteem, in line with what found by Koole et al. (2009).

The cause-effect relation between implicit positive association with self and the self advantage in face-recognition has been recently investigated by Ma and Han (2010). These authors found that the self-face advantage was reduced once the implicit positive association with the self was experimentally weakened by means of a self-concept threat priming procedure. Nevertheless, to our knowledge, no study so far investigated the relation between self-esteem and the self-advantage relative to body-parts other than the face. Critically, Ma and Han only used an implicit measure (the IAT) and an implicit face-recognition task (i.e., to discriminate head orientations of self-face and a personally familiar face) while it could be interesting to add an explicit measure and investigate in more detail subjects' performance in an overt recognition task. Notwithstanding the limitations, in future work it could be very interesting to examine whether the reduction of the self-advantage shown in face recognition following the weakening of implicit self-esteem by Ma and Han (2010) would occur for overt and covert body-recognition of other body-parts as well.

Furthermore, our results may be interesting also because they are relative to "neutral" body parts such as hands and feet rather than to "critical" body parts that are usually linked to body concern and dissatisfaction and that indeed often represent the focus of pathological misrepresentation in patients suffering from eating disorders (i.e., hips, thighs; e.g. Sachdev et al., 2008).

Finally, some considerations can be made with regard to our second aim. First, we replicated the findings of Frassinetti and colleagues (2008; 2010), thus confirming that the matching-to-sample task is a valuable method for investigating self-recognition. Then, we found that participants were faster to respond to their own than to other people's body-parts even in the overt task. This seems to indicate that a "self advantage" may also emerge in this kind of paradigm, in which instructions directly focus the subject's attention on body ownership. The fact that the self-advantage did not emerge in the overt paradigm when considering accuracy needs further research, although similar results were previously obtained, for instance by Devue and collaborators (2007). More generally, future research should investigate body-recognition using different paradigms in order to better understand the mechanisms underlying this function and whether the self-advantage in different tasks is mediated by the same perceptual or social cognitive mechanisms.

To conclude, the present contribution shows that body-recognition, similarly to face-recognition, is significantly dependent on one's own, especially implicit, self-esteem rather than being an equally shared ability among people. Overall, investigating the relation between individual personality differences and cognitive functions may help a better understanding of important psychological mechanisms, and contribute to the advance of both neurosciences and social cognitive science.

CHAPTER 4

The malleability of self-face representation and the role of psychological traits

4.1 INTRODUCTION

Results reported in Chapter 3 overall suggest that the self-recognition ability is less universal than previously believed. In particular it seems to partially depend on the individual level of self-esteem, especially implicit.

A growing amount of research recently showed that the self-representation is also much more malleable than believed in the past, not only in psychiatric and neurological patients (e.g., Vallar & Ronchi, 2009) but also in healthy people. Indeed, a rubber hand, which is clearly artificial and not belonging to the self, is relatively easily and quickly experienced as part of one's own body following synchronous visuo-tactile stimulation (Botvinick & Cohen, 1998; Tsakiris, 2009 for a recent review). When touches are delivered on the individual's hidden hand while he/she is seeing the rubber hand being touched in a compatible location in synchrony, the subject experiences a feeling of ownership of the artificial hand and an increased physical similarity between the rubber and the real hand (Longo, Schüür, Kammers, Tsakiris, & Haggard, 2009). Surprisingly, also the representation of the self-face, perhaps the most distinctive among self bodily features, was shown to be affected by the synchronous visuo-tactile stimulation (Tsakiris, 2008). Indeed, individuals judged as their own pictures containing a bigger amount of another person's facial features after being stimulated with synchronous as compared to asynchronous visuo-tactile stimuli. This suggests that experiencing ongoing, veridical multimodal sensory stimuli may quickly update cognitive representations (for example that relative to the visual appearance of one's own face!) that until recently were believed to be very stable.

The present research moves from the idea that individuals' susceptibility to the update of self-face representation might vary depending on self-esteem (particularly implicit self-esteem) and narcissism. Moreover, we planned to examine the relation between self-face representation and personality traits -such as empathy- that have a strong interpersonal nature.

The introductory part of the present chapter will open with an overlook of infants' and animals' experience with mirrors, aimed at pointing out the uniqueness of this experience, its relation to self-awareness and the role probably played by the integration of multisensory inputs. Subsequently, the main findings on the dynamic properties of self-body and face representation will be briefly reviewed.

Finally, the rationale and aims of Experiment 5 will be introduced in paragraph 4.2.

4.1.1 Self-face is special

As human beings, self-face is our most distinctive physical feature and a fundamental component of our identity. Indeed, differently from other self-related stimuli, our face represents a property that we do not share with other people, unless we have a twin (Devue & Brédart, 2008). The importance of the face in defining an individual may be easily noticed in common experience: passports typically contain a picture of our face, in addition to our name.

We are able to easily recognize our own face-images, either in mirrors or photographs and videos and, in the last decades, neuroscientists have intensively studied self-face processing and recognition. Even if remarkable attempts to approach the issue of face-recognition using different sensory modalities exist (e.g., Kitada et al., 2009 have studied subjects' ability in haptic identification of faces), most studies explored the visual modality. Several paradigms are commonly used to investigate self-recognition: some assess individuals' behavioural performance (Tong & Nakayama, 1999; Devue et al., 2009) while others search for neural correlates through neurophysiology or neuroimaging (e.g., Platek et al., 2006; Uddin et al., 2005a). Tasks can vary highly: be more or less direct (i.e., consisting on the explicit request to identify one's own face), use pictures or videos to compare famous, familiar or unknown individuals' images to the participant's own face, and test different populations, i.e. healthy people and/or neurological and psychiatric patients (e.g., Keenan et al., 2003).

Hemispheric dominance for self-face recognition has been a matter of controversy, with most behavioural studies supporting the hypothesis of a right hemisphere dominance (e.g., Keenan et al., 1999; Keenan et al., 2001). However, work relative to split-brain patients strongly suggests that both cerebral hemispheres are capable of self-recognition. In facts contradictory results have been obtained: for example, whereas Keenan and collaborators (2003) found a right hemispheric dominance in their patient, Turk (2002) concluded that the left hemisphere is dominant and other authors found no hemispheric dominance (see Uddin et al., 2005b).

At a more precise anatomical level, a number of fMRI studies confirmed that both hemispheres are likely implied during self-face recognition (see for instance Kircher et al., 2001), with greater involvement of the right hemisphere, particularly in parietal and frontal cortical areas (Platek et al., 2004). Further data relative to the neural correlates of self-face recognition as well as other behavioural and neurophysiological evidence were presented in Chapter 2 (see paragraph 2.1.2) and are not discussed further here.

Overall, it appears clear that the self-face is a special stimulus as far as it engages the activation of a number of specific cortical regions, with a right hemispheric dominance but a bilateral distribution. Nevertheless, the anatomical criterion is not the only demonstration of the special *status* of the self-face.

Researchers have extensively studied the ability of self-recognition in mirrors shown by infants and animals, in order to get a clue relative to self consciousness. In 1970, a series of rigorous experiments was performed by Gallup with the aim of examining species-specific behaviour during mirror exposure (Gallup, 1970). After being exposed to a mirror for ten days, a group of chimpanzees (our closest primate relatives) was anesthetized and an odourless red mark was applied above their eyebrow, so that it could not be seen by the animals. After the reintroduction of the mirror, chimpanzees from the group previously exposed to the mirror (but no animals from a control group) touched the mark on their face, while looking at themselves in the mirror, showing a certain degree of recognition of their own image in the mirror. Gallup considered this behaviour as implying a basic form of self-awareness, or the presence of a rudimentary self-concept. Since then, a number of studies have demonstrated -more or less clearly- mirror self-recognition in several species of non-human primates, dolphins, Asian elephants and other animals (e.g., Suarez & Gallup, 1981; Plotnik, de Waal, & Reiss, 2006). These findings have been referred to as "demonstrations of a self-concept in a subhuman form" (Gallup, 1970, *p. 87*). Overall, Gallup's data and conclusions about self-recognition in animals are useful to remark similarities and differences with respect to human behaviour, in particular in infants, even if they are still debated. Indeed, despite Gallup's account of the mark test as an index of self-recognition and self-awareness in chimpanzees is highly influential, some authors questioned this conclusion focusing on infants' performances. Most children develop the mirror self-recognition ability by the age of 18-24 months (Anderson, 1984). However, cases of both false positive and false negative exist. On the one side, infants sometimes touch their nose after viewing a mark on their mother's nose (Mitchell, 1993), making it difficult to conclude that the mirror test only reflects processes concerning the self rather than both self and others; on the other side, in some cultures children do not pass the mark test before being 6/7 year-old. Remarkably, a number of reasons other than self-awareness could lead to a failure in the mark test; for example, a misunderstanding of the relation between the real and the reflected space (e.g., Priel & de Schonen, 1986).

4.1.2 Infants in the mirror

Notwithstanding the limitations reported above, the mark test (or rouge test; Amsterdam, 1972) has been considered as a manifestation of mirror self-recognition in infants, appearing during the second year of life in normally developing children. Typically, in this test a rouge mark is covertly applied on the subject's face (often cheek, nose or forehead) and the experimenter is interested to see whether infants touch the mark when subsequently placed in front of a mirror. Amsterdam (1972) recognized four developmental periods of infants in front of a mirror: first, infants tend to consider their own image as a playmate; subsequently their curiosity regarding mirrors explodes and they touch and look behind them, showing explorative behaviours. This phase is followed -by 20 months- by withdrawal behaviours and avoidance. Finally, most infants actively explore their face in the mark test and show social expressions such as embarrassment. Similarly, Rochat (2003) identified five steps that infants go through regarding the experience of mirror reflection, starting from confusion and unawareness and finally reaching self-consciousness. Therefore, it is worth noting that several complex cognitive and affective progresses are needed before infants may show the self-recognition ability, that in turn indicates a more complex form of self-identity and self-awareness.

The way children develop the ability to recognize themselves in mirrors fascinated not only developmental psychologists but also philosophers. For instance, Merleau-Ponty explained in a long essay (1964) his idea that the mirror not only permits the child to perceive his/her own facial features, but also makes available a more unitary image (objectification) than that obtained through interoceptive, proprioceptive and exteroceptive sources. In short, the mirror would allow the child to see himself as he/she is seen by others, and to realize that what he/she sees in the mirror is what other people also perceive of him/her. According to this author, recognizing oneself in a mirror image entails some synthesis of "coexistence with others" (Merleau-Ponty, 1964, *p. 140*). Rochat and Zahavi (2010) consider Merleau-Ponty's view as a possible explanation of the transition from the mirror image as perfect playmate to child's embarrassment in front of the mirror (social behaviour).

More central to our concern, a number of studies seems to support the idea that infants already show some basic perceptual abilities in discriminating what pertains to themselves *versus* to others in mirror images long before the manifest ability to pass the mark test. That is, the ability to discriminate between the self-body and other bodies precedes by far the manifest conceptual and explicit self-awareness of self-recognition as measured with the mark test, and may represent an important precursor. Recently, a study of Rochat and Striano (2002) showed that infants looked and smiled more at a mirror video depicting another person (reproducing the same gestures made by the infant) with respect to the self-image, thus suggesting an early ability to discriminate between self and others. Moreover, they always preferred the video displaying the online contingency as compared to a video delayed by 2 seconds, a preference that is likely based on the ability to process a complex combination of features, movement, dynamic and temporal information. Notably, results did not differ depending on infants' age (4 *versus* 9 months), indicating the early emergence of such an ability.

A number of studies has attempted to determine which of the cues provided by mirrors are used by infants to recognize themselves. In general, it seems that from 3 months of age infants enjoy the experience of visual-proprioceptive contingency afforded by mirrors. Some researchers have indicated that mirror self-recognition might depend on infants' ability to notice the contingent relationship between the self and a mirror or live video feedback (Bigelow, 1981). In several papers, Mitchell argued that mirror-self-recognition simply requires a kinaesthetic sense of one's own body, a capacity for kinaesthetic-visual matching and an understanding of mirror-correspondence (Mitchell, 1997*, p. 41*).

In short, early in development and long before explicit mirror self-recognition, infants develop a perceptual ability to identify themselves (sense of the ecological self), by exploring the rich intermodal redundancies and spatio-temporal contingencies. For mirror self-recognition to emerge during the second year, children need to "objectify" their selves (see also Merleau-Ponty, 1964), combining the direct perception of the ecological self with the indirect "me" reflected in the mirror.

Recently, Miyazaki and Hiraki (2006) found a significant developmental trend with regard to success in the mark test in 3-years-old children: while 88% of children passed the mark test when live video feedback were provided, percentage decreased to 71% with 1-second delayed feedback and to only 38% using a 2-s delayed feedback. Apparently, infants first identify themselves online and only later develop cognitive resources and conceptual capacities necessary to self-recognition with delayed feedback. Therefore, this study seems to document a developmental asynchrony.

Interestingly, a study evidenced that self-recognition measured by the mark test persists longer in subjects with Senile Dementia of the Alzheimer Type (SDAT) under contingent mirror-viewing than non-contingent video-viewing conditions (Biringer & Anderson, 1992). Indeed, all patients with moderately severe cognitive decline showed self-recognition in the mirror condition, while less than half were able to pass the test in the delayed video condition. Moreover, 25% of patients with severe cognitive decline failed to pass the mark test in mirror-condition and only one could pass the test in the case of delayed video. These findings are particularly interesting in the light of the pattern of self-recognition emergence in infants discussed above, with mirror self-recognition preceding the self-recognition of a non-contingent self-image. Critically in fact, it appears that the inverse pattern might occur in age-related decline.

It is worth noting that infants and elderly adults are not the only for which multisensory simultaneity is a precious cue for self-recognition. Even normal adults are sensitive to it, especially in particular conditions such as certain perceptual illusions, as we will see in the next paragraph.

4.1.3 Rubber Hand Illusion and other illusions

As seen above, the role of movement is implicit in many description of self-recognition, especially in the developmental context. Consistently, infants are able to discriminate their own leg movements displayed in a mirror from those of another infant as early as 5 months of age, probably relying on their ability to perceive the contingency between their behaviour and its effect (Bahrick & Watson, 1985).

A study of van den Bos and Jeannerod (2002) seems to confirm that the sense of one's self might be brought about by the detection of a contingent relationship among several sensory modalities. These authors simultaneously presented subjects with two images depicting their own and an alien (the experimenter's) hand. The two hands either made the same, a different or no movement. Subjects were required to decide which of several observed actions was the one corresponding to the action performed by themselves. Researchers observed an increased number of misattributions when the two hands made identical movements, although performance was almost perfect in the other conditions (different movements and no movement). Interestingly, the pattern of results seems to suggest that, especially when clear morphological cues are lacking, self-recognition is mainly influenced by the position of the seen hand with respect to the body and the synchrony between performed and seen movements.

Similarly and even more crucially, the argument that the detection of contingent relationship among modalities (i.e., vision, touch and proprioception) may contribute to the self-recognition is supported by a now classical work of Botvinick and Cohen (1998). In this study, one of the participant's hands was hidden from participant's view and a realistic rubber hand was placed in front of the subject. The experimenter synchronously touched the participant's and the rubber hand with a brush for ten minutes while the subject fixed the rubber hand. Responses to self-report questionnaires administered at the end of the stimulation showed that participants experienced an illusion: they seemed to feel the touch of the viewed and not the hidden brush, as if the rubber hand was their own hand. Besides, the illusion occurrence was supported by the displacement of subjects' judgement of the position of their hidden hand toward the position of the rubber hand and by the fact that -on average- people that underwent a slightly asynchronous stimulation did not experience the illusion. Authors' conclusion was that the "illusion's spurious reconciliation of visual and tactile inputs relies upon a distortion of position sense" (Botvinick & Cohen, 1998).

In general, illusions are of great interest for psychologists for what they can reveal about perceptual processes. The illusion of the rubber hand suggests that integration and interpretation of visual, tactile and proprioceptive information contributes to the sense of ownership and self-recognition.

The Rubber Hand Illusion (RHI) has been replicated several times (see Tsakiris, 2009 for review) with slightly different procedures. Lloyd concluded that "... the rubber hand illusion is a pervasive perceptual phenomenon, which can be elicited in less than 15 seconds in approximately eight out of ten people" (Lloyd, 2007). Usually, the illusion is indicated by two measurements: a questionnaire relative to the introspective experience of the illusion and the proprioceptive drift (i.e., the distance between the actual and the felt position of the real harm).

The rubber hand is not the only object that had been used to elicit the illusion and debate is still open regarding the limits of the illusion. Some authors believe that the intermodal matching between vision and touch is necessary and sufficient condition for the RHI to emerge and can be induced by an inanimate object not featuring the shape of a body-part (e.g., Armel & Ramachandran, 2003), while others suggest that this is not sufficient and a top-down modulation would occur, given that factors other than the visuo-tactile synchronization modulate the illusory experience (i.e., the illusion is stronger with corporeal objects in plausible anatomical and postural positions; see Tsakiris, Carpenter, James, & Fotopoulou, 2009; Costantini & Haggard, 2007). Critically, a study of Longo and collaborators recently showed that similarity between the rubber and the subject's hand does not influence the illusion but conversely the illusory experience increases the perceived similarity between the two hands (Longo et al., 2009).

Interestingly, a number of studies have also expanded the original finding by investigating the illusion or similar phenomena induced by visuo-tactile synchrony in other body-parts or whole bodies. For instance, Petkova and Ehrsson (2008) induced a sensation of body swapping by projecting to the head-mounted display worn by the participant the image recorded from two cameras placed close to a mannequin eyes and directed downwards to film the mannequin body. Moreover, Slater and co-workers experimentally produced an illusion of ownership of a virtual arm by tactually stimulating the hidden real hand and the seen virtual hand in a synchronous fashion (Slater, Perez-Marcos, Ehrsson, & Sanchez-Vives, 2009).

Overall, the RHI is a paradigm widely used to investigate body ownership and related phenomena such as perceived similarity (see Longo et al., 2009). Very recently, researchers started to examine the functioning of similar illusion on the face, the more distinctive body part that each of us owns (Tsakiris, 2008).

4.1.4 Self-face recognition: Classical and new approaches

From our own perspective, our own face is special even if it looks like any other face to other people. The face represents the most peculiar part of our own body and an important constituent of our sense of identity. Significantly, psychologists carefully consider the possible deleterious effects on the sense of identity in burned or disfigured patients and, more recently, in individuals that underwent face transplant (Bluhm & Clendenin, 2009).

Also the way in which we visually experience our own face, as compared to other faces, is special, since this typically occurs through reflecting surfaces. Therefore we see our own face more often in frontal view, what may cause significant biases in the representation of our own face. A likely consequence of this frontal view over-exposition, for example, is the known underestimation that people make about the length of their own nose (about 12%), when asked to represent it on a line (Thompson, 2002). Moreover, a number of studies suggested that people prefer and judge as more representative of themselves the mirrored image of their own face as compared to non-mirrored images (Mita, Dermer, & Knight, 1977; Rhodes, 1986). More recently, a work by Brédart (2003) indicated that participants used asymmetrically located cues (e.g., a mole) in order to judge the most typical view of their own face, while a more configural processing drove their response relative to other familiar faces.

Besides, as reviewed in Chapter 2, hemispheric dominance and neural correlates is another major focus of interest of research related to self-face perception (see Gillihan & Farah, 2005 for review). This body of work seems to suggest overall that the way we experience our own face affects its representation in memory and that, in turn, own face recognition requires a matching with such memory traces.

Recently, Tsakiris (2008) pointed out that research on self-face recognition focused almost exclusively on the retrieval of one's own face representations from memory (see Brédart, 2003; Brady, Campbell, & Flaherty, 2005). The author, on the basis of the importance that current multisensory inputs integration exerts in self-body representation, hypothesized that similar mechanisms could play an important, although neglected, role in the case of self-face recognition as well. Even if it is likely that we recognize ourselves by recognizing stored visual features previously observed in mirrors, pictures and videos, it is possible that for self-mirror images, concurrent, synchronous sensory-motor information represent critical clues for self attribution. Therefore, capitalizing on RHI research, Tsakiris investigated the specific contribution of multisensory stimulation for self-face recognition, assessing the extent to which synchronous and asynchronous visuo-tactile stimulation may alter self-face recognition. Participants were requested to stop a movie when the face started to look more like self than other (or other than self). The movie showed either the participant's own face gradually transforming in the other face or conversely the other face transforming into the participant's face. This self-recognition task was repeated before and after participants were repeatedly stroked on their face while looking at a morphed face (containing a blending of self and other features) being touched in synchrony or asynchrony. Results showed that following the exposure to synchronous but not asynchronous visuo-tactile stimulation subjects showed a bias in recognizing their own face, whereby morphed faces containing a higher percentage of "non-self" face were considered as belonging to the observer. In other words, the other person's face was somehow included in the cognitive representation of one's own face, suggesting that multisensory signals could update the self-face representation similarly to what happens for the self-body representation. The fact that the update occurred only following synchronous visuo-tactile stimulation ruled out the possibility that this was instead an unspecific effect of the visual exposure to the other face. Moreover, the experiment was repeated using a familiar face rather than one's own face. The lack of any change from pre- to post-test confirmed the self-specificity of the phenomenon.

Subsequently, Sforza and collaborators replicated this finding and referred to the induction of an illusion relative to the personal identity (i.e., the incorporation of the partner's facial features into the self-representation as an effect of the synchronous visuo-tactile stimulation) as "enfacement" (Sforza, Bufalari, Haggard, & Aglioti, 2010). These authors used a slightly different procedure to elicit the illusion. The main difference was that a close friend of the participant was present in the laboratory and functioned as model during the stimulation phase. In this work, both behavioural and introspective measures of the illusion were collected. Introspective measures consisted of self-report questionnaires adapted from previous work on RHI (e.g., Longo, Schüür, Kammers, Tsakiris, & Haggard, 2008; Botvinick & Cohen, 1998). It was also found that the strength of the illusion correlated positively with the participants' empathic traits and with the physical attractiveness of the partner.

Finally, a third and -to our knowledge- last study recently examined whether synchronous multisensory stimulation leads to self-other merging (Paladino, Mazzurega, Pavani, & Schubert, 2010). In this study, people who experienced the illusion (as measured using a questionnaire) experienced a larger resemblance between their own and the models' faces. Moreover, the illusion affected participants' judgement of the inner state of the other person, closeness felt toward the other person and conformity behaviour, suggesting that multisensory integration can create a sense of self-other similarity.

Thus, self-face representation appears to be malleable; nonetheless, psychological traits linked to this fascinating characteristic have never been investigated in detail. In the experiment described in the present chapter, we sought for evidence that personality traits, and in particular self-esteem, could bias the sense of ownership of self *vs.* other face images.

4.2 RATIONALE OF THE STUDY

The aim of the present study was that of examining whether relevant personality traits affected individuals' susceptibility to the above explained illusion generated by the visuo/tactile stimulation. In order to evaluate the illusory experience we used two measures: on the one hand, we focused on the introspective side by asking subjects to what extent they agree/disagree with a series of statements adapted from previous work (Longo et al., 2008; Petkova et al., 2008). On the other hand, we aimed at improving the only behavioural measure available at that time. Tsakiris (2008) had used videos of faces gradually changing from "100% self" to "100% other" (and viceversa) and asked participants to stop them at the point where they judged that the passage from one identity to the other occurred. Since videos consisted of serially presented morphed pictures giving the impression of a face gradually blending into another face, they might have induced task-specific cognitive expectations that in turn might have affected subjects' performance. Therefore, we planned to use a standard staircase procedure (Meese, 1995) in which pictures were presented one at a time in a seemingly random order, as it will be explained in detail in the section relative to the method. Moreover, we used an unfamiliar model's image in the stimulation phase instead of the 50-50% morphed face.

Starting from our results in Experiments 3 and 4, showing that the self-recognition ability is qualified by individuals' self-esteem, especially implicit, we hypothesized that self-esteem may be related to the susceptibility to the illusion and to the malleability of self-face representation. In particular, we hypothesized a negative correlation: people with higher self-esteem would possess a more stable self-face representation and therefore would be less susceptible to the illusion and less prone to incorporate non-self facial features in the self-face representation. The existence of a link between implicit self-esteem and self-recognition investigated using a morphing procedure was recently suggested by Epley and Whitchirch (2008). These authors demonstrated that self-enhancement effects (i.e., the fact that people's automatic association with the self are usually positive, see for instance Greenwald & Banaji, 1995) extend to recognition of the self-face. Participants were more likely, and faster, to recognize a morphed face containing elements of the face of an attractive other person as their own, with respect to real or unattractively morphed stimuli. Furthermore, as already mentioned in Chapter 3, Ma and Han (2010) experimentally manipulated the participants' implicit positive association with self using a self-concept threat priming and found that, as a consequence, the self-advantage (measured in terms of latency) in an implicit face-recognition task disappeared.

In addition, given that several studies have examined the links among implicit self-esteem, explicit self-esteem and narcissism (e.g., Jordan et al., 2003; see also paragraph 3.1.7), we introduced in the present study a widely used measure of narcissism -the Narcissistic Personality Inventory (Raskin & Terry, 1988)- in its most common version with 40 items. The NPI was developed on the base of DSM-III (American Psychiatric Association [APA], 1980) clinical criteria for narcissistic personality disorder; nevertheless, it was designed to measure narcissistic traits in non-clinical population so that also people that score very high on the NPI often do not meet criteria for diagnosis. Finally, the Interpersonal Reactivity Index (Davis, 1983) was adopted to examine empathy. Empathy, in a broad perspective, refers to the reactions of individuals to the observed experiences of other people (Davis, 1980; 1983). The IRI assesses both affective and cognitive components of empathy. The inclusion of this inventory in the present work was due to several considerations: empathy likely plays a major role in interactions between self and others and may well bias an illusion requiring a "blend" and, so to say, an "acceptance" of another face into the self-face. Moreover, a link exists between empathy and narcissism in that people with very high (pathological) narcissism are thought to lack empathy. Therefore, our hypothesis was that people lacking empathy would experience a weaker illusion, as demonstrated by behavioural and introspective measures.

In summary, we aimed at investigating the role played by relevant personality traits such as self-esteem, narcissism and empathy in order to allow a better comprehension of the cognitive processes involved in self-face recognition and self-face representation malleability.

4.3 EXPERIMENT 5

4.3.1 Method

4.3.1.1 Participants

Forty healthy participants (24 females, 16 males; mean age = 24.3 years, standard deviation = 6.7) took part in the experiment. All participants were Caucasian, native English speakers and had normal or corrected-to-normal vision. Participants provided their written informed consent to participate in the study and were paid for their participation. They all were unaware of the specific aim of the research. The study was approved by the Departmental Ethics Committee, Department of Psychology, Royal Holloway, University of London.

4.3.1.2 Procedure

The study comprised three experimental sessions that took place in different days. In the first session the participant completed in the following fixed order a self-esteem IAT, a measure of explicit self-esteem (i.e., the Rosenberg Self-Esteem Scale; Rosenberg, 1965), the Narcissistic Personality Inventory (Raskin & Terry, 1988) and the Interpersonal Reactivity Index (Davis, 1983). All measures were administered with Inquisit 3.0.2 on a 20 inches computer screen (Viglen Intel Core 2 Duo E7200).

Moreover, during the first session a picture of the participant's face was taken. Participants were required to come to the laboratory without piercing, make-up in the case of women and beard/moustaches in the case of men, and were asked to remove their glasses, when appropriate. They were also instructed to remove their hair from their faces and to fixate toward the camera with a neutral expression. Pictures were taken with a digital camera Nikon coolpix 5700 from a distance of around 35 cm in an artificially illuminated standard environment. Pictures were mirror-transposed and a black template was used to remove the background, the hair and ears, using Adobe Photoshop CS4. Subsequently, each participant's picture was morphed with a same-gender unfamiliar model's picture. A computerized morphing procedure was implemented (Abrosoft Fantamorph) to merge the participant's face with the model's face in 1% steps. As a result, 100 pictures showing a gradual blending of the facial features of the two faces (see Figure 11) were obtained. Pictures were stored and subsequently used in the self-recognition task during the second and third experimental sessions.

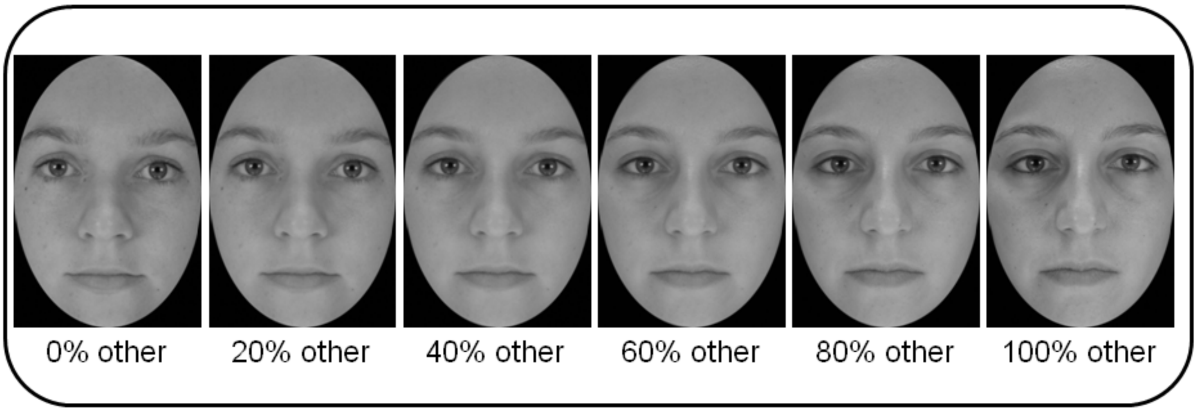

Figure 11. Examples of a series of morphed pictures used as stimuli. Participant's picture is on the left (0% other, 100% self); model's picture is on the right (100% other, 0% self).

4.3.1.3 Materials[10]

Self-Esteem IAT. The IAT was the English version of that used in Experiments 3 and 4 (see Table III in the Appendix for the complete list of the category labels and items).

Explicit self-esteem. The original English version of the RSES (Rosenberg, 1965) was used. Participants rated their agreement to the items on a 4-point Likert scale.

Narcissism. Participants were required to complete the Narcissistic Personality Inventory (Raskin & Terry, 1988). This is a self-report questionnaire originally developed to explore individual differences in narcissism in non-clinical populations. The authors used the DSM-III behavioural criteria for the narcissistic personality disorder (American Psychiatric Association [APA], 1980) as a theoretical frame to conceive a series of dyadic items thought to reflect narcissistic traits. In a series of studies, the number of items was gradually reduced. Here, the 40-item questionnaire was used since it currently represents the most widespread measure used by non-clinical researchers. Subjects were asked to choose for each pair the alternative item that best matched themselves, even if the match was not perfect.

Empathy. In order to obtain a multidimensional measure of empathy, the Interpersonal Reactivity Index developed by Davis (1983) was used. The rationale of the IRI is that empathy can best be considered as a set of constructs, all concerning attitude towards the others. The IRI is a self-report questionnaire constituted by four 7-item subscales, each tapping some aspect of the concept of empathy. More specifically, the Perspective Taking (PT) scale measures the

[10] See the Appendix for details.

tendency to spontaneously adopt the point of view of other people; the Fantasy (FS) scale assesses the tendency to transpose oneself into the feelings and actions of fictitious characters in books, movies and plays. Both these scales are more cognitive in nature. The Empathic Concern (EC) scale is instead more oriented to the emotional side of empathy: it taps “other-oriented” feelings of sympathy and the tendency to experience feelings of warmth, compassion and concern for less fortunate others. Finally, the Personal Distress (PD) scale also assesses typical emotional reactions of the respondents. However, it is more “self-oriented”, being focused on feelings of personal anxiety, unease and discomfort in tense personal settings or in reaction to the emotions of others. All four scales showed satisfactory internal and test-retest reliability (Davis, 1983). In the present research, twenty-eight items that compounds the IRI were presented in a random order. Participants responded to each item using a 5-point Likert scale from 1 (“does not describe me well”) to 5 (“describes me very well”).

Self-face recognition task. Participants saw a series of pictures, presented one at a time on the centre of the monitor (a 20'' LCD-screen) and were asked to judge whether the face depicted “looked more like their own face or more like the other person’s face” using two alternative response-keys labelled “self” and “other”. Pictures depicted a face with a varying degree of morphing between the participant’s and the model’s faces.

A standard staircase procedure (Meese, 1995) was used in order to find the degree of morphing at which participants could not decide whether the morph looked more like the “self” or the “other” face, i.e. the point of subjective equality (PSE). Two staircases were randomly intermingled, one starting from the “100% other” and the second from the “0% other” morphed picture; therefore, one staircase proceeded in the direction “from other to self” and the other in the opposite direction “from self to other”. In each trial of the task, the staircase from which the morph was presented to participants was randomly selected. An hybrid algorithm was used: when a change in response direction occurs, two consecutive alike responses are required for a reversal to be considered. The initial step size was 5%, reduced to 2% after the first reversal and to 1% after the second reversal. Each staircase ended after four reversals and the task ended after the completion of both staircases. The degree of morphing corresponding to the PSE was calculated as the mean of the morphing percentages at which the last three reversals have occurred. The responses were logged and they served as a baseline measure of self-face recognition.

In order to familiarize subjects with the experimental procedure and to make sure of their comprehension, participants received a preliminary training on the task. They were shown with pictures obtained by morphing the face of Tom Cruise and that of David Beckham and asked to decide whether the image "looked more like Cruise's face or more like Beckham's face" using two alternative response-keys.

Visuo-tactile stimulation phase consisted on a pre-recorded movie lasting 120 seconds, in which the face of a gender-matched unfamiliar person's face (the same used to create the morphed pictures) was touched on the right cheek every two seconds with a cotton-bud. The video was edited (Camtasia Studio) on the screen placed at eye-level approximately 0.5 m away from the participants, that were only asked to observe it. While watching the video with the face being touched, participants were touched by the experimenter with an identical cotton-bud in a mirror-reversed congruent location at a rate of about 0.5 Hz. Each stroke covered a distance of about 2 cm on the face, from the zygomatic bone downwards. Critically, the felt stimulation could be either synchronous or asynchronous with the seen stimulation; however, the total number of delivered stimuli was identical in the two conditions (synchronous and asynchronous). The asynchrony between visual and tactile stimulation in the asynchronous condition was approximately one second. The experimenter listened to an audio file through headphones to pace the delivery of tactile stimuli.

Figure 12. Setting of the experiment. The participant observes the model's face being touched in front of her, while being touched in a compatible position in her own cheek.

In order to behaviourally assess the effect of synchronous or asynchronous visuo-tactile stimulation, participants were required to complete again the self-face recognition task described above at the end of the stimulation procedure. Therefore, each experimental block consisted of three stages: pre-test, visuo-tactile stimulation and post-test and the change in the degree of morphing from pre- to post-test served to quantify the change that occurs in self-face representation following the visuo-tactile stimulation. The whole experimental block was repeated a second time in the same session, after a wash-out resting interval of 5 minutes. All subjects participated in two session, in which either the synchronous or asynchronous visuo-tactile stimulation was delivered. The session order was counterbalanced between subjects. Also the hand used to respond to the pictures was counterbalanced.

In addition, at the end of each session participants were asked to complete a questionnaire relative to the stimulation phase in order to assess the subjective feelings associated to the experience and investigate the perceived phenomenology of the illusion. Fourteen items (see Appendix, VII) were adapted from the previous work of Longo and colleagues (Longo et al., 2008) and Petkova and colleagues (Petkova & Ehrsson, 2008), relative to the rubber hand and the full body illusion. Items were presented to the subjects in a random order. Participants rated their agreement with each statement using a 7-point Likert scale from -3 ("strongly disagree") to +3 ("strongly agree").

4.3.2 Results

4.3.2.1 Data transformation

According to Greenwald and collaborators (Greenwald et al., 2003) we computed the D score relative to the self-esteem IAT applying a penalty of 600 ms to the incorrect trials. A more positive implicit self-esteem corresponds to a higher D score (α = .85). Regarding the explicit self-esteem, a total score was calculated, after the appropriate reversals of five scores of the RSES items (α = .72). Four scores were obtained for the IRI, one for each of its subscales: perspective-taking scale (α = .83), fantasy scale (α = .81), empathic concern scale (α = .77) and personal distress scale (α = .78). Always, higher scores in the questionnaires corresponded to higher levels of the trait under investigation.

As mentioned above, two measures were obtained regarding the effect of the visuo-tactile stimulation on the self-face representation. The difference between the post-test and the pre-test scores relative to the self-recognition task represented a behavioural and more objective measure. Since the point of subjective equality was expressed in terms of percentage of "other" in the picture presented (e.g., the value 48 means that the participant could not decide anymore about the identity of a morphed face containing 48% of "other" and 52% of "self"), a positive difference implies that after the visuo-tactile stimulation participants "accept" a bigger degree of “other” in the representation of their own face. Similarly, response scores to the questionnaire were considered separately for the synchronous and the asynchronous condition, providing an introspective measure of the illusion. The score in the questionnaire administered after the asynchronous stimulation represents a control condition to be used as a comparison for the critical score obtained following the synchronous stimulation.

4.3.2.2 Self-face recognition task

A preliminary analysis was performed in order to control whether the direction of morphing in the two staircases (“from other to self” *versus* “from self to other”) affected the pre-test values. The variable Direction of Morphing was considered in the responses given by each subject in the pre-test stage of the first experimental block. The t-test was not significant: $t(39) = 1.04$, $p = .304$, thus excluding an effect of the direction of the staircase in subjects’ performance. We also excluded statistically any effect of subjects’ gender and session order (synchronous-asynchronous *vs.* asynchronous-synchronous).

The subsequent analysis focused on the differences between post-test and pre-test. Since subjects performance was not significantly different in the first and second experimental blocks, data from the two blocks were collapsed. A 2X2 ANOVA with Condition (synchronous *vs.* asynchronous visuo-tactile stimulation) and Direction of Morphing (“from other to self” *vs.* “from self to other”) as within-subjects factors was performed on these values. The main effects were not significant, while the interaction was not far from significance: $F(1,39) = 3.25$, $p = .079$.

Even if no significant effects were found, Figure 13 clearly shows that the effect of the visuo-tactile stimulation is different in the two staircases. In particular, the synchronous but not the asynchronous stimulation appears to push participants to “incorporate” the other person’s facial features in their own face representation when the effect is measured in the staircase proceeding “from other to self”. Conversely, results relative to the direction “from self to other” are somehow surprising, with a bigger effect following asynchronous than synchronous visuo-tactile stimulation.

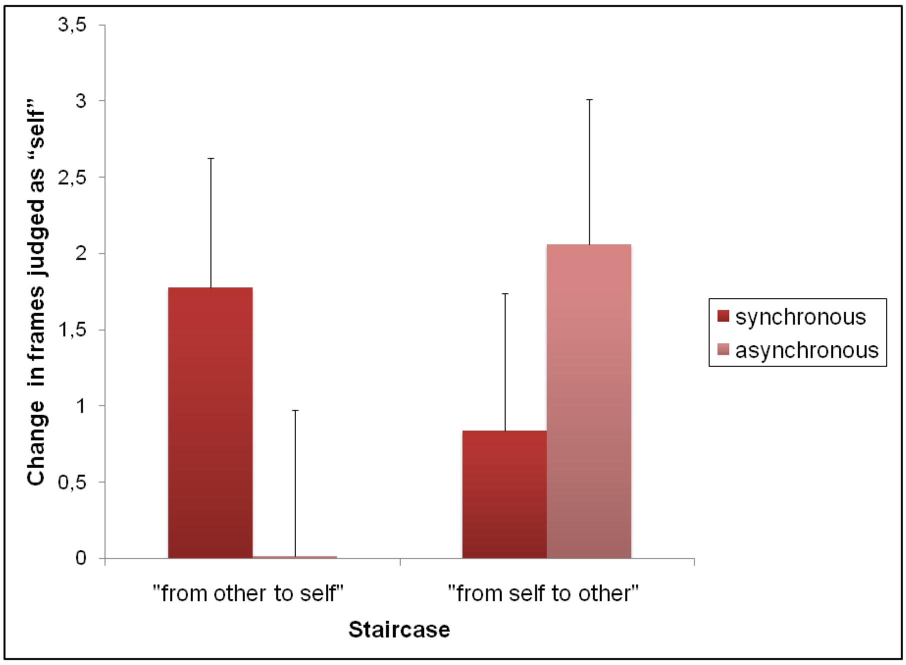

Figure 13. Mean change (± standard error) in frames perceived to look more as "self" as a function of synchronous/asynchronous visuo-tactile stimulation and direction of staircase ("from self to other" or "from other to self").

The presence of a larger effect (i.e., a larger difference between the post- and the pre-test) in the " from other to self" direction with respect to the opposite direction "from self to other" as a consequence of synchronous stimulation corroborates previous findings (e.g., Tsakiris, 2008). Since results in the "from self to other" direction are unexpected and lack a clear interpretation, at this stage only values from the direction "from other to self" were considered for explorative correlations with scores relative to personality traits.

4.3.2.3 Introspective evaluation of the illusion

Subjects' responses to the questionnaires were first averaged separately for session with synchronous (α = .93) and asynchronous (α = .90) visuo-tactile stimulation. The t-test performed on these values was significant, $t(39) = 4.65$, $p < .001$ indicating that participants experienced some degree of illusion at an introspective level. Subjects' gender and session order (i.e., synchronous-asynchronous *versus* asynchronous-synchronous) did not qualify this difference.

A series of paired t-tests was performed contrasting responses to each question in the synchronous versus asynchronous session. As shown in Figure 14, differences in the ratings following synchronous and asynchronous stimulation were significant for questions 1, 2, 4, 5 and 6: t = 6.51, p = .0126 for statement 1; t = 5.18, p = .0126 for statement 2; t = 3,43, p = .014 for statement 4; t = 3.88, p = .0126 for statement 5; t = 3.68, p = .014 for statement 6. Bonferroni-corrected p-values are reported.

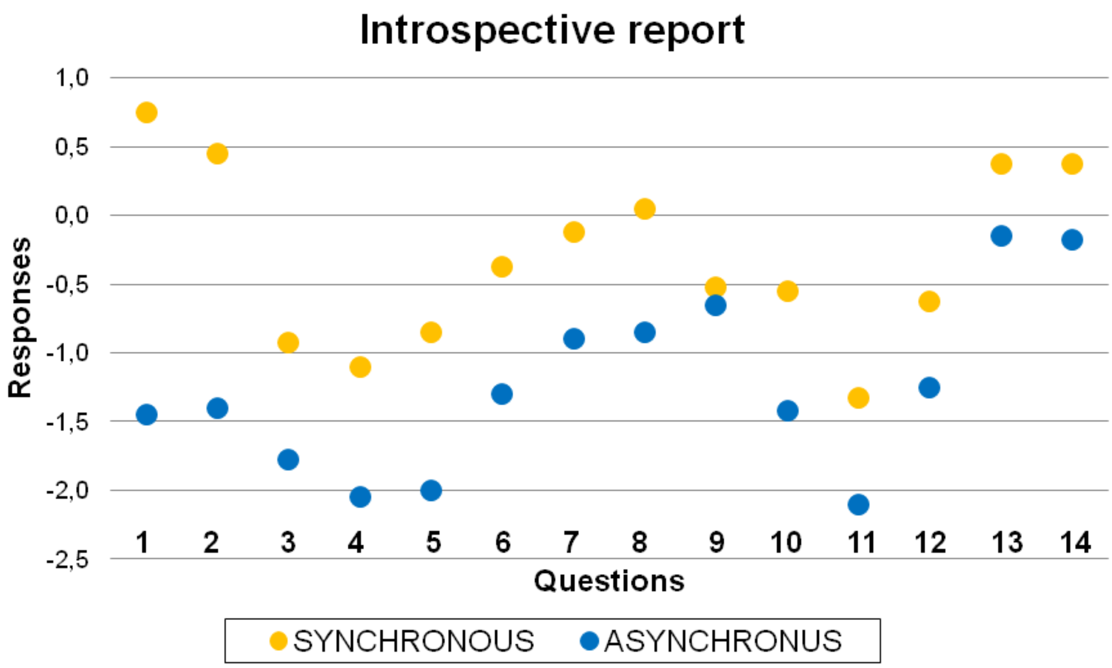

Figure 14. Data relative to the introspective experience of the illusion.

A further analysis was conducted following the methodology adopted in a previous study. Longo and colleagues (Longo, Schüür, Kammers, Tsakiris, & Haggard, 2008) performed a Principal Components Analysis (PCA) on data referring to the experience of the RHI. One hundred and thirty one participants completed structured introspective reports in which they rated -using a 7-point Likert scale- their agreement/disagreement with 27 statement relating to their subjective experience of the illusion. Results revealed four major components of the experience (i.e., embodiment of rubber hand, loss of own hand, movement and affect); moreover, secondary analysis showed that the embodiment component had three subcomponents (ownership, location and agency).

Since the big majority of our 14 statements were derived from the above mentioned study by Longo and collaborators' (2008), they were grouped according to the components found in that study. Four clusters were obtained: "location" refers to whether participants experience a confusion about the location of felt and seen touches (questions 1 and 2), "ownership" over the other person's face (3-9), "agency" is the feeling of control over the other face (10-11) and "loss of own face" refers to sensation such as loss of control and lack of vividness (12-14). Clusters showed satisfactory internal consistencies in both synchronous and asynchronous conditions:

location (r = .65 and r = .70 for synchronous and asynchronous condition respectively), ownership (α = .91 and α = .88), agency (r = .56 and r = .41) and loss of own face (α = .54 and α = .77). Scores relative to all but the component "loss of own face" were significantly different following synchronous and asynchronous visuo-tactile stimulation as revealed by paired t-tests: t = 6,44, p = .003 for component location; t = 3.73, p = .004 for component ownership; t = 3.38, p = .008 for component agency. Bonferroni-corrected p-values are reported. The difference between scores in the "loss of own face" component after synchronous *versus* asynchronous condition was, anyway, not far from being significant. This pattern of results seems to suggest that participants' own face experience is less affected by the synchronous visuo-tactile stimulation than usually reported in RHI field (e.g., Longo et al., 2008; Tsakiris, 2009), likely because the face holds a more stable representation and/or is the more unique body part we own. Moreover, it is worth noticing that while location, ownership and agency are three subcomponent of the embodiment component, loss of own face represents a separate major component (see the above reported PCA findings from Longo et al., 2008).

Correlations between these four clusters and scores relative to personality traits were subsequently calculated in order to examine whether personality variables are related to the individual susceptibility to the illusion (see paragraph 4.3.2.6).

4.3.2.4 Personality traits

As explained above, several traits of personality were tested during the first experimental session. In order to offer a complete picture of results, the mean scores and relative standard deviations are reported in Table 5. Moreover, correlation values are displayed.

Table 5: Correlations relative to Experiment 5.

	M	*SD*	1	2	3	4	5	6	7
1. IAT self-esteem	.62	.31	1						
2. Explicit self-esteem	2.95	.43	.23	1					
3. Fantasy (FS)	4.14	.71	-.06	-.16	1				
4. Empathic Concern (EC)	4.42	.55	.07	-.04	**.44****	1			
5. Perspective taking (PT)	3.99	.68	.12	.08	-.10	**.31***	1		
6. Personal Distress (PD)	2.83	.68	-.18	-.27	**.43****	.05	-.06	1	
7. Narcissism	.34	.20	.05	**.41****	-.02	**-.31***	-.23	-.30	1

*Note: ** p < .01, * p < .05 (two-tailed)*

A first consideration is the lack of correlation between implicit and explicit measures of self-esteem, a pattern that reflects findings of most previous studies (see Bosson, Swann, & Pennebaker, 2000). Moreover, explicit but not implicit self-esteem was found to positively correlate with narcissism. This may be partially due to the absence of correlation between two measures of self-esteem in our sample, but more interestingly it confirms the claim made by Jordan and colleagues, that individuals with incongruent explicit and implicit self-esteem (high explicit and low implicit, i.e. "defensive" self-esteem) hold highest levels of narcissism (Jordan et al., 2003).

Notably, data reported in Table 5 confirm a pattern emerged from the original work of Davis (1983) relatively to the intercorrelations among the IRI scales. The author, on the basis of the literature, hypothesized and found a pattern similar to that found in the present experiment. Specifically, Perspective Taking was positively correlated with Empathic Concern on the one side and independent of the Personal Distress on the other side. Fantasy was positively correlated with EC. In addition, a positive correlation was evidenced between FS and PD.

Interestingly, narcissism was negatively correlated with both and only the more affective scales for empathy (i.e., EC and PD[11]).

4.3.2.5 Correlation between personality traits and the behavioural measure of the illusion

Considering now the staircase "from other to self", the difference between the change in the point of subjective equality following synchronous or asynchronous visuo-tactile stimulation was calculated. This index represents the strength of the illusion: the stronger the experience of the illusion, the higher the index.

The index was found to correlate negatively (r = -.26, p = .054, one-tailed) with the implicit self-esteem as measured with the Implicit Association Test, suggesting that people with higher implicit self-esteem is less susceptible to experience the illusion, measured as a change in the self-face representation. However, no significant correlation was found with the explicit self-esteem (r = -06). Moreover, the behavioural index relative to the illusion was positively correlated with the Fantasy scale of empathy (r = .26, p < .05, one-tailed).

4.3.2.6 Correlation between personality traits and the introspective report relative to the illusion

Correlations were calculated between scores relative to personality traits (see Table 5) and scores in four clusters (location, ownership, agency and loss of own face) following the

[11] Negative correlation between narcissism and PD scale has p = .06, two-tailed.

synchronous stimulation. Ownership and Perspective Taking were correlated (r = .36, p < .05, two-tailed). To show that this correlation was specific for the synchronous condition, we recomputed the correlation after partializing the asynchronous condition (pr = .34, p < .05). Moreover, Perspective Taking was not correlated with Ownership after asynchronous stimulation (r = .13, p > .40).

4.4 DISCUSSION AND CONCLUSIONS

Experiment 5 confirms previous findings, showing that the synchronous stimulation of the participant's and the model's face induces a bias in the perception of a face stimulus as "self" or "non-self". The critical difference with the control condition (i.e., asynchronous stimulation) was mainly reflected by the introspective report of the participants, but showed a trend also in the self-recognition task.

After the synchronous visuo-tactile stimulation, a bigger change in the point of subjective equality (i.e., the point of morphing at which participants could not distinguish anymore between self and other) from pre- to post-stimulation test was observed in the staircase "from other to self" than in staircase "from self to other". Remarkably, a similar pattern of results emerged in Tsakiris' study (2008) in which a bigger difference from pre- to post-stimulation judgements was found when the video depicted the other face transforming in the self face compared to the opposite direction of morphing. An explanation of the difference between the two staircases could be derived from previous work showing that "the subjects regarded the images in the version "self vs. unknown" (i.e., from self to other) as being more related with self, whereas the images in the version "unknown vs. self" (i.e., from other to self) had relations more with the unknown identities" (Woon Yoon & Kircher, 2005) and also that "comparing others to the self highlights differences between self and other, whereas comparing self to other yields more similar self/other ratings" (Decety & Sommerville, 2003). Of course this consideration has to be taken carefully since, in our paradigm, stimuli belonging to the two staircases were intermingled. Critically, in the staircase "from other to self" the update of self-face representation including other person's facial features was present after synchronous but not asynchronous multisensory stimulation, while in the opposite staircase a similar effect was not found. In general, it is supposable that the standard staircase procedure (Meese, 1995) might have at least partially produced this pattern of results. It is possible that the staircase procedure, requiring more time than videos to be completed, felt outside any supposedly effective after-stroking window, resulting in overall weaker behavioural effects. Moreover, the first staircase to be completed might have functioned as an anchor for the completion of the second, thus confounding the data.

Nonetheless, the analysis conducted on the correlation between the behavioural measure of the illusion -considering only the "from other to self" staircase- and scores in personality traits inventories gave interesting results. The initial experimental hypothesis was confirmed: people that showed a higher implicit self-esteem were less susceptible to experience the illusion and to consider bodily features of other people as part of their own face-representation. Notably, a general better self-recognition ability cannot account for this result in that what is considered here is the difference between the post-stimulation and the pre-test stimulation phase. This result is even more interesting in that the behavioural measure of the illusion is considered as an implicit index, whereas the introspective report is a more explicit measure in which participants are required to actively think about the feeling they had during the visuo-tactile stimulation. Interestingly, no correlation was revealed between the behavioural measure and explicit self-esteem. Instead, a positive correlation was found with the Fantasy scale of empathy. This is an interesting result, especially when considered in comparison with Sforza and colleagues' (2010) findings. These authors used a similar paradigm of multisensory stimulation and found a correlation between their behavioural measure and Empathic Concern and Perspective Taking scales. Critically -however- participants to that experiment were stimulated on their face while seeing a familiar person that was physically present and was stimulated in front of them; a very different situation from that experienced in our paradigm, where subjects saw videos of an unfamiliar model in a computer screen. Therefore, it is likely that Fantasy component of empathy, defined as the tendency to transpose oneself into the feelings and actions of fictitious characters in books, movies and plays (Davis, 1980; 1983), played a major role in our case.

As mentioned above, from participants' self-report emerged that they experienced the illusion following synchronous but not asynchronous visuo-tactile stimulation. In particular, significant differences were found in the "location", "ownership" and "agency" factors but not in the "loss of own face" factor. As low average scores in the questionnaire seem to suggest (see also Sforza et al., 2010), the illusion is probably less vivid with face as compared to hand or whole body stimuli (see Longo et al., 2008; Moseley, Olthof, Venema, Don, Wijers et al., 2008). Therefore, the visuo-tactile stimulation of the face may be sufficient to give to participants a feeling of ownership over the other face but not enough to decrease the perception of their own face, that is perhaps the most individual and distinctive part of the human body.

Interestingly, with respect to correlation among personality traits and the introspective illusory sensations, the higher participants scored in the Perspective Taking scale of empathy, the higher they scored in the "ownership" component of the questionnaire, in the synchronous but not asynchronous condition. Self and other representations are strictly interconnected starting from early in development (Rochat & Striano, 2002) and this interconnection might account for human capacity to identify with others. Here -viceversa- human capacity of identification with others predicted the illusory experience of ownership of the model's face (i.e., self-other merging). The result is also supported from that of Sforza and colleagues (2010) in behavioural measures and suggests a direction for future investigation that might focus on the experience of the illusion in people with deficit in interpersonal relation (i.e., in individuals with autism spectrum disorders; for review see Blair, 2005).

Overall, the standard staircase procedure proved not to be the best way to investigate the "enfacement" illusion. In future experiments the method must be improved, for instance presenting pictures from one staircase at a time. This procedure might also be used in order to investigate in deeper detail whether a difference exists in subjects' judgements depending from the picture used as starting point (self *vs.* other) and gain better understanding of the cognitive process underlying self-recognition and self-other distinction. In general, the method of illusory ownership sensations of bodily segments remains an intriguing and easy way to investigate the self-representation plasticity in healthy people. Furthermore this method could shed light on the mechanisms underlying certain pathological conditions with altered sense of body image, ownership or awareness (e.g., schizophrenia, anorexia nervosa, etc.). Moreover, the illusory experience may be interesting for the emerging field of social neuroscience, given the suggestion that sharing multisensory experience can make us feel to be more similar (Tsakiris, 2008; Longo, et al., 2009; Paladino et al., 2010).

Finally, given that, according to the initial experimental hypothesis, some of the personality traits were correlated and predicted the illusory experience, it may be interesting to investigate their relation with RHI and full-body illusion as well, especially in individuals showing pathologically low self-esteem, such as patients with eating disorders (see Meijboom et al., 1999) and body dysmorphic disorders (Buhlmann et al., 2008; 2009).

CHAPTER 5

General discussion, conclusions and future directions

The results of the present research provide various contributions to the study of the self-recognition ability in visual modality. Notably, the perspective adopted was unusual. Indeed, visual self-recognition is traditionally thought to involve the retrieval of visual representations stored in memory, when it involves the recognition of faces, while it would rely on interactions among current sensory/motor signals and more abstract representations in the case of body. This general point of view was inverted in the present work: static pictures of non-face body-parts (arms, legs, and especially hands and feet) were used in order to examine the ability to distinguish between self and others, without any movement-related cue. On the other side, the possibility that multisensory inputs (i.e., visual and tactile) might play a role in self-face recognition and also in the continuous update of self-face representation was investigated by using the recently developed method of illusory "enfacement" (Tsakiris, 2008; Sforza et al., 2010; Paladino et al., 2010). This change of perspective may *per se* bring about interesting insights.

The aim of the work was twofold: on the one hand, to find the neural correlates of the ability to recognize one's own body-parts compared to other people's body-parts through vision, an issue that has been addressed to a much lesser extent than for self-face recognition. On the other hand, whether the self-recognition ability is critically modulated by relevant personality traits, linked to the self-concept in general (i.e., self-esteem) or in a more strongly interpersonal perspective (i.e., empathy) was investigated.

Overall, our results supported the existence of an advantage for self-body recognition compared to other people's body recognition and confirmed that the matching-to-sample paradigm developed by Frassinetti and collaborators (2008; 2010) is a valuable method of investigation. This appears even more important when considering that visual recognition of the self-body is a still scarcely studied field of research, especially if compared to the extensively investigated issue of self-face recognition (see Gillihan & Farah, 2005 for review), and therefore new methods of research are needed. Moreover, previous studies mainly focused on whole-body or body-parts such as hips and waist (Sugiura et al., 2006; Devue et al., 2007), also because these stimuli are best suited to studying specific domain (e.g., that of eating disorders; see for example

Sachdev et al., 2008), whereas scarce research work has been devoted to the processing of more distal parts of the body (i.e., hands and feet) in healthy people.

The processing of distal body-parts -the extremities- is impaired more often than that of proximal body-parts in brain damaged patients showing deficit in self-body perception (i.e., in neuropsychological disorders such as personal neglect and somatoparaphrenia; Vallar et al., 2009), and therefore a better comprehension of the cerebral areas causally involved in such a processing in healthy people would offer a valuable contribute. In this regard, the paradigm of matching-to-sample is interesting also because static stimuli are used. Right brain damaged patients that show deficit in self-body recognition are usually impaired in their motor and/or sensory functions in the contralesional side of the body and thus they necessarily rely more upon visual than motor and proprioceptive cues for recognition of those body-parts. Besides, Frassinetti and colleagues found that the self-advantage in right brain-damaged patients can be selectively absent with static while present with dynamic bodily stimuli (Frassinetti et al., 2010). Hence, in spite of negative results reported in Chapter 2, we suggest that using static pictures in "virtual lesion" TMS studies would allow the better approximation of the real situation of these patients and would be a useful choice for further studies in future. For all the above mentioned reasons, we firmly believe that investigating the causal role of specific cortical regions in the visual self-recognition of the extremities by using TMS could allow a deeper understanding of both healthy and pathological conditions.

Developing valuable methods of investigation for self-body and other-body recognition ability may be important in the clinical field, also in order to evaluate brain-damaged patients in a more exhaustive way. Preliminary results seems to suggest that the so-called body form agnosia exists, is functionally and anatomically distinct from the body action agnosia (see Moro et al., 2008), and can be considered as the counterpart for bodies of the prosopoagnosia for faces. Moreover, a recent work of Frassinetti and colleagues (2009) provided initial evidence of a modular representation of the corporeal self, in that a simple dissociation was found: a group of patients showed impairment in self-body but not self-face processing. It is possible indeed that the occurrence of body form agnosia and deficits in self-body recognition is higher than believed, but underestimated for a series of causes. First, the fact that it is often associated with extensive lesions that impair the processing of the face besides that of the body; second, that patients may rely upon facial or motion-related cues for recognition. Holding easy and reliable methods to assess the ability to recognize body identities in general and self-body in particular is therefore important for diagnostic and rehabilitative purposes.

As far as the first aim of the project -relative to the neural correlates - is concerned, the results of Experiments 1 and 2 did not allow definitive conclusions regarding the role of the cortical areas under investigation for self body-parts recognition. The self-advantage (i.e., the better performance shown by subjects when matching their own body-parts pictures as compared to unfamiliar body-parts pictures, firstly shown by Frassinetti and colleagues, 2008) was not significantly diminished following repetitive transcranial magnetic stimulation. Despite it is possible that the stimulated areas are actually not involved in this cognitive function to the same extent that they are in self-face recognition (Uddin et al., 2006), several technical remarks may also account for this result. For instance, the TMS protocol used in the present study might have been inappropriate to interfere with self-body recognition, i.e. a very high-level cognitive function that is even believed to be related to self-awareness. In future studies different TMS protocols, such as an on-line, high frequency stimulation paradigm, might be used (Pascual-Leone & Walsh, 2002). Moreover, the possible influence of learning effects should be carefully avoided, given their possible effect of hiding TMS effects. Finally, it is worth noticing that the ability of self-recognition turned out to be very variable among individuals, and this variability might have prevented a significant modulation effect to emerge in the sample examined.

In the light of the variability emerged in Experiments 1 and 2, the main aim of experiments presented in Chapter 3 was to investigate an unexplored aspect in the understanding of the mechanisms involved in self-body recognition, that is the role of individual personality traits, and in particular of self-esteem, in biasing self-body recognition. The hypothesis that self-esteem modulates self-body recognition echoes research in the field of eating and body dysmorphic disorders relative to the link between self-body processing and evaluation (Cockerham et al., 2009; Buhlmann et al., 2008; 2009). Moreover and importantly, a role of self-esteem was recently demonstrated for face-recognition (Ma & Han, 2010). Overall, the present research aimed at providing support to previous studies showing that the association between self-esteem and body image does not occur only in psychopathology (e.g., Hoffmeister et al., 2010).

Besides, investigating whether different paradigms were comparably efficient as measures of self-body recognition was another aim of Experiments 3 and 4, and therefore an indirect (i.e., the matching-to-sample task) and a direct (i.e., judging whether a stimulus belonged to one's own or someone else's body) tasks were proposed. Both tasks proved to be valid measures of the self-advantage. Indeed, subjects were on average more accurate and fast when matching their own rather than other people's body-parts in Experiment 3 and were faster when judging self than other body-parts in the overt task of Experiment 4. The fact that subjects were not more accurate when explicitly asked to judge the body-part identity deserves further investigation, although is in accord with previous findings (e.g., Devue et al., 2007). The direct paradigm might reveal itself as a valid alternative to the matching-to-sample task also in future TMS studies, since it is possible that latency proves to be more sensitive than accuracy to this technique.

The results of two studies (Experiments 3 and 4) showed overall that self-esteem is a predictor of the ability to recognize one's own body-parts. Results were slightly different depending on the task: in Experiment 3, with the covert task, both explicit and implicit self-esteem were positively correlated with subjects' self-body recognition. In terms of incremental validity, the explicit self-esteem showed predictive validity over and above the implicit measure, although the self-esteem IAT was not far from being significant. When participants were asked to directly recognize their own body-parts (in Experiment 4), implicit self-esteem was found to predict individual ability of self-recognition over and above the explicit self-esteem. These results may be better understood in the light of previous research showing that implicit self-esteem is preferentially correlated to more spontaneous, automatic and usual behaviour, i.e. -in the present case- the overt recognition of one's own body (see the dual process-model of Strack & Deutsch, 2004; Spalding & Hardin, 1999).

In order to better understand the robustness of the effects of self-esteem in body-recognition, a joint analysis of the two studies as a single sample with two different tasks (covert *vs.* overt self-body recognition) was conducted. The self-esteem IAT was a significant predictor of the general ability to recognize one's own body-parts over and above the nature of the task (covert or overt). These findings therefore corroborate and expand (by using implicit and explicit measures of self-esteem and direct and indirect tasks) those of Ma and Han (2010), that focused only on the influence of implicit self-esteem in indirect self-face recognition. In the perspective of further improving the knowledge of the processes behind body recognition, it could also be interesting to investigate the causal relationship between self-esteem and self-body recognition by momentarily modulating the level of self-esteem, for instance by using the self-concept threat priming paradigm used by Ma and Han.

The present findings -moreover- pointed out that, while in Experiment 3 measures of implicit and explicit self-esteem were significantly correlated, they were not correlated in Experiment 4. It is important to note that the inconsistency between measures of implicit and explicit self-esteem is not uncommon in the literature (for a review, Jordan, et al., 2008; Zeigler-Hill, & Jordan, 2010). This inconsistency has been considered on the one side to be a proof of the distinct existence of explicit and implicit self-esteem (Greenwald & Farnham, 2000; Rudolph, et al., 2008) and on the other side to be the result of the conditions under which measures are taken (e.g., LeBel, 2010; Pelham et al., 2005). For example, individual differences in self-attitude accessibility has been recently found to moderate the relation between explicit and implicit self-esteem (Lebel, 2010). Note that statistically, this variation in the correlations between measures of implicit and explicit self-esteem might explain the variations in the incremental validity of implicit self-esteem. Further studies should investigate in deeper details the role of congruence/incongruence of implicit and explicit self-esteem in body perception, with particular attention to individuals with fragile self-esteem (high explicit-low implicit self-esteem) that were found to have the poorer performance in the overt task (see Chapter 3 for details).

To conclude, the contribution presented in Chapter 3 reveals that body-recognition, similarly to face-recognition, is significantly dependent on one's own, especially implicit, self-esteem rather than being an equally shared ability among people. Moreover, as self-body evaluation has been shown to be closely linked to self-esteem (e.g., Hoffmeister et al., 2010), the present research demonstrates that one cognitive function involved in body perception -that is self-body recognition- is also influenced by self-esteem. This would be true not only when considering psychopathological disorders (e.g., eating and body dysmorphic disorders), but also in healthy people. On a broader perspective, these results also support the hypothesis that individual differences (e.g., personality factors such as self-esteem) play a role in cognitive functions.

A final consideration is that the results of Experiments 3 and 4 were obtained with paradigms that use body-parts such as hands and feet, that are unusual in this field of research. One may suggest that the role of implicit and explicit self-esteem would be even greater in self-body recognition when considering "critical" body-parts such as hips or thighs that are usually linked to body concern and dissatisfaction and therefore are typically used in the research devoted to eating disorders. Investigating whether the processing of more "critical" body-parts would be even more dependent from individuals' self-esteem might therefore help to shed light on the processes underlying eating disorders and other psychopathological conditions.

Finally, Experiment 5 was conducted in order to investigate whether individuals with higher implicit self-esteem possess a body-representation that is more stable and less malleable, besides being more accurate. The prevision was confirmed since a negative correlation between self-esteem IAT and the update of the self-face representation following synchronous visuo-tactile stimulation was found. In other words, people with more positive implicit self-esteem were less prone to incorporate the facial features of an unfamiliar person after seeing this face being stimulated in his/her cheek while being synchronously stimulated in their own cheek. Moreover, the introspective feeling of ownership over the other person's face elicited by the synchronous visuo-tactile stimulation was stronger in participants that scored higher in the Perspective Taking scale of the Interpersonal Reactivity Index (Davis, 1983), that measures the tendency to spontaneously adopt the point of view of other people.

The exploratory nature of Experiment 5 and its preliminary findings leave many open questions. First, improving methodological aspects may be necessary in order to fully exploit the potential of the "enfacement" illusion for the study of self-face representation. To this aim, an effort is needed to understand why, in our sample, differences occurred depending on the direction of the picture change in the staircase procedure (i.e., “from other to self” *versus* “from self to other”). Then, it might be interesting to study the self-representation malleability in individuals that lack empathy (e.g., patients with autistic spectrum disorders; see Blair, 2005 for review) and see whether the illusion is present or absent. Moreover, the role played by personality factors such as self-esteem, narcissism and empathy may be examined in the rubber hand illusion, an issue that was never investigated so far. Interestingly, anorexic patients, for whom undue influence of self-esteem on body perception and evaluation represents often a risk and a maintaining factor of the disease, were recently found to be less (almost not) susceptible to the RHI than healthy people (Mansi, personal communication). Finally, it would be incredibly exciting to examine self-recognition abilities in individuals candidate to cosmetic surgery or, in the extreme cases, face-transplant, before and after the surgery, to gain insights about the update of self-representation and the sense of self-continuity following these radical changes.

Overall, this research fruitfully bridges knowledge deriving from the cognitive neurosciences and social cognition, and the results are interesting to link health and psychopathology, especially in the field of eating disorders. Further studies are needed in order to gain a deeper comprehension of the neural correlates, the cognitive mechanisms and the personal variables that underlie the sense of bodily self, which remains incredibly stable during the lifetime, in spite of all physical changes that naturally occur.

Appendix

Table I. *Italian items used in the **self-esteem IAT in Experiments 3 and 4**.*

"IO" (ME)	**"ALTRI" (OTHERS)**
"me" "io" "mio" "mia" "miei"	"loro" "esse" "essi" "altri" "altre"
"POSITIVO" (POSITIVE)	**"NEGATIVO" (NEGATIVE)**
"positivo" "gioia" "bello" "contento" "paradiso"	"negativo" "dolore" "brutto" "triste" "inferno"

II. *Italian version (Prezza et al., 1997) of the **Rosenberg Self-Esteem Scale** (Rosenberg, 1965) used **in Experiments 3 and 4**.*

Participants rated their agreement using a 4/6-point Likert scale from 1 ("strongly disagree") to 4/6 ("strongly agree").

1. Credo di essere una persona di valor, o almeno di valere come le altre.
2. Credo di avere molte qualità.
3. Tutto sommato penso di essere un fallimento. *
4. So fare le cose come la maggior parte della persone.
5. Credo di non avere molto di cui essere fiero/a. *
6. A volte penso di valere poco. *
7. Ho un atteggiamento positivo verso me stesso/a.
8. Nel complesso, sono soddisfatto/a di me stesso/a.
9. Vorrei avere più rispetto per me stesso/a. *
10. A volte mi sento proprio inutile. *

The * indicates negative items that need to be reversed before total score calculation.

Table III. *English items used in the **self-esteem IAT in Experiment 5**.*

“ME”	**“OTHERS”**
“self” “me” “my” “mine” “I”	“them” “their” “they” “others” “people”
“POSITIVE”	**“NEGATIVE”**
“positive” “rainbow” “happy” “pleasure” “pretty”	“negative” “pain” “agony” “fear” “ugly”

***IV. Rosenberg Self-Esteem Scale** (Rosenberg, 1965) used **in Experiment 5**.*

Participants rated their agreement using a 4-point Likert scale from 1 (“strongly disagree”) to 4 (“strongly agree”).

1. On the whole, I am satisfied with myself.
2. At times, I think I am no good at all. *
3. I feel that I have a number of good qualities.
4. I am able to do things as well as most other people.
5. I feel I do not have much to be proud of. *
6. I certainly feel useless at times. *
7. I feel that I'm a person of worth, at least on an equal plane with others.
8. I wish I could have more respect for myself. *
9. All in all, I am inclined to feel that I am a failure. *
10. I take a positive attitude toward myself.

The * indicates negative items that need to be reversed before total score calculation.

***V. Narcissistic Personality Inventory** (Raskin & Terry, 1988) used **in Experiment 5**. Participants were required to choose the alternative statement that best matches them.*

1. A. I have a natural talent for influencing people.
   B. I am not good at influencing people.

2. A. Modesty doesn't become me.
   B. I am essentially a modest person.

3. A. I would do almost anything on a dare.
   B. I tend to be a fairly cautious person.

4. A. When people compliment me I sometimes get embarrassed.
   B. I know that I am good because everybody keeps telling me so.

5. A. The thought of ruling the world frightens the hell out of me.
   B. If I ruled the world it would be a better place.

6. A. I can usually talk my way out of anything.
   B. I try to accept the consequences of my behavior.

7. A. I prefer to blend in with the crowd.
   B. I like to be the center of attention.

8. A. I will be a success.
   B. I am not too concerned about success.

9. A. I am no better or worse than most people.
   B. I think I am a special person.

10. A. I am not sure if I would make a good leader.
    B. I see myself as a good leader.

11. A. I am assertive.
    B. I wish I were more assertive.

12. A. I like to have authority over other people.
    B. I don't mind following orders.

13. A. I find it easy to manipulate people.
    B. I don't like it when I find myself manipulating people.

14. A. I insist upon getting the respect that is due me.
    B. I usually get the respect that I deserve.

15. A. I don't particularly like to show off my body.
    B. I like to show off my body.

16. A. I can read people like a book.
    B. People are sometimes hard to understand.

17. A. If I feel competent I am willing to take responsibility for making decisions.
    B. I like to take responsibility for making decisions.

18. A. I just want to be reasonably happy.
    B. I want to amount to something in the eyes of the world.

19. A. My body is nothing special.
    B. I like to look at my body.

20. A. I try not to be a show off.
    B. I will usually show off if I get the chance.

21. A. I always know what I am doing.
    B. Sometimes I am not sure of what I am doing.

22. A. I sometimes depend on people to get things done.
    B. I rarely depend on anyone else to get things done.

23. A. Sometimes I tell good stories.
    B. Everybody likes to hear my stories.

24. A. I expect a great deal from other people.
    B. I like to do things for other people.

25. A. I will never be satisfied until I get all that I deserve.
    B. I take my satisfactions as they come.

26. A. Compliments embarrass me.
    B. I like to be complimented.

27. A. I have a strong will to power.
    B. Power for its own sake doesn't interest me.

28. A. I don't care about new fads and fashions.
    B. I like to start new fads and fashions.

29. A. I like to look at myself in the mirror.
    B. I am not particularly interested in looking at myself in the mirror.

30. A. I really like to be the center of attention.
    B. It makes me uncomfortable to be the center of attention.

31. A. I can live my life in any way I want to.
    B. People can't always live their lives in terms of what they want.

32. A. Being an authority doesn't mean that much to me.
    B. People always seem to recognize my authority.

33. A. I would prefer to be a leader.
    B. It makes little difference to me whether I am a leader or not.

34. A. I am going to be a great person.
    B. I hope I am going to be successful.

35. A. People sometimes believe what I tell them.
    B. I can make anybody believe anything I want them to.

36. A. I am a born leader.
    B. Leadership is a quality that takes a long time to develop.

37. A. I wish somebody would someday write my biography.
    B. I don't like people to pry into my life for any reason.

38. A. I get upset when people don't notice how I look when I go out in public.
    B. I don't mind blending into the crowd when I go out in public.

39. A. I am more capable than other people.
    B. There is a lot that I can learn from other people.

40. A. I am much like everybody else.
    B. I am an extraordinary person.

Assign one point for each response that matches the key:

A: 1, 2, 3, 6, 8, 11, 12, 13, 14, 16, 21, 24, 25, 27, 29, 30, 31, 33, 34, 36, 37, 38, 39;

B: 4, 5, 7, 9, 10, 15, 17, 18, 19, 20, 22, 23, 26, 28, 32, 35, 40.

VI. Interpersonal Reactivity Index *(Davis, 1983) used* ***in Experiment 5****.*

Participants rated their agreement using a 5-point Likert scale from 1 ("does not describe me well") to 5 ("describes me very well").

1. I daydream and fantasize, with some regularity, about things that might happen to me. (FS)
2. I often have tender, concerned feelings for people less fortunate than me. (EC)
3. I sometimes find it difficult to see things from the "other guy's" point of view. (PT) *
4. Sometimes I don't feel very sorry for other people when they are having problems. (EC) *
5. I really get involved with the feelings of the characters in a novel. (FS)
6. In emergency situations, I feel apprehensive and ill-at-ease. (PD)
7. I am usually objective when I watch a movie or play, and I don't often get completely caught up in it. (FS) *
8. I try to look at everybody's side of a disagreement before I make a decision. (PT)
9. When I see someone being taken advantage of, I feel kind of protective towards them. (EC)
10. I sometimes feel helpless when I am in the middle of a very emotional situation. (PD)
11. I sometimes try to understand my friends better by imagining how things look from their perspective. (PT)
12. Becoming extremely involved in a good book or movie is somewhat rare for me. (FS) *
13. When I see someone get hurt, I tend to remain calm. (PD) *
14. Other people's misfortunes do not usually disturb me a great deal. (EC) *
15. If I'm sure I'm right about something, I don't waste much time listening to other people's arguments. (PT) *
16. After seeing a play or movie, I have felt as though I were one of the characters. (FS)
17. Being in a tense emotional situation scares me. (PD)
18. When I see someone being treated unfairly, I sometimes don't feel very much pity for them. (EC) *
19. I am usually pretty effective in dealing with emergencies. (PD) *
20. I am often quite touched by things that I see happen. (EC)
21. I believe that there are two sides to every question and try to look at them both. (PT)
22. I would describe myself as a pretty soft-hearted person. (EC)
23. When I watch a good movie, I can very easily put myself in the place of a leading character. (FS)
24. I tend to lose control during emergencies. (PD)

25. When I'm upset at someone, I usually try to "put myself in his shoes" for a while. (PT)
26. When I am reading an interesting story or novel, I imagine how I would feel if the events in the story were happening to me. (FS)
27. When I see someone who badly needs help in an emergency, I go to pieces. (PD)
28. Before criticizing somebody, I try to imagine how I would feel if I were in their place. (PT)

The * denotes items to be scored in reverse fashion.

Note:
PT = perspective-taking scale
FS = fantasy scale
EC = empathic concern scale
PD = personal distress scale

VII. *Statements of the* ***questionnaire for the assessment of the introspective experience relative to the visuo-tactile stimulation*** *used in Experiment 5 (adapted from Longo et al., 2008 and from Petkova et al., 2008).*
Participants rated their agreement using a 7-point Likert scale from -3 ("strongly disagree") to +3 ("strongly agree").
Items are grouped in four components.

LOCATION:

1. I felt the touch delivered in the other's face.
2. The touch I felt was caused by the cotton bud touching the other's face.

OWNERSHIP:

3. The other's face was my face.
4. The other's face was part of my body.
5. The other's face belonged to me.
6. I was looking at my own reflection in a mirror rather than at the other's face.
7. The other's face began to resemble my own face in terms of shape.
8. The other's face began to resemble my own face in terms of skin tone.
9. The other's face began to resemble my own face in terms of facial features.

AGENCY:

10. The other's face would have moved if I had moved.
11. I was in control of the other's face.

LOSS OF OWN FACE:

12. My own face was out of my control.
13. I couldn't really remember how my face was.
14. The experience of my face was less vivid than normal.

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