Individual differences in physical self-representation

Thesis submitted for the degree of Doctor of Philosophy

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Declaration of original authorship

I confirm this is my own work, and the use of all materials from other sources has been properly and fully acknowledged.

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Abstract

Understanding oneself lies at the centre of the human experience. Yet, to study the 'self' using the empirical process is an enormously challenging endeavour. The self manifests through multiple layers and aspects, which ultimately combine to form a representation that is unique to each individual. One such aspect of self-representation pertains to the 'physical self', which is the focus of studies described in this thesis.

Physical self refers to a core component of the self-concept, providing a constant anchor for rest of the self-components. Broadly, the physical self refers to the bodily features and their spatial relationship to each other. Physical self is vital for our social functioning through enabling a key distinction between self and other. Individual differences in physical self-representation can thus help characterise some of the building blocks of larger constructs such as cultural differences, and psychopathology.

This thesis focuses on studying physical self-representation across two sensory modalities, visual and auditory. Individual differences are explored at two levels. First, the impact of culture is tested through studying physical self-representation in two different cultural settings, Western Europe and India, since culture is believed to be associated with crucial differences in the nature of self-representations. Second, the impact of autism-related traits is tested through studying how physical self-representation maps onto autistic traits in both clinical and subclinical populations, since atypicalities in self-representation are noted in psychopathological conditions such as autism spectrum disorder (ASD).

The main findings from the thesis suggest domain-specific self-representations can function independently of each other where necessary. Nature of physical self-representation shows task specificity, i.e. there are significant differences in response patterns depending on whether it is evoked explicitly or implicitly. These studies also found broadly similar patterns of physical self-representation in two different cultures. Finally, another theme emerging from the studies in this thesis is that individual differences in autistic traits are associated in a modality-specific manner with physical self-representation in both clinical and sub-clinical populations.

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1. Introduction

"Knowledge of the self is the mother of all knowledge. So it is incumbent on me to know my self, to know it completely, to know its minutiae, its characteristics, its subtleties, and its very atoms "

Khalil Gibran

1.1 Dimensions of 'self' – as conceptualized by William James

William James in his classic work 'Principles of Psychology', wrote a chapter on 'the consciousness of self' which introduced the multidimensional concept of 'self' (James, 1890). In its widest scope, he described the 'self' as encompassing its constituent dimensions, feelings, and emotions generated within oneself (self-feelings) and the self-generated actions that aim for self-preservation. The first dimension of the self-construct is the material self(James, 1890)or the minimal self(Gallagher, 2000) which constitute the physical body. The second dimension of self, the spiritual self, has within it the psychological aspects of the self which form the subjective/inner being. It allows one to assess the psychological dispositions of the self – the ability to argue and rationalise, to have moral sensibilities and exert self-will. The spiritual self also allows one to assign beliefs, ideologies, traits and ideas to oneself forming the psychological self-representation. Following the initial descriptions by James, research in the field of self-representation has focused on the domains of physical (material) and psychological (spiritual) self.

The two domains of physical and psychological selves constitute a personal identity closely linked with the social-self (Brewer, 1991; Mead, 1913). The social aspect of the self-construct allows one to construct one's physical and psychological selves through the eyes of others. As described by the looking-glass theory of self, the uniquely human traits that one associate with oneself develop through interaction with other individuals (Cooley, 1902). Hence the perception of the self, embedded within one's psyche, is often evoked and modified in social contexts.

The pure ego –a 'sense of ownership' offers the next layer of the self-construct; it is the understanding that the feelings evoked in one and movement of one's body is owned by the 'self' and is unique to it. Pure ego is necessary for a concept of personal identity (James, 1890). The 'sense of agency' is the understanding that one is the cause of their actions; which are goal-directed with the aim of self-preservation. Thus, through the different layers of the self-construct and its interactions with the surrounding social and cultural contexts, be it immediate experience or cultural norms and values, everyone has a unique awareness of 'self' (See Fig. 1.1).

Following the initial foundation lay down by James (1890) of the central awareness of being, the concept of 'self' with its several dimensions, has been the focus of intense research in philosophy, psychology, and neuroscience (Gallagher, 2000; Leary & Tangney, 2011). Self-awareness as a phenotype emerges from interactions between genes and the environment (Rochat, 2011). The minimal self-awareness that is present at birth interacts with its environment to allow rapid development of perceptual, conceptual and ethical aspects of self, much of which is defined by and is in relation to social relations (Rochat, 2011). A recent review proposed a taxonomy for self-related phenomena with an emphasis on multiple levels of self-processing (Thagard & Wood, 2015). The authors categorize the 'self' in terms of representation of self and others (self-concepts, self-other representation), effectual-self (self-regulation, self-enhancement) and alteration in self-representation and self-control (self-development, self-expansion). These different categories are then discussed at four levels – social, individual, molecular and neural. Thus, the complexities in self-construct can be studied across different biological and psychological levels.

This chapter will provide an overview of behavioural and neural processes involved in physical and psychological domains of self-representation. Domains of self-representation do not develop in isolation but through interaction with social environments and social contexts. This overview will also focus on the influence of cultural affiliations as a social environmental factor on domains of self-representation. Furthermore, daily social interactions depend on processes of self-other representation in the form of self-other overlap and self-other distinctions. Atypical self-representation and processes involved in self-other interactions are implicated in social behaviour deficits observed in psychopathological conditions like schizophrenia (Franck et al., 2001; Irani et al., 2006; Platek & Gallup, 2002) and autism spectrum disorder (ASD; See Section 1.2.4). This overview will also focus on the psychopathology of ASD as a model of atypical self–representation. Self-related concepts in the field of psychology and neuroscience reviewed here are in the context of the empirical chapters to follow. The cognitive and neural investigation of 'self' in awareness, representation, disorders and clinical conditions is extensive and encompasses several topics beyond those covered in this thesis.

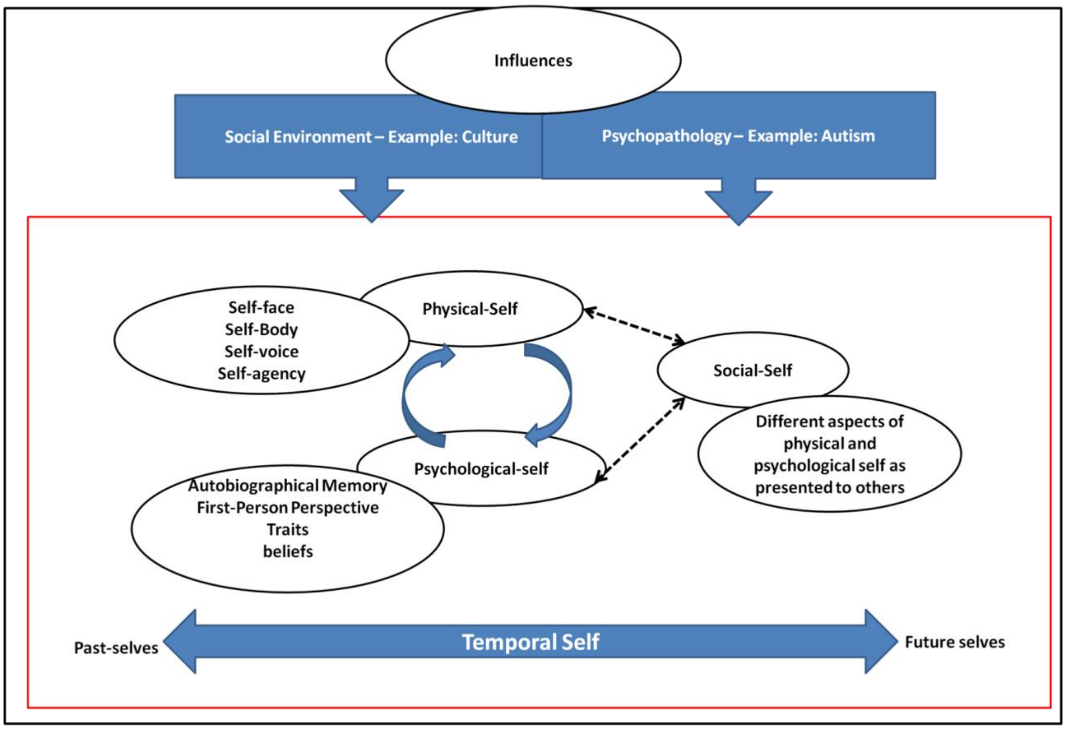

Fig.1.1 Schematic representation of different domains of self-representation constituting different levels along with possible interaction and influences.

1.2 Self-representation

1.2.1 Physical domain

The mental representation of the physical self refers to the representation of the bodily features and their spatial relationship to each other (Blakemore, Frith, & Wolpert, 1999; Prinz, 2013). Investigation of physical self-representation has primarily focussed on recognition of the physical self externally, i.e. through mirror-images, video recordings and still photographs (Amsterdam, 1972;Brédart, Delchambre, & Laureys, 2006;Devue, Van der Stigchel, Brédart, & Theeuwes, 2009;Keenan, Gallup, & Falk, 2003;Keenan, Ganis, Freund, & Pascual-Leone, 2000;Kircher et al., 2001;Nielsen & Dissanayake, 2004;Pannese & Hirsch, 2011;Platek, Wathne, Tierney, & Thomson, 2008;Sugiura et al., 2000;Sui, Zhu, & Han, 2006;Uddin, Kaplan, Molnar-Szakacs, Zaidel, & Iacoboni, 2005). To detect a presented stimulus as 'self' the external stimulus is compared to the mental representation of the physical self; thereby engaging physical self-representation. The visual recognition of physical self is often the study of self-awareness of what is 'me' or the objective self-awareness, as opposed to what is "I" or the subjective experience of self. To clarify, one can misidentify an image wrongly as self ('this is me'), however, one cannot misidentify the self-thought generated in the process ('I think this is me') (Gallagher, 2000). Investigating the objective self-awareness allows studying misidentification of physical 'self', to study self-related cognition in both typical and atypical populations. The self-awareness of what is 'I' does not allow for misidentification, thus, the study of self often involves self as an object or a cause of action as it is difficult to carry out experimental manipulation of the subjective self-experience. In addition to the studies of visual self-recognition, the physical self is often studied as the agency that causes actions (Sarah-Jayne Blakemore & Frith, 2003; Decety et al., 1994; Fourneret & Jeannerod, 1998; Jeannerod, 2003).

As proposed by James, the bodily-self constitutes the innermost part of the material self. James proposed that clothes combined with the body result in the material self. One can argue that the attire itself may not be a part of one's physical self but a part of the self-projection one seeks to create in the mind of social others. Attire may supplement the physical self in the formation of personal identity but it can be argued that it is not necessary for physical self-recognition. It is not clearly known to what extent personal identity of an individual is associated with the material self. Is the perception of one's entire physical identity inclusive of external factors like the clothes or hairstyle one wears?

One can investigate the role of external factors on physical-self by studying reaction time and accuracy advantages in physical self-recognition from participant's self-face (stripped of external features like hair) compared to a complete fully clothed photograph. If indeed hair style and clothing is an integral part of physical/material-self one may be better at recognizing physical self through such stimuli where clothing is included. The role of body and attire on physical identity and recognition of physical self is yet to be investigated in full details and such future investigations can further elaborate on the Jamesian concept of the bodily self.

Mirror Self-recognition

There is an innate representation of body schema in the brain. A fully developed body-representation is built upon this innate representation of the physical self through sensory experiences and proprioceptive feedback (Jeannerod, 2003). It is theorized that the development of the awareness of the physical self as a unique object is a precursor to higher order self-awareness (Rochat, 2011). Developmentally, the most common method of investigating physical-self representation is the self-face recognition in the mirror (mirror self-recognition; MSR; Anderson, 1984; Gallup, 1982; Gallup Jr, 1983). In developmental studies of self-awareness, MSR is measured as the ability of a child to detect a mark on their face using a mirror. This initial visual detection is followed by touching, exploring and in some cases trying to remove the mark which is believed to indicate the ability to understand the contingency between the mirror reflection and one's body and face. MSR emerges in the 18-24-month period of typical development (Brooks-Gunn & Lewis, 1984). The onset of MSR coincides with preferential looking towards self-image indicating that MSR is a reliable measure of the development of salience of the 'self' as an entity (Nielsen & Dissanayake, 2004). The underlying cognitive processes involved in MSR include kinaesthetic-visual matching and understanding of mirror correspondence (Mitchell, 1993). Looking at the mirror reflection of self leads to attention allocation to self-image and this attention to self is theorized to lead to introspection and awareness of one's mind (Lewis & Ramsay, 2004). MSR is also associated with the emergence of pretend play and use of personal pronouns, which are aspects of self-representation, important for the development of general self-awareness and theory of mind (Lewis & Ramsay, 2004). This has led to the theory that physical self-recognition in general, and MSR, in particular, is closely linked with the development of psychological self-representation and higher order self-awareness (Gallup, 1998; Lewis, 2012; Lewis & Ramsay, 2004). Examination of the physical self in a mirror provides a useful mechanism to analyse how one appears in the eyes of others. Examining oneself in a mirror can provide a clearer picture of self-image augmenting the internal abstract representation of the self (Prinz, 2013). Thus, mirrors are important cultural tools that help build self-representation, and the capacity to self-evaluate through mirrors provide a basis for self-development in both physical and psychological domains of the self.

Behavioural and neural correlates of self-face recognition

A theoretical model of face recognition proposes that faces are processed as units representing visual features and familiar faces are processed at a faster rate due to stronger visual representations that allow faster recognition (Bruce & Young, 1986). Self-face recognition studies using the serial presentation of self and other faces have found a self-face recognition advantage in terms of faster reaction time and higher accuracy (Keenan et al., 1999; Tong & Nakayama, 1999). Self-face recognition advantage is mediated by an implicit positive bias towards the recognition of the physical self (Ma & Han, 2010).

The observed self-face advantage in accuracy and reaction time is found to have hemispheric laterality, showing right hemispheric dominance for self-face recognition (Keenan et al., 1999). Several cognitive functions like language (Knecht et al., 2000;Loring et al., 1990;Vigneau et al., 2006) and emotion processing (Bourne, 2005;Lane, Kivley, Du Bois, Shamasundara, & Schwartz, 1995;Sato & Aoki, 2006) show lateralization effect i.e., the dominant role of areas belonging to one side of the cerebral hemisphere in a particular behaviour indicating asymmetrical nervous system functioning (Geschwind & Galaburda, 1985). Using morphed and unmorphed faces including self-face, left-hand responses were faster than right-hand responses, indicating right hemispheric dominance for self-recognition (Keenan et al., 1999). In another self-face recognition study, participants judged the frames of a self-other face morph videos to indicate the frame where they no longer recognised the face as self-face and categorised the frame as the other face(Keenan et al., 2000). It was found that with left-hand responses participants showed a self to other category shift for frames closer to the other face end of the morphing video. In other words, there was a positive perceptual/identification bias in self-face recognition for left-hand responses with lower levels of self-related information resulting in identifying a face as self-face. It is possible that there is a valence (as indicated by perceptual bias) by hemispheric interaction underlying the right hemispheric advantage for self-face processing.

The right hemispheric involvement in self-face recognition has also been confirmed using functional neuroimaging. A meta-analysis of 9 functional magnetic resonance imaging (fMRI) studies showed that self-face recognition has a dominant right hemispheric involvement along with a bilaterally distributed network (Platek et al., 2008). An fMRI study of viewing self- face compared to an unfamiliar face revealed right hippocampal formation, right insula and right anterior cingulate, left prefrontal cortex and superior temporal cortex activation for self-face compared to unfamiliar faces. Only the right insula was activated for viewing a familiar (partner's face) compared to unfamiliar faces (Kircher et al., 2001). An event-related fMRI study showed activation of the right hemisphere 'frontoparietal' mirror network (inferior parietal lobule, inferior frontal gyrus, and inferior occipital gyrus) when labelling a morphed face as 'self' from self-familiar face morphs (Uddin et al., 2005). In summary, the right hemisphere is shown to play a dominant role in self-face processing and right inferior frontal gyrus, in particular, is found to be consistently activated in self-face processing.

The right hemispheric involvement in self-face recognition has also gained support from clinical studies (Keenan, Wheeler, Platek, Lardi, & Lassonde, 2003; Uddin, 2011a). In a split brain patient, images of self and other faces were presented to one hemisphere at a time (lateralized visual presentation –to contralateral visual hemifield) as the skin conductance of the patient was measured. The highest skin conductance (indicating physiological arousal) in response to self-face was observed when self-face was presented in the left visual hemifield indicating right hemisphere dominance (Preilowski, 1979). In a patient with complete callosotomy, it was observed that a higher percentage of correct searches for self-face were made for left-handed responses indicating right hemisphere involvement (Keenan, Wheeler, et al., 2003). In summary, evidence from behavioural, neuroimaging and clinical studies has established the role of the right hemisphere in self-recognition in the visual modality.

However, the psychophysical properties of physical self-representation are not well characterized. Psychophysical properties of physical self-representation can be studied by varying the stimulus intensity in a physical dimension (for example percentage of the self-face present in the stimulus) and studying the effect of such systematic variation on the perception of that stimulus type. One of the overreaching aims of this thesis is to characterise individual differences in the psychophysical properties of physical self-representation. Characterizing individual differences in the psychophysical properties of physical self can show differences in both self-other overlap and distinctness in self-representation in the physical domain. The next section reviews the role of self-face in social behaviour highlighting the relevance of studying the behavioural representation of physical self in relation to self-other overlap and self-other distinction.

Self-face processing in social behaviour

Self-awareness is crucially relevant to social behaviour, and self-face recognition as a metric of physical self-representation is interlinked with social behaviour. One such social behaviour is 'theory of mind' that allows the essential understanding that others' beliefs are separate from one's own belief system and requires distinct mental representations of self and others (Frith & Frith, 2005). A meta-analysis of functional neuroimaging studies of self-face recognition and theory of mind tasks (including false belief attribution) found overlapping areas of activation in the superior temporal gyrus and ventral part of the medial prefrontal cortex (van Veluw & Chance, 2014). This indicates that there may be a possible interaction between the bottom-up sensory processes involved in self-face recognition and top-down processes involved in mental state attribution and theory of mind.

The ability to recognise oneself physically, specifically through self-face is believed to be associated with prosocial behaviours like empathising and emotion recognition, requiring both self-other overlap and self-other distinction (Bird & Viding, 2014). These two aspects, the merging and dissociating of the self from others is a key process underlying social behaviour. For example, producing a smile and visually seeing the same action in the mirror provides a direct contingent matching between self-action and self- observation. However, there is also a contingency between one's own smile and observing someone else smile where the other person acts as the social mirror. This contingency is built upon both self-other overlaps in sensory-motor representation as well as self-other distinction. Embodied communication can occur through social mirroring (Prinz, 2013). Seeing someone else smile (target - T) can lead to the mirroring of that action (by person M). On seeing M imitate the smile, T can receive direct feedback of self-generated action through the act of social mirroring. Social mirroring by M allows T to infer the smile (of M) being similar to the self-generated smile that is produced through similar mechanisms. Thus, physical self-awareness is not an isolated event but a key construct in our social interactions. Self is perceived via fellow social interactors and is crucial in building self-awareness and social behaviour(Cooley, 1902). To understand self-representation in any domain it is important to delineate the perceptual characteristics of self-representation and measuring psychophysical properties of physical self-representation can provide a basis for such characterizations.

At the neural level, self-recognition tasks are found to activate frontoparietal mirror networks in self–other discriminations, indicating simulation within motor representations (Meltzoff & Brooks, 2001) in imitative behaviour. The activation of mirror systems during self-face recognition provides evidence for the simulation model of the theory of mind (Uddin et al., 2005); that the state of others needs to be simulated through self in order to infer their mental states. This arises from the basic understanding that mental models of others are similar to one's own, and simulation through self allows access to others' minds (Gallese, 2007; Gallese & Goldman, 1998; Keysers & Gazzola, 2007). Theories and mechanisms in self-other overlap and self-other distinction underlie the importance of self-representation in typical social functioning. It is thus relevant to characterize the psychophysical properties of physical self-other overlap and self-other distinction in neurotypical individuals. Chapter 2 of this thesis investigates the behavioural representation of physical self, one of which is in the visual modality using self-face, in two different cultural settings, namely Western European and Indian, to gain a more detailed understanding of physical self-representation.

As reviewed in the above sections, the behavioural and neural correlates of self-face processing have been studied extensively, particularly in relation to right hemispheric advantages in self-face processing. However, the psychophysical properties of physical self-representation across different sensory modalities remain to be tested. The following section reviews the limited literature on physical self-representation in the auditory modality.

Behavioural and neural correlates of self-voice recognition

'Self' can be experienced physically through visual, auditory, tactile and olfactory inspection. The study of the physical self can be thus undertaken through investigations of different sensory modalities in the same individual. However, investigations of the physical self-recognition in different sensory modalities are considerably less frequent.

Humans are increasingly becoming more familiar with the recordings of their own voice through voice messages, voice mails, and other such media. Thus, in the current social world, self-voice recognition can serve as an index for physical self-awareness similar to self-face. Indeed, auditory modality is commented on as an important aspect of self/other distinction (Candini et al., 2014). At the perceptual level, self-voice representation is qualitatively different from that of self-face representation. The pictorial representation of self-face is similar in visual features of the mirror reflection of the self-face, the exteroceptive self-face stimulus that one is most familiar with. This allows the assumption that pictorial representation of the self-face can be reliably and accurately recognized by typical individuals. Self-voice, however, differs in the way it is perceived when it is self-generated compared to when it is recorded. This is primarily because the self-generated voice is conducted through both air and bone whereas the recorded self-voice is perceived through air conduction alone. This result in the somewhat different perceptual experience of listening to recordings of self-voice compared to when self-voice is perceived during the speech. Furthermore, while listening to self-voice individuals are shown to attend to the vocal features and not the lexical or individual specific qualities of the voice (Holzman, Rousey, & Snyder, 1966).

Superior accuracy is observed for self-face recognition compared to self-voice recognition (Hughes & Nicholson, 2010). Several studies have shown that personal identity is easier to determine from faces compared to voices (Ellis, Jones, & Mosdell, 1997; Hanley, Smith, & Hadfield, 1998; Joassin, Maurage, Bruyer, Crommelinck, & Campanella, 2004). Accuracy and reliability of self-voice recognition increase with exposure to the recordings of self-voice as in the cases of radio presenters and professional recording artists (Holzman et al., 1966). Studies investigating the cross-modal interaction of physical self in the visual and auditory modalities have reported both facilitation and inhibition in one sensory modality when presented with self-primes in other sensory modalities (Hughes & Nicholson, 2010; Platek, Thomson, & Gallup, 2004). In an event-related potential (ERP) study, reduced P300 amplitude, an index of attention, was observed for self-voice compared to other voice indicating fewer attentional resources were delegated to recognizing self-voice. Reduced attention to self-voice may indicate self-voice may not act as a salient stimulus in relation to self (Graux, Gomot, Roux, Bonnet-Brilhault, & Bruneau, 2015). In a self-other voice morph study, participants required lower levels of self-related information to stop categorizing a voice morph as a famous voice using their left hand than right hand (Rosa, Lassonde, Pinard, Keenan, & Belin, 2008). At a neural level, the right inferior frontal gyrus, previously shown to be activated in the self-face recognition, was also activated in recognition of self-voice (Kaplan, Aziz-Zadeh, Uddin, & Iacoboni, 2008). It can be argued that similar to self-face recognition, self-voice recognition is also associated with a right hemispheric dominance. Using cross-modal priming through self-odour and self-voice primes led to facilitation of self-face recognition. It can be argued that self-related information from different sensory modalities converge in higher-up processing sites in the brain like right IFG leading to integrated processing of self-related information in different sensory modalities that leads to observed cross-modal facilitation by self-primes (Platek et al., 2004). However, given the account of findings of both inhibition(Hughes & Nicholson, 2010) and facilitation(Platek, Thomson, & Gallup, 2004) of self-face processing in the presence of self-voice, the understanding of the associations between self-processing in the visual and auditory modalities remains incomplete. This thesis aimed at furthering the understanding of physical self-representation across visual and auditory modalities. To investigate physical self-representation across and between modalities, in addition to the investigation of self-face recognition, another aim of Chapter 2 of this thesis is to investigate physical self-representation in the auditory modality using self-voice recognition and study the individual differences in the association between physical self in visual and auditory modalities.

Self as a salient stimulus

Personal relevance of a stimulus increases attention capture of such a stimulus from the environment for further in-depth processing. Physical-self related stimuli automatically form a large part of personal relevance and exhibit high salience. Self-relevant information like self-name is shown to capture attention through unattended channels, a phenomenon known as a “cocktail party” effect (Moray, 1959). The self-related salience has also been demonstrated using ERP by showing increased positive component (P300-a measure considered to index the allocation of attention) to self-name (Gray, Ambady, Lowenthal, & Deldin, 2004). The salience of the self-related stimuli is relational in nature in that any self-related stimulus has most relevance to the owner and this increased salience related to self should result in increased attention to any self-related stimulus. In line with this theory, increased attention to self-face was observed in response to self-face viewing which resulted in faster processing of subliminal primes presented temporally adjacent to the self-face (Pannese & Hirsch, 2011). Presentation of self-face increased attention to self-face that interfered with cognitive tasks (Brédart et al., 2006). Additionally, it was observed that self-face is identified faster from other faces even in atypical orientations, e.g., faces presented with inverted head orientation (Tong & Nakayama, 1999). Self-face thus demonstrates immediate attention orientation for the owner indicating high relational salience. There is also one report that suggests that self-face may also possess high reward value for the owner of the face. Using an eye-tracking study it was observed that self-face was not processed faster (Devue et al., 2009), but once located, self-face was difficult to disengage from. In the absence of threat or need for increased vigilance, a stimulus-driven increase in sustained attention to self-face may be associated with increased value associated with self-face. The visual processing strategies involved in recognizing the highly familiar, salient and possibly rewarding self-face is relatively unexplored. As discussed in above sections, most studies probing self-face recognition have focussed on neural correlates of self-face viewing and faster reaction time advantages in self-face recognition. If self-face is visually processed as another familiar face, this should be evident in similar visual processing strategies observed in response to familiar faces (Heisz & Shore, 2008; Van Belle, Ramon, Lefèvre, & Rossion, 2010). Chapter 4 of this thesis investigates the visual processing strategies employed in self-face recognition and the association of such strategies with the behavioural representation of self-face.

Physical self-representation – effect of task specificity

As discussed above, most studies investigating self-processing have studied the behavioural and neural correlates of explicit self-awareness. This involves asking participants to do forced choice tasks on self-other face recognition by evaluating the presented face as ‘self’ or ‘other’. This is primarily because explicit self-processing can be reliably evoked by task instructions (asking participants to evaluate and identify a face as ‘self’ or ‘other’) and experimentally manipulated (by morphing faces of different identities). However, day to day social encounters also evokes implicit processing of the self where self-related information is processed with perceptual/cognitive biases (Rameson, Satpute, & Lieberman, 2010). For instance, participants judged faces as more trustworthy if they had increased physical similarities to self-face (Verosky & Todorov, 2010). This positive self-bias was observed without participant’s knowledge of any self-related information being present in the task. In the absence of any explicit knowledge, ratings of trustworthiness for faces resembling self-face activated reward-related brain areas - indicating positive appraisal of faces that resembled self-face being inherently rewarding(Platek & Krill, 2009). Thus, implicit self-processing occurs below the level of awareness with the ability to influence decision-making behaviour. Textual stimuli were presented in an fMRI task and manipulated to have different levels of self-relevant information without participants’ knowledge or explicit instructions regarding self (Moran, Heatherton, & Kelley, 2009). Activation of the medial prefrontal cortex and anterior cingulate was observed in response to the implicit evaluation of texts which had higher levels of self-related information. Similar areas were also activated for the explicit self-reference task (Moran et al., 2009). This overlapping activation suggests that in the psychological domain implicit and explicit evaluation of self may activate similar neural networks.

In the physical domain, both passive (judgment on the orientation of the face) and active recognition of self-face (explicit recognition) was shown to increase skin conductance indicating heightened physiological arousal (Sugiura et al., 2000). In the same study, using fMRI, the higher involvement of the right hemisphere was observed for active self-recognition but not for passive self-recognition. These results indicate that physical self-processing may occur through different cognitive routes for specific processing levels of self-related information. Implicit self-processing remains relevant in relation to psychiatric disorders where implicit negative self-evaluation is shown to correlate with higher incidence of depression (E. Franck, De Raedt, & De Houwer, 2007; Orth, Robins, & Meier, 2009). Task-specific responses (explicit self-face recognition and implicit self-evaluation) can demonstrate the role of task specificity in the behavioural representation of self-face.

Chapter 3 of this thesis investigates the role of task specificity in behavioural self-face representation. To achieve this aim, participants performed an explicit self-face recognition task and an implicit self-evaluation task (without explicit knowledge of self-related information being present).

Psychometric measurements of self-face and self-voice recognition

The morphing paradigm using self and other related information in different modalities provides a mechanism of studying self-representation in the form of self-other overlap and distinction. 'Self' can manifest either as an object or as the model through which the subjective experience takes place. It is difficult to study self in the subjective mode in terms of misidentification, except perhaps in infancy e.g. 18 months. For example, one can say 'I think the face in the photograph is me'. In this case, there can be no means of misidentification in that the person who is stating this is the only one who can verify the truth of the statement. In other words, internal experience of the self cannot be misattributed. Hence, most of the subjective self studied through the investigation of self-referential cognition cannot provide a direct index of self-representation. However, the recognition of the physical self is object-oriented, where self is seen as an object that represents a category (like self-face) or as an agent that causes action. In the case of objective self, misidentification can result in attributing something as self when a large part of the information presented is non-self. In a morphing paradigm, self-related information can be quantified as it is created by combining information of both self and other in different proportions providing a continuum of self-other identity and allows studying of both the subjective perception as well as misidentification of self. For example, if a face morph has ninety-five percent other face and five-percent self-face, categorizing that as self-face can be considered as a relative misidentification of the self as another. Furthermore, as previously noted, self-other overlap and distinction both play a critical role in social cognition. In the physical domain, a self-other morphing continuum can test boundaries of self-other representation and individual differences in this boundary.

Quantitative representation of the self through measurement of psychophysical variables (for example – slope of the self-response curve) that change as a function of stimulus features allows one to draw conclusions on the subjective self-other boundary. In morphing techniques, self-face can be identified incorrectly; the subjective experience of their own face may cause participants to label a morphed face as self (though it may have information from the 'other' face). Thus, this paradigm can objectively measure individual differences in sensitivity to self-recognition. Morphing paradigms are used to study face and emotion perception (Joassin et al., 2004; Keenan et al., 2000; Rosa et al., 2008; Uddin et al., 2005). A morphing paradigm also allows parametric manipulation of task difficulty in face-recognition, making it possible to match difficulty levels in the identification of face and voice stimuli in morphing tasks (Joassin et al., 2004). Thus, morphing provides a useful way to study individual differences in physical self-representation between different sensory modalities.

For this thesis, physical self-representation was measured using a morphing technique for the visual and auditory modalities. Morphing allows one to combine two different faces or voices (self and unfamiliar voice) in different percentages using a series of stimuli that grade from hundred-percent to zero-percent self. Percentage of trials judged as self for different morph levels generate a self-response curve. The slope of this self-response curve is an estimate of the change in responses as a function of stimulus characteristics. The slope of the self-recognition response curve is used as a dependent variable throughout this thesis. Since the purpose of this thesis is to investigate in details how physical self-representation is mapped out in relation to another, this measurement thus allows estimating how the representation of the physical self varies across the manipulation strategy employed in each condition (See Fig. 1.2). This estimate gives a more accurate understanding of the mental representation of self compared to the point in a stimulus continuum where the presented target stimulus matches with the participant's visual/auditory memory representation of that stimulus, the point of subjective equality (PSE). Although PSE gives a measure of individual differences in perception, in the current study the slope variable provides a better estimate of self-representation. PSE provides a point estimate whereas slope provides a measure of the distribution, and how distinct this self-related distribution is from the other related distribution. As such, the slope provides a measure of distinctness of self from other, rather than an arbitrary point estimate in visual/auditory space.

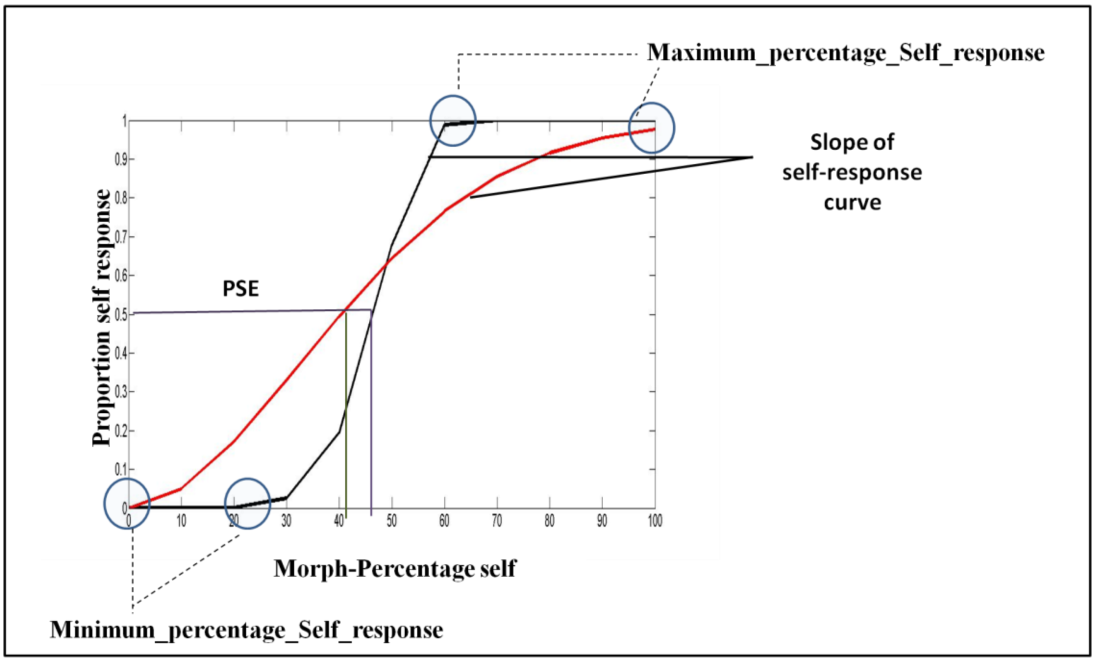

Fig. 1.2 Schematic representation of self-response curve and the relevant psychophysical variables. The two curves in the figure above represent two model participants; the self-response curve with the steeper slope (black) has a corresponding larger PSE indicating a more distinct self-representation and reduced self-other overlap. The self-response curve with the shallower slope (red) also has a corresponding smaller PSE indicating a less distinct self-representation. The figure also shows the corresponding morph levels at which self-response reaches hundred-percent (maximum) and zero-percent (minimum) for the two observers.

Following this overview of ***physical*** self-representation, the next section will discuss the domain of ***psychological*** self-representation and the opposing theories on the interdependent and independent functioning of the physical and psychological self-representations.

1.2.2 Psychological domain

The domain of the psychological self is a function of higher-order explicit self-awareness. It constitutes episodic knowledge in the form of autobiographical memory related to the self (experiences of events), first-person perspective and semantic knowledge about self (Gillihan & Farah, 2005). Knowledge of self can be in relation to psychological traits ('I am an honest person') as well as in relation to physical attributes ('I have brown hair').

Autobiographical memory or memory related to self is a significant aspect of self-identity and self-related emotion processing (Conway & Pleydell-Pearce, 2000). Autobiographical memories include knowledge regarding self and episodic memories (Conway, Singer, & Tagini, 2004). To investigate neural correlates of autobiographical memory in comparison to the non-personal account of events, a positron emission tomography (PET) study recorded regional cerebral blood flow in response to the passive listening of passages of impersonal events and passages of personal events (Fink et al., 1996). The study observed increased symmetrical cerebral blood flow to both temporal lobes (temporal pole and superior and middle temporal gyri) in response to the passive listening of impersonal events. In the same study increased cerebral blood flow to the same loci was observed in the personal condition; however, this was right hemisphere lateralized similar to that observed for physical self (Fink et al., 1996). Additionally, there was activity in other right hemispheric locations (temporomesial, dorsal prefrontal, posterior cingulate areas) as well as left cerebellum in the personal condition (in comparison to rest). These findings suggest a distinct neuroanatomical substrate for autobiographical memory which is separate from brain areas involved in the consolidation of non-self related episodic memory.

The self-related memory system is also studied using the self-reference effect (SRE), a commonly implemented paradigm used to investigate how self-related information is encoded and retrieved from memory. Traits judged in relation to self compared to close/famous other, as well as semantic conditions (counting the number of syllables), are shown to evoke better recall rates in delayed recognition and free recall tasks (Rogers, Kuiper, & Kirker, 1977). Results from SRE tasks have concluded that a deeper level of encoding exists for self-referential information, indicating a more elaborate schema and an implicit recall bias for self-related traits (Rogers et al., 1977; Symons & Johnson, 1997). However, instances of similar recall rates are observed for words describing traits in relation to close others (Bower & Gilligan, 1979).

Investigation of neural correlates of self-referential processing has linked it to the default mode network (DMN). The DMN primarily refers to the ventromedial prefrontal cortex (vmPFC) and posterior cingulate cortex (PCC). These areas are consistently shown to have high levels of activity during the baseline rest condition with a reduction in activity when performing externally oriented cognitive tasks (Esposito et al., 2006; Fransson, 2006;

Gusnard & Raichle, 2001; Raichle & Snyder, 2007). One of the proposed functions of the DMN is self-referential processing (Buckner & Carroll, 2007; Gusnard, Akbudak, Shulman, & Raichle, 2001). Specifically, since the vmPFC is implicated in tasks involved in self-referential processing (Macrae, Moran, Heatherton, Banfield, & Kelley, 2004), the default mode activity in this area has been linked to self-referential thoughts at rest. However, it should be noted these studies primarily used reverse inference to arrive at this conclusion by using activation patterns to reason backward linking DMN to self-related processing (See Poldrack, 2006 for a discussion on reverse inference in neuroimaging). In a meta-analysis of 87 studies, it was observed that the perigenual anterior cingulate cortex (PACC) was more involved in self-processing in comparison to familiarity, social-others and task specificity (Qin & Northoff, 2011). Furthermore, activity in the PACC overlapped with DMN activity. Additionally, the meta-analysis found that medial prefrontal cortex and posterior cingulate cortex activity did not show task specificity as they were activated for self as well as familiar stimuli processing (Qin & Northoff, 2011). The meta-analysis indicates that brain areas involved in processing information related to familiar others include self as a familiar stimulus and the PACC appears to be the only area specific to self-referential cognition.

Temporal awareness is the awareness that self as an entity is continuous in time. Individuals often refer to psychological attributes of the self in relation to time (H. Markus & Nurius, 1986; Ross & Wilson, 2003). One study observed that participants described current self in relation to a past reference to self rather than in relation to social others (Wilson & Ross, 2000). Comparison to past selves (for example: ‘I was not a punctual person. But nowadays I always arrive on time’) is found to be rewarding in nature (Wilson & Ross, 2000) and allows for self-gratification from self-improvement. Psychological self-representation as a construct develops through time with reference to the past and future selves. Evaluation of psychological self-representation is often conducted in reference to favourable or damaging past events. Temporal distance of autobiographical memory is found to be misjudged in order to portray the current psychological self in the favourable light where favourable events are perceived to be closer in time and damaging events are perceived to be further away in time in relation to the current self (Ross & Wilson, 2003). Furthermore, comparison with the past or future selves influences the current evaluation of self (Hanko, Crusius, & Mussweiler, 2010).

In the domain of physical self, an fMRI study investigated the neural correlates of temporal (the past and the current) self-recognition (Apps, Tajadura-Jiménez, Turley, & Tsakiris, 2012). Childhood and current self-face were morphed with a current familiar face and a familiar face from childhood respectively. Participants viewed videos of current self-familiar face morphs and childhood-self-familiar face morphs. Viewing current self-face resulted in activation of general face-selective areas (inferior occipital gyrus, superior parietal lobule, and the inferior temporal gyrus) and the activation varied with the amount of self-related information present in the morphs. Viewing childhood self-face resulted in neural activation in areas involved in memory retrieval (hippocampus and the posterior cingulate gyrus) and body-ownership (temporoparietal junction and the inferior parietal lobule). The differences in neural processing of past and present physical-self indicate how the domains of self-representation are processed differently in relation to time. Thus, both psychological and physical self-representation appear to interact with the temporal continuity of self (temporal-self) in a dynamic manner to create what James referred to as personal identity (James, 1890).

Association between physical and psychological self-representations

The development of mirror self-recognition is often associated with the development of higher order self-awareness (Keenan, Gallup, et al., 2003; Lewis & Ramsay, 2004; Rochat, 2011; Russell & Hill, 2001). It is hypothesized that the cognitive process of physical self-recognition begins with attention allocation to self (Gallup, 1982). The continuous practice of this attention allocation to self during early years of development is theorized to lead to introspection and self-related thought processing. This self-referential thought processing is believed to result in the development of higher order self-awareness or the awareness of the ‘mind’ (Gallup, 1982,1998; Gallup Jr, 1983). Thus, it is theorized that psychological self-awareness has its foundation on the platform of physical self-representation (Nielsen & Dissanayake, 2004; Russell & Hill, 2001). If self-representation is holistic in nature, someone with a generally distinct self-representation should exhibit more distinct self-representation in both physical and psychological domains. One could theorize that associations between the physical and psychological domains of self are possible through attention allocation mechanisms. If an individual attends to any self-related stimuli with greater attention resources to self, it is likely to result in higher evaluation (for physical self) and higher introspection (for psychological self) resulting in a more distinct representation across the two domains. There is some evidence in the domain of body-awareness that has shown that viewing mirror self-reflection results in increased interoceptive sensitivity i.e., sensitivity to changes in internal physiological states, in individuals with low baseline levels of interoceptive sensitivity (Ainley, Tajadura-Jiménez, Fotopoulou, & Tsakiris, 2012). Interoceptive sensitivity allows one to monitor and process internally generated physiological signals; this link between exteroceptive and interoceptive signal processing provides evidence of the moderating effect of one domain of self on another.

However, self is also known to have different constructs that can be accessed and stored independently and show domain specific properties (Gillihan & Farah, 2005; Neisser, 1988; Williams, 2010). The association between the two domains of self-representation have not been mapped or empirically tested. In order to add empirical support to the theories of the interdependent or the independent functioning of the two domains of self-representation, Chapter 5 investigates the association between physical self-representation (as measured using self-face recognition) and psychological self-representation (as measured using SRE).

1.2.3 Self-representation across cultures

The dynamic nature of self-representation is demonstrated through studies of self-representation across different cultural settings(Vogeley & Roepstorff, 2009). The temporary reversal in the nature of self-representation through different cultural primes like culturally relevant images or textual contents (Gardner, Gabriel, & Lee, 1999; Ng, Han, Mao, & Lai, 2010; Sui, Zhu, & Chiu, 2007) shows that self-representations are flexible and can be modified temporarily. In cultural psychology, self-constructs were initially categorized as the private, public and the collective selves (Baumeister, 1986; Greenwald & Pratkanis, 1984). It is argued that cultural differences lead to differences in expression and access to these levels of self (Triandis, 1989) resulting in two different types of self-construal: independent and interdependent. Self-construal refers to processes through which one interprets/constructs one’s self (Hofstede, 1980; Markus & Kitayama, 1991; Triandis, 1989). Initially investigated in American and Japanese individuals, it was observed that American individuals primarily exhibited independent self-construal where self was viewed as a unique identity and the focus was on self-fulfilment and personal goal achievement. Japanese individuals, in contrast, exhibited interdependent self-construal where the self was viewed as being a part of a group with a drive to achieve collective goals (Markus & Kitayama, 1991). Most individuals have both independent and interdependent traits. However,culture-based norms, rules, beliefs, and practices result in one type of self-construal to be dominant within a culture(Markus & Kitayama, 1991; Singelis, 1994; Triandis, 1989). The independent-interdependent self-construal traits at an individual level are linked to the population level traits of individualism and collectivism respectively. A culture with the majority of the individuals possessing dominant independent self-construal is an “individualistic culture” (Cross, Hardin, & Gercek-Swing, 2010). Conversely, a culture with the majority of individuals possessing dominant interdependent self-construal is a “collectivistic culture” (Cross et al., 2010).

These differences in self-construal levels have led to identifying many western cultures as individualistic cultures (primarily European-American and Western and Central European population) and East Asians cultures as collectivistic cultures (primarily Chinese, Japanese and Korean population) (Hofstede, 1980; Markus & Kitayama, 1991; Triandis, 1989). However, a critical point to observe here is that cultural patterns are heterogeneous and self-representations are complex comprising different domains. It is over simplistic to group nationalities and cultures on the basis of these two dimensions alone. For example, a manifestation of self-construal in first, second and third generation migrant individuals can be markedly different from the natives of a particular culture (Barry, 2000). Since many urban populations across the world comprise migrants, acculturation experiences or bicultural self-construal (Gardner, Gabriel, & Dean, 2004; Marian & Kaushanskaya, 2004) must be considered when discussing cultural affiliations. The different aspects of self-construal and culture are beyond the scope of this overview. The term westerners and East Asians mentioned in the overview and throughout this thesis are broadly defined terms mostly in reference to European-American and Western and central European population for western culture and Chinese, Japanese and Korean population as East Asian cultures and the nationalities explicitly referred to as individualistic or collectivistic cultures in the referred studies.

A well-established method of evoking either an independent or an interdependent self-construal is through the use of individualistic or collectivistic cultural primes. At the behavioural level, primes that promote a specific cultural value like culturally relevant texts or images, have shown to reliably reorient self-construal of the participants (both westerners and East Asians) towards that particular culture (Oyserman & Lee, 2008a,2008b; Ybarra & Trafimow, 1998). In the domain of autobiographical memory, Asian Americans primed to focus on American self, recalled autobiographical memories which were more self-focussed and less socially oriented compared to participants who were primed to focus on their Asian self (Wang, 2008) indicating cultural context can dynamically influence autobiographical memory. In East Asian individuals (Chinese students) priming with Chinese primes resulted in increased use of interdependent sentences while priming with western (American) primes resulted in increased use of independent sentences in a self-descriptive task(Sui et al., 2007). In a follow-up experiment, priming with western (American) primes, these participants performed worse in a delayed recognition task with reduced recall rates for information coded in relation to mother compared to self-referential information (Sui et al., 2007). Comparable recall rates for self and mother condition was observed for the Chinese culture specific primes and non-culture specific control prime conditions. Thus following individualistic primes, an elaborate self-schema inclusive of close-other typically observed in East Asians is altered to a more self-focused schema. Using the SRE paradigm European-Canadian participants showed better recall rates for self-referential traits compared to collective traits (Wagar & Cohen, 2003). However, Asian-Canadian participants demonstrated reduced SRE in comparison to memory for other referential information. It can be argued from this result that Asian-Canadian participants have a more extensive representation for collective-self in comparison to independent (private-self) in memory (Wagar & Cohen, 2003).

In the domain of physical self-representation, cultural differences in mirror self-recognition (MSR) have emerged from differences in parenting styles. A study investigating different aspects of MSR in autonomous (German), relational (rural India and rural Nso) and autonomous-relational (urban middle-class India) socioeconomic contexts observed culture-specific development in MSR (Kärtner, Keller, Chaudhary, & Yovsi, 2012). In an autonomous society (German) where caregiving/parenting styles support toddlers to develop in autonomy, higher MSR rates were observed in comparison to relational social contexts. The study observed the earlier development of self as an independent agent in autonomous societies and concluded that focus on culture specific parenting models is needed in studies of self-representation in development. Earlier self-recognition was also observed in Greek urban middle-class children where caregivers practice *distal* parenting style focussing on face-to-face communication and object stimulation (Keller et al., 2004). In contrast, earlier development of self-regulatory behaviour was observed in Cameroonian Nso children where caregivers practise proximal parenting style focussing on body contact and body stimulation with toddlers.

Cultural differences are also observed in viewing and processing of faces. In response to viewing faces from different races, western Caucasian individuals showed a triangular pattern of gaze fixation on faces (Blais, Jack, Scheepers, Fiset, & Caldara, 2008). In contrast, East Asian (nationality details were not provided) participants showed a focused gaze fixation on the central region of the face. One possible explanation may be the difference in social value systems between East Asian and Western cultures. In East Asian cultures, direct eye contact with strangers is deemed rude behavioural practice and hence face processing strategies are developed to avoid direct eye-contact. Hence, it can be speculated that if an urban East Asian population is tested on self-face recognition they may exhibit similar behaviour but different visual processing strategies in self-face representation when compared to a western population. In westerners with a baseline of low body-awareness (interoceptive awareness), viewing self-face resulted in an increase in interoceptive awareness (Maister & Tsakiris, 2014). This result was not observed for East Asian participants. The results indicate that in westerners viewing self-face resulted in increased body awareness and increased processing of bodily signals not observed in East Asians.

Considering these well-established cultural differences in self-representation any investigation of self-representation needs to be studied in different cultural contexts. Chapter 2 investigated physical self-representation across sensory modalities in a sample recruited from Indian population, a population previously untested with experimental paradigms of self-representations. Chapter 5 investigated psychological self -representation using measures of SRE and self-reports of self-construal traits in a sample recruited from the Indian population.

India represents a vast and heterogeneous population comprising inhabitants from diverse backgrounds. There are suggestions that individualism and collectivism coexist in India (Sinha & Tripathi, 1994). The coexistence of individualistic and collectivistic values are likely in urban middle-class India where a large proportion of the inhabitants are educated and often exposed to western values and cultures. It can be speculated that collectivistic values are likely to be the dominant form in rural India where such beliefs and practices can promote group survival. Indian culture is shown to have collectivistic traits (in the form of social norms and identity) similar to East Asian population (Hofstede, 1980; Triandis, 1989). In the absence of any experimental psychology studies on self-representation in India, Chapter 2 and Chapter 5 of this thesis aimed to explore and characterize different domains of self-representation in the Indian population.

As discussed in the previous sections, self is a diverse and complex construct. Self-awareness and different dimensions of self-representation contribute to typical social functioning. The next section will present an overview of ASD as a model of atypical self-representation where a breakdown of typical self-related processing is theorized to be an underlying cause of observed social deficits.

1.2.4 Self-representation in Autism Spectrum Disorder (ASD)

<u>Autism Spectrum Disorder and autistic traits</u>

This subsection summarises some of the current views on ASD and the relationship between clinically diagnosed ASD and autistic traits. Autism is a neurodevelopmental disorder with a complex and heterogeneous symptom profile. In the 5th Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association,2013), the triad of behavioural symptoms in autism - atypical social behaviour, communication deficits and restrictive and repetitive interests have been condensed into two domains of social communication and fixated interests and repetitive behaviour. Previously autism was used as an umbrella term to include autism disorder, Asperger’s Syndrome, and Pervasive Developmental Disorder–Not Otherwise Specified (PDD-NOS) (American Psychiatric Association, 2000). Currently, all three are grouped under Autism Spectrum Disorder (ASD), and an individual can have symptoms that lie in severity anywhere along the spectrum (Matson, Hattier, & Williams, 2012). It is argued that different domains of impairment observed in ASD cannot be explained by one single causal biological phenomenon (Happé, Ronald, & Plomin, 2006). The triad of symptoms observed in ASD is reported to show low levels of correlation with each other indicating the dimensional nature of the disorder (Ronald et al., 2006). ASD can be thus considered a disorder of multiple impairments where different dimensions of cognitive processing interact in a complex manner. Different domains of impairments associated with trait features of ASD can be captured by different self-report (or caregiver-report) questionnaires (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Constantino & Gruber, 2007; Wheelwright et al., 2006). For instance, evidence of social deficits in ASD is supported by reduced self-reports of trait empathy using the empathy quotient (EQ) questionnaire (Wheelwright et al., 2006).

Measurement of autistic traits in the general population can help investigate how autistic symptoms map onto social behaviour. Autistic traits are distributed continuously across the population, and individuals with ASD score highly on these measures (Baron-Cohen et al., 2001). Autistic traits can be measured using several questionnaires like the Autism Spectrum Quotient (AQ) (Baron-Cohen et al., 2001), Social Responsiveness Scale (SRS) (Constantino & Gruber, 2007), Autism Spectrum Screening Questionnaire (ASSQ) (Ehlers, Gillberg, & Wing, 1999), Childhood Autism Rating Questionnaire (CARS) (Schopler, Reichler, & Renner, 2002) and the modified Checklist for Autism in Toddlers (CHAT) (Robins, Fein, Barton, & Green, 2001). ASD individuals are found to lie at the extreme tail end of the continuous distribution of autistic traits with individuals scoring thirty-two or higher on the AQ scale having eighty percent or higher chance of having an ASD diagnosis (Baron-Cohen et al., 2001). Measuring autistic traits in the general population allows one to measure associations between trait features and experimental manipulations, providing the initial foundation for undertaking follow-up investigation with the clinically diagnosed tail of the autism distribution. In the current thesis, studies measuring autistic traits used AQ (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) Developed from the triad of behavioural symptoms observed in ASD, AQ tests participants in five domains of behaviour, namely social skills, attention switching, attention to detail, communication and imagination.

The Self in Autism Spectrum Disorder

Historically ‘self’ has been an important aspect in characterizing autism. The term autism arises from the Greek word ‘autos’ which means ‘self’ and was initially used by Eugen Bleuler to describe social withdrawal observed in Schizophrenia (Bleuler, 1951). The term was used by Leo Kanner to describe children in his clinic who exhibited social detachment with heightened self-focus (Kanner, 1943). In an independent description, Asperger (Asperger, 1944) described ‘extreme egocentrism’ in certain individuals. According to the Jamesian theory of self (1890), the pure ego allows oneself to view self as a unique entity continuous in time while the social aspects of self are to represent oneself in relation to others and help understand similarities existing between self and others. The self in ASD manifests as a dysfunction of both these aspects of self in the form of heightened egocentrism and reduced understanding of self in relation to others. The duality of self is the ability to understand that ‘self’ is unique yet similar to ‘other’ selves around it. The lack of such dual understanding of self-concept in ASD has led to the ‘absent-self’ hypothesis in ASD (Baron-Cohen, 2005; Frith & De Vignemont, 2005; Frith & Happé, 1999; Lombardo & Baron-Cohen, 2010; Lombardo et al., 2010). The ‘absent-self’ is not in reference to a lack of self in individuals with ASD but instead refers to the different aspects of atypical self-awareness observed in ASD e.g., reduced distinction between self and others.

In the physical self- domain, using MSR as a measure of physical self-awareness has yielded conflicting reports in ASD, possibly because of heterogeneity in symptom severity. Using MSR one study found that failure in visual self-recognition was predicted by speech and communication impairment in ASD children (Spiker & Ricks, 1984). The study argued developmental delay in visual self-recognition mirrors developmental delay in language functions in ASD. In contrast, intact MSR and a preference for mirror reflection in comparison to a taped video of self were observed in ASD children (Neuman & Hill, 1978). In another study of MSR hundred-percent self-recognition was observed for typically developing children in comparison to fifty-five percent observed in ASD children (Carmody & Lewis, 2012). The authors concluded that atypical self-recognition abilities do not exist universally across ASC children but in a sub-population of ASD children. However, MSR cannot be considered a perfect measure of self-recognition or self-awareness and deficits may be captured using a combination of tasks. One such study that used a delayed self-recognition task and a self-other action memory task, found intact self-recognition but delayed self-other recall in children with ASD (Dunphy-Lelii & Wellman, 2012). In a separate study, unattenuated responses to delayed self-recognition were observed in children with ASD indicating intact temporal awareness in ASD (Lind & Bowler, 2009). Hence, it can be argued that different aspects of self-processing can be disproportionately affected by ASD.

To study attention allocation to self-referential stimuli, event-related potential (ERP) responses to self-face and self-name (as well as close, famous and unfamiliar conditions) were investigated in neurotypical and adult ASD populations (Cygan, Tacikowski, Ostaszewski, Chojnicka, & Nowicka, 2014). Neurotypical adults showed significant positive responses at 300 ms (P300- an index of attention allocation in perceptual processing stages) for self-face/self-name in comparison to other conditions. However, ASD participants showed comparable P300 responses for self and close other conditions. It can be argued that when compared to close others, self is not attended preferentially in individuals with ASD. This can be considered as evidence for a reduced distinction between self and close other in ASD. The same study also observed reduced lateralized responses (right hemisphere advantage) in the self-face condition in individuals with ASD indicating a possible lack of self-face advantage at the level of neural responses (Cygan et al., 2014). Atypical attention to both external cues and internal body signals (interoceptive awareness) is also observed in ASD. A study observed increased interoceptive awareness over a sustained period in children with ASD (Schauder, Mash, Bryant, & Cascio, 2015) relative to control children. Increased interoceptive awareness observed in children with ASD showed a negative association with susceptibility to the rubber hand illusion, a paradigm that measures malleability of physical self-representation. It can be argued that increased attention to internal bodily cues may be coupled with reduced attention and integration of exteroceptive signals in ASD.

In the domain of psychological self-representation, similar findings of reduced overlap between self and close other were observed in individuals with ASD (Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007). Using an SRE paradigm similar memory sensitivity was observed for self and close other referential information in the ASD group but higher memory sensitivity for self was observed in the control group, indicating reduced self-other distinction in memory. In comparison to the control group reduced recall rates for self-related traits in comparison to the semantic memory condition, was also observed in individuals with ASD (Toichi et al., 2002). At the neural level, the ASD group showed reduced vmPFC activity in response to self-other trait judgments and during resting state condition (Kennedy & Courchesne, 2008)compared to the control group. It can be argued that there might be a task independent dysfunction of vmPFC in ASD.

Current evidence suggests a dissociation between the two domains of self-representation in ASD with atypical processing in the psychological domain but an intact physical self-representation as evidenced by the capacity to perform MSR (Uddin, 2011b; Williams, 2010). However, there are not many studies characterising physical self-representation in adults with ASD. One fMRI study of self-other face processing in children with ASD found a lack of self-other distinction in the physical domain similar to that observed in the psychological domain (Uddin et al., 2008). Using morphed images of self and other face, the study found viewing morphs with a greater percentage of self-face resulted in activation of a right prefrontal system in both typically developing and ASD children. However, the same network was also activated for viewing other faces in in ASD children but not in typically developing children. Furthermore, group level activation differences also existed in the right IFG implicated in self-face processing. The study observed no behavioural differences in reaction time between the ASD and control groups and both groups were able to perform the task at the behavioural level. This indicates brain-behaviour dissociation in self-other face processing in ASD with reduced self-other neural representation in the visual modality. No equivalent study exists in the adult ASD population at the behavioural or neural level. Uddin (2011b) comments on the lack of empirical evidence from neuroimaging on self-face processing in ASD. I would extend this to a lack of empirical evidence from behaviour and psychophysical properties of physical self-representation in ASD. One of the primary aims of this thesis is to study individual differences in physical self-representation in association with autistic traits in the general and clinically diagnosed ASD population.

1.3 Experimental Aims

Based on the overview above, the broad aims of this thesis are to investigate:

a) Individual differences in physical self-representation across modalities in two different cultural settings (Chapter 2)

This investigation aims at extending the understanding of physical self-representation across different sensory modalities, a research area that is currently underexplored. The nature of the association between different modalities of physical self-representation is unknown. This chapter aims to investigate this association, using psychophysical measurements of physical self-representation in visual (self-face) and auditory (self-voice) modalities. To implement this aim the study uses morphing paradigms that allow self-related stimulus to be intermixed with other related stimulus for the purpose of mapping self-other overlap in different modalities. Using this morphing set-up individual difference in associations between self-representation in different modalities is studied. Considering culture shapes different aspects of self-representation, physical self-representation is investigated in two different cultural settings – Western Europe and India. This study thus provides initial insights into the nature of self-representation in India, a culture where experimental psychological accounts of self-representation are currently lacking. The second level of individual differences is provided by measuring autistic traits using which association between physical self-representation and trait features of ASD are mapped out. Thus, this chapter provides an investigation of physical self-representation at an individual level and in relevant contexts of sensory modalities, cultures, and psychopathology.

b) Task-specific response patterns in physical self-representation (Chapter 3)

There are several accounts that demonstrate that self-representation can be evoked at different levels, e.g. at an explicit awareness level and in an implicit evaluative level. Considering the primary focus of this thesis is on self-representation through self-recognition responses, the aim of this chapter is to investigate how different tasks can influence self-representation by evoking different levels of self-processing within the same domain. This is a relevant point when drawing conclusions about self-representation since different tasks can evoke different patterns of self-relevant responses. This chapter aims at understanding if task-specific response patterns are observed in physical self-representation by manipulating the self-related information in a novel way. Self-other morphs in the visual modalities are used in different task conditions that are believed to evoke either implicit or explicit level of physical self-processing and how differences in this processing level influence psychophysical properties of physical self-representation is investigated.

c) Visual processing strategies in physical self-representation (Chapter 4)

Self is a salient stimulus which may be differently processed to other familiar stimuli. At the level of visual processing strategies, it is not clear if physical self is processed in a similar or different manner compared to familiar and unfamiliar faces. This chapter uses eye tracking to study visual processing strategies employed in recognising a morphed face as self and if these strategies are different from those employed in judging a morphed face as an unfamiliar other. This chapter also provides a basis to answer the question if self-face processing is visually similar to the processing of familiar faces reported in the earlier literature. Lastly, the chapter investigates how visual processing of a face judged as self-face is associated with the behavioural representation of self-face thus studying the link between visual processing strategies and its association with physical self–representation.

d) Self-representation across physical and psychological domains (Chapter 5)

Although theories of both independent and interdependent functioning between different domains of self-representation are existent in literature, there is a lack of empirical evidence studying the association between the physical and psychological domains of self-representation. This chapter studies the association or lack thereof between physical self (measured using self-other face and self-other voice recognition) and psychological self-representation (using the self-recognition effect in memory). The chapter also provides first experimental accounts of individual differences in psychological self-representation in India as a follow-up to the study of physical self-representation in India as detailed in Chapter 2.

e) Individual differences in physical self-representation in ASD (Chapter 6)

There are several studies that suggest atypical self-processing in the psychological domain of self-representation in individuals diagnosed with ASD. However, in adult ASD population, physical self-representation is less well characterised. To provide a clearer view of self-representation in ASD, this chapter uses the same morphing paradigm as Chapter 2 to study physical self-representation in visual and auditory modalities in individuals diagnosed with ASD. Considering several reports of gender differences in symptoms and brain structures in ASD, in addition to studying individual differences in physical self-representation in the ASD population, this chapter also investigates gender differences in physical self-representation in ASD.

The follow-up chapters will detail the investigation of these aims followed by the general discussion of findings from this thesis with outlines for future directions.

2. Physical self-representation across sensory modalities: evidence from two cultural settings

This chapter describes a study investigating individual differences in physical self-representation in two different sensory modalities and in two different cultural settings. The chapter briefly reviews the role of self-face and self-voice recognition as measures of physical self-representation and current understanding of cultural differences in physical self-representation. The role of atypical self-representation in social behaviour deficits in ASD is also discussed. The chapter then outlines an investigation of physical self-representation as measured by self-recognition in visual and auditory modalities and the association of these representations with autistic traits. The differences and similarities in the results obtained are discussed in relation to cultural affiliations of the participant sample pools and the ASD phenotype.

This chapter is partially adapted from the following published article:

Chakraborty, A& Chakrabarti, B. (2015). Is it me? Self-recognition bias across sensory modalities and its relationship to autistic traits. *Molecular Autism*, *6*(1), 1.

2.1 Introduction

The concept of 'self' has challenged thinkers and empiricists across disciplines, cultures, and time. William James (James, 1890) proposed a leading theoretical account of self-representation which states that one of the key components of self is the 'material self', the innermost part of which is the ownership of one's own body (See Section 1.1 & Section 1.2.1). The awareness of 'bodily-self 'or 'physical-self 'is fundamental to human social behaviour since it enables the most basic distinction of self from other. This physical self-awareness emerges early and can be tested using mirror self-recognition (MSR) in human infants aged 18- to 24-months (Amsterdam, 1972). Physical self-recognition is theorized to be a precursor to the development of general self-awareness (Bertenthal & Fischer, 1978; Gallup, 1982; Lewis, 2012). Self-awareness in turn shares common underlying processes with mental state attribution and recognition of emotional state in others - aspects of behaviour that allow for introspection, leading to the development of mentalizing/theory of mind (Bird & Viding, 2014; Keenan, Gallup, & Falk, 2003; Keenan, Wheeler, & Ewers, 2003; Lombardo, Chakrabarti, & Baron-Cohen, 2009). Consequently, the investigation of physical self-representation and self-recognition is fundamental to understanding the architecture of social behaviour, most forms of which require a distinction between self and other.

Physical self-representation is multimodal in nature and manifests across different senses. Representation of self-face, self-voice, and self-body can all be regarded as instances of physical self-representation. In adults, most studies investigating self-other processing in the physical domain have used self-face recognition as a metric of self-representation (Keenan et al., 1999; Kircher et al., 2001; Uddin, Kaplan, Molnar-Szakacs, Zaidel, & Iacoboni, 2005). Understandably, this focus on the visual representation of the physical self is based on the universal human ability to recognize self-face from mirror-reflection and photographs. MSR is used as a hallmark test for physical self-recognition developmentally and requires 'an essential cognitive capacity for processing mirrored information about the self' (Gallup, 1982, p. 240). The ability to recognise oneself from a mirror image is theorized to lead to the development of self-awareness, a sense of self, and a self-concept. However, one cannot assume that human infants acquire a fully developed visual self-representation prior to exposure to the mirror-self (Mitchell, 1993). Accordingly, the ability to perform MSR is believed to be preceded by three possible mental models of physical self that exist prior to fully developed MSR - (1) a visually based, incomplete self-image of the part of the body that it can see, (2) a non-visual self-image, (3) or a mixture of these self-images (Mitchell, 1993).

Studies of MSR in children and self-face recognition in adults have enhanced the understanding of physical self-representation. However, the investigation of the physical self as a multimodal construct has not been investigated in broad details. One study investigating the bimodal nature of physical self-representation observed that a combined presentation of self-face and self-voice inhibits (rather than facilitates) self-recognition, with self-face and self-voice being processed independently (Hughes & Nicholson, 2010). In an fMRI study, overlapping patterns of activation in the right inferior frontal gyrus were observed during processing of both self-voice as well as self-face, suggesting a possible overlap in neural activation in the processing of physical self-representation in different modalities (Kaplan, Aziz-Zadeh, Uddin, & Iacoboni, 2008). Self-face recognition has previously been tested by presenting un-morphed self and other faces in a serialized random order (Brady, Campbell, & Flaherty, 2004; Keenan, Gallup, et al., 2003; Keenan et al., 1999) and also as morphed continuum (Keenan, Ganis, Freund, & Pascual-Leone, 2000). However, there has been no direct behavioural test of physical self-representation across sensory modalities. To address this gap in the literature, the first aim of this study was to investigate physical self-representation across modalities of visual and auditory self-representation through the measurement of self-recognition. For this purpose, a paradigm was implemented using self-other morphs in both visual (face) and auditory (voice) modalities. Self-recognition responses for morphed faces and voices were measured as an index of physical self-representation. The second aim of the study was to investigate individual differences in self-other overlap across auditory and visual modalities using self-face and self-voice recognition from self-other morphed faces and voices respectively.

Self-other distinction and self-representation in the physical domain are both believed to be implemented in higher social cognition (Keysers & Gazzola, 2007; Lewis, 2012; Meltzoff & Brooks, 2001). Since dysfunction of social cognition is one of the defining features of the ASD condition, it is of relevance to characterize individual differences in physical self-representation behaviourally in relation to trait features of ASD. The third aim of the current study was to explore individual differences in the association between autistic traits and self-other overlap in the visual and auditory modalities. Autistic traits are distributed continuously across the population, and individuals with ASD score highly on these measures (Baron-Cohen et al., 2001). Importantly, trait measures of ASD have the same etiology at the extreme ends, suggesting that autistic traits provide a robust dimensional measure of ASD-related symptoms in the general population. Individuals with ASD may have reduced self-other distinction (Frith & Happé, 1999; Lombardo & Baron-Cohen, 2010) and exhibit deficits in self-processing in relation to self-other judgments (Lombardo et al., 2010; Uddin et al., 2008)and autobiographical memory(Goddard, Howlin, Dritschel, & Patel, 2007; Losh & Capps, 2003) . This has led to the proposal of an 'absent self' in ASD, based on studies that show reduced memory for self-relevant words (Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007; Toichi et al., 2002), reduced self-other discrimination in the ventromedial prefrontal cortex (Lombardo et al., 2010), and diminished autobiographical memory in ASD (Goddard, Howlin, Dritschel, & Patel, 2007; Losh & Capps, 2003). However, none of these previous reports have directly tested psychophysical metrics of physical self-representation in relation to autistic traits. Investigating the nature of self-representation from both sub-clinical and clinical perspective can provide a more detailed understanding of the functioning of self-representation. Accordingly, the third aim of the current study was to investigate how the measure of physical self-representation maps onto autistic traits.

Self-representation is a dynamic and multi-level construct (James, 1890). Self-representation is updated continuously as a function of time and the social environment in which it resides. Of this environment, culture as a component is reported to have a major influence on the development of self-representation (Han & Northoff, 2008; Markus & Kitayama, 1991; Markus & Kitayama, 2010). It is thus important to characterize any representation of self in different cultural contexts. To investigate the effects of environment (particularly cultural factors) on higher order self-awareness necessitates an investigation of self-representation in different populations and in different cultural settings. To address this aim, the second study of this chapter was conducted in a sample recruited from the Indian subcontinent. In order to characterize physical self-representation in a culturally different population, the primary aim of the second study was to test the same hypotheses using identical task paradigms as the first study. As discussed in Chapter 1 (See section 1.2.3) self-construal is the individual level index of self-representation and consists of the independent and interdependent selves. Independent self-construal represents self as a unique entity with goals and aims separate from close-other. Interdependent self-construal represents a more elaborate self – schema that is inclusive of close others and where individual values and goals are integrated with the collective goals. The interdependent and independent self–schemes coexist in most individuals, but the baseline dominant self is either independent or interdependent in nature. The independent and interdependent selves are closely linked to the culture level individualist-collectivist values (Cross, Bacon, & Morris, 2000; Cross, Hardin, & Gercek-Swing, 2010).

Studies investigating cultural differences in self-concepts have shown westerners (primarily European-American and Western and Central European population) and East Asians (primarily Chinese, Japanese and Korean population) have markedly different self-construal affiliations (Hofstede, 1980; H. R. Markus & Kitayama, 1991; Triandis, 1989). At the baseline level, westerners primarily exhibit an independent self-construal where the self is viewed independent to social - others and as a unique entity. In contrast, East Asians primarily view the self in relation to others and as an entity inclusive of the social context (Hofstede, 1980; Triandis, 1989). This difference in self-construal affiliation has been linked to differences in cognitive processing styles as well as social behaviour between cultures at both behavioural (Lin, Lin, & Han, 2008; Oyserman & Lee, 2008) and neural levels (Cheon, Mathur, & Chiao, 2010; Chiao et al., 2010; Han & Northoff, 2008).

There are fundamental differences in the cognitive processing of the two domains of self – physical and psychological (Williams, 2010). Physical self-representation is primarily built upon proprioceptive feedback and sensory signals to create the embodied physical entity that constitutes body-ownership. Evidence suggests cultural differences in exteroceptive self-awareness and individuals from different cultural affiliations are found to process external bodily features differently (Maister & Tsakiris, 2014). Self-face recognition and/or viewing are also able to activate a greater level of self-awareness in western participants compared to East Asian participants (Sui, Liu, & Han, 2009). This is attributed to higher levels of self-focus in westerners compared to East Asians.

In addition, cultural differences are also observed in body image processing. Body image is defined as the mental image we hold of our body and this construct influences how we assess and relate to others within a social environment (Jung & Lee, 2006). Self-schemas are developed in a hierarchical manner in order to organize access and define self-related information. Accordingly, individuals who value physical appearance to a greater level also develop more elaborate self-schema for appearance. Irrespective of culture, the higher cognitive load on self-appearance assessment results in higher body image dissatisfaction in women compared to men. However, across cultures, the comparison between American and Korean women revealed reports of higher levels of self-focus on appearances in Korean women compared to American women (Jung & Lee, 2006). Valuation based on physical attractiveness varies across culture and has been shown to be a major cause of self-related body image concerns. Negative physical self-perception is also related to low self-esteem and a higher incidence of depression and anxiety which varies across cultures (Bohne, Keuthen, Wilhelm, Deckersbach, & Jenike, 2002; Jung & Lee, 2006).

In light of the significance of cultural influence on self-representations, the current study investigated physical self-representation in two different cultural settings. It was hypothesized that at behavioural level one would observe similar results in physical self-representation in the Indian population as was observed in the Western European Caucasian population in study 1.

2.2 Study 1: Self-recognition across sensory modalities in a Western European sample

2.2.1 Aims

The first aim of this study was to test the category boundary for physical self-representation across the visual (self-other face recognition) and auditory (self-other voice recognition) modalities in a sample drawn from the general Western European population. The second aim of the study was to test the association between self-other overlap in physical self-representation in the visual and auditory modalities. The third aim of the study was to explore individual differences in the association between autistic traits and self-other overlap in visual and auditory modalities.

2.2.2 Predictions

The following predictions were made for Study 1:

1. The threshold for category boundary will be at a higher morph percentage for self-face compared to self-voice indicating a stronger representation of the physical self in the visual modality. This prediction is made on the basis that self-face is a more familiar stimulus with better representation and consolidation in memory. A stronger representation of self-face would suggest that individuals will be more sensitive to minor deviations from self-face, and hence will require greater self-related information in the morph to identify it as 'self'. Self-voice in comparison may not be as familiar, and hence individuals may identify a given stimulus as 'self' with comparatively lower levels of self-related information (Hughes & Nicholson, 2010).

2. At an individual level, the association between two modalities of physical self-representation (as measured by the slope of self-recognition responses) is not predicted. Initial evidence from MSR was used to theorise self as a unitary mechanism with higher order self-awareness being dependent on the development of physical self-representation (Lewis & Ramsay, 2004; Russell & Hill, 2001). However, different levels of self-representations are also theorized to have the ability to function independently (Gillihan & Farah, 2005; Neisser, 1988; Williams, 2010). In the absence of any previous direct comparison, there is no predicted direction for any potential association.

3. At an individual level, autistic traits are predicted to be associated with physical self-representation. However, in the absence of any directly relevant prior evidence, there is no prediction on the directionality or modality specificity of this association.

2.2.3 Methods

2.2.3.1 Participants

Thirty-nine white Caucasian participants aged between 18 and 40 years were recruited in the study (10 males,29 females, age = 23 ± 4.5 years). Only white Caucasian participants were chosen since the ‘other’ faces used in this experiment were constant across participants and were of this ethnicity.All participants had normal or corrected to normal vision and normal hearing and were right handed. Participants took part in a two-part experiment, in the first part photos and voice recordings of participants were taken which were to be used in the second part, in which participants performed the experimental tasks.The two parts were spaced one to three days apart from each other. All participants also completed the Autism Spectrum Quotient (AQ) questionnaire online after the second part. Three participants did not complete the voice part of the experiment due to technical issues. From the thirty-six participants who had both face and voice data, data for two participants could not be computed for the maximum self-response analysis (N=34) and data from three participants could not be computed for the category boundary analysis (N=33; See section 2.2.4.1) due to the poor goodness of fit.All participants signed a consent form giving their informed consent to take part in the study. The study was approved by School of Psychology and Clinical Language Sciences Ethics Committee, University of Reading(reference no: 2012/117BC).

2.2.3.2 Stimuli Preparation

<u>*Face*</u>

Self-other face morph stimuli were individually tailored for each participant.Each participant was photographed using a digital camera(Toshiba Camileo S30, Toshiba Corporation, Tokyo, Japan) in identical conditions under artificial lighting. Four volunteers (2 males for male participants and 2 females for female participants) selected to serve as ‘unfamiliar faces’ were also photographed under the same conditions.Participants looked directly at the camera and were seated at a distance of 100 cm with a white background while holding a neutral expression. The photographs were then converted to grayscale and external features (hairline, jawline, and ears) were removed. This photograph was mounted on an oval frame and cropped to a dimension of 350 × 500 pixels using GIMP ("GNU Image Manipulation Program," 2013). Two sets of stimuli were created for each participant's face, morphing self-face with two ‘unfamiliar faces’ using Sqirlz Morph(Xiberpix, Solihull, UK) (freeware).Each face morph continuum had 21 images at 5% stepsizes (100% self, 95, 90……10, 5, 0% self) (See Fig. 2.1). In the test phase, images were presented at a viewing distance of approximately 55 cm, on a 30.5 cm × 23 cm inch colour TFT active matrix XGA LCD monitor(1,024 × 768 pixels) run at 60 Hz by a PC running Windows 7.

Voice

Stimuli were individually tailored for each participant.Each participant's voice was recorded and digitized at44.1 kHz in a sound-proof booth using a high-resolution microphone and Adobe Audition. Each recording was made as participants uttered a train of monosyllable "ba" in a neutral voice, at the rate of 1 syllable per second. This was chosen as the stimulus to avoid differences due to accents and semantic information that can influence self-voice recognition from sentences. Additionally, using syllabic trains avoid confounds due to grammar, syntax, and psychological characteristics of other speakers that people focus on when hearing their own voice(Holzman, Rousey, & Snyder, 1966). Two gender-match unfamiliar/other voices were also recorded under similar conditions.

Each voice train was trimmed to one single "ba" utterance of 1,000 ms, followed by noise removal, equalization(filter of 3 dB), and normalization to a peak volume of 0 dBusing Audacity("Audacity® "). The preprocessed voice stimulus was then morphed with the unfamiliar voice usingSTRAIGHT("Speech analysis, synthesis method STRAIGHT,") signal processing package implemented in Matlab ("MathWorks - MATLAB and Simulink for Technical Computing,"). Two sets of morphing continua each of the 11 voice excerpts were thus created (from 100% self to 0% self in steps of 10%).

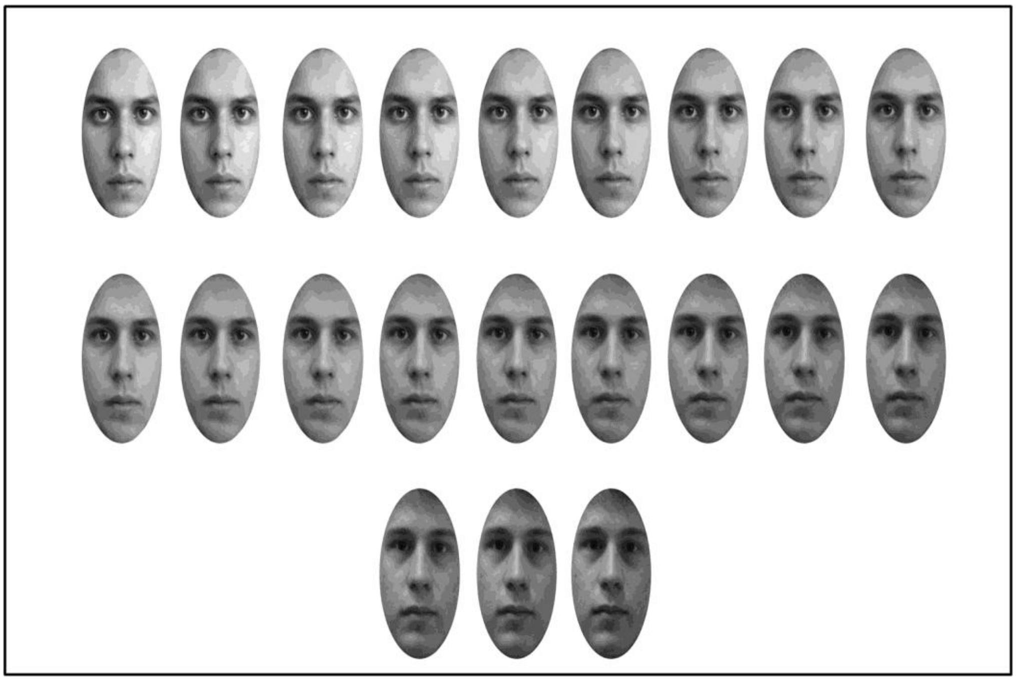

Fig. 2.1 The above figure illustrates a prototype stimuli set representing face morphs at a 5% step size.

2.2.3.3 Task Design

Face

The test run comprised 2 blocks, each consisting of 2 sets of 'self-unfamiliar' morph continuums of 42 images in total, presented twice in a randomized manner. Each block had a total of 84 trials, thus each run had a total of 168 trials. Each trial consisted of a cross-hair presented for 500 ms followed by the stimulus which lasted for 1,000 ms during which participants were required to respond. Participants had to identify each image as 'self' or 'other' by pressing 'a' key for self-face (left-hand self-response) and 'l' key for other face in one block, and the response keys were reversed in the next block (right-hand self-response; See Fig. 2.2). All participants were asked if the 'unfamiliar face' looked familiar for any reason, at the end of the experiment. No participants reported being familiar with either of the 'unfamiliar' faces.

Voice

The test run comprised of 2 blocks, each consisting of 2 sets of ‘self-unfamiliar’ voice morph continua consisting of 22 stimuli in total, presented twice in a randomized manner. Each block had a total of 44 trials, thus making each run consists of 88 trials. Each trial consisted of a cross-hair presented for 500 ms followed by the stimulus which lasted for 1,000 ms during which participant was required to respond.

Participants used a similar button press task to identify a voice as self/other as the face task. No participants reported being familiar with either of the two ‘unfamiliar’ voices.

The order of face and voice tasks was counterbalanced across participants. Both tasks were run using E-Prime version 2.0 ("E-Prime® 2.0,"). Following the entire experiment, each participant had to rate the perceived visual/auditory similarity between the 100% self (face and voice) with the respective 2 ‘unfamiliar’ faces and voices. Additionally, participants also rated the perceived similarity between 50% self (face and voice) morph with the respective 2 ‘unfamiliar’ faces and voices. This was to ensure that individual differences in perceived familiarity/self-similarity to the ‘other’ faces or voices did not bias the ‘self-identification’ response. Besides the 100% self-stimulus, the 50% morph was chosen for the above rating task because morphing techniques can create morphs that may appear to look more like one face or another across individuals at the same morph level. This was done to test if there was a difference in similarity ratings across participants in explicit appraisals of 50% morph similarity to self or other. Ideally, the 50% morph should have a perceived similarity rating half-way between the self and other faces/voices.

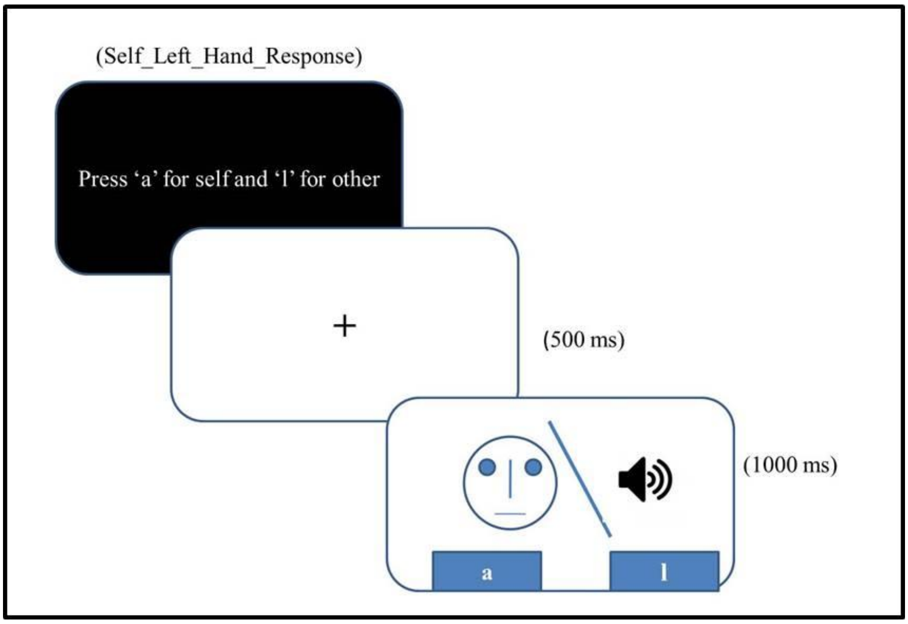

Fig. 2.2A schematic representation of a trial in the self-recognition task. Participants pressed the 'a' key for identifying a presented face/voice morph as 'self' and 'l' key for identifying a face/voice morph as 'other' in the self left-hand response. These key responses were reversed for the self-right hand response.

2.2.3.4 Data Analysis

Statistical tests and plots were generated using SPSS (SPSS Statistics for Windows, Version 22.0.Armonk, NY) and ggplot2 package (Wickham, 2009) implemented in R software (Team, 2012). Unless reported otherwise, all test statistics presented in the results section are one-tailed for main effects analyses and two-tailed for individual differences analyses.

For each level of morph, the percentage self-response (that is, how often was a given morph identified as 'self') was recorded, and a response curve was generated (separately for face and voice). For each modality, the percentage 'self-response' was normalized within participants, to account for baseline differences in self-recognition.

The maximum trials identified as 'self' (at any given morph level) was calculated for both modalities. The parameter of maximum 'self' identification gave an estimate of the range of self-recognition responses for both modalities. The morph level at which the 'self' identification reached the minimum percentage was calculated and averaged at the group level for both modalities. This parameter allowed estimating differences in the threshold for category boundary from ‘self’ to ‘other’ between both modalities. It was predicted that category boundary for ‘self’ to ‘other’ will be at a higher morph level for the visual modality compared to the auditory modality. That is participants on average would require increased levels of ‘self’ related information to be presented to term a face morph as ‘self’ when compared with the same for the voice morph.

The slope of self-recognition for each participant, for each modality, was calculated using a logistic psychometric function fitted for maximum likelihood estimation for Weibull distribution (See section 1.2.1 for the rationale of choosing the slope of the self-response curve as the variable of interest). Depending on the stimulus-related information change across the different morph levels required by an individual participant to shift from the self to other category, the psychometric function gives a steep or shallow slope (See Fig. 1.2). The steepness of this slope is interpreted as an extent of overlap between the self-face/voice and other face/voice representation. A steeper slope indicates a reduced overlap between the self and other representation. In other words, a steeper slope represents a more distinct self-representation.

AQ score for each participant was calculated using the formula as suggested by Baron-Cohen et al. 2001 (Baron-Cohen et al., 2001) (See Appendix A).

Main Effects Analysis:

To characterize the distribution of self-response across two modalities, the maximum percentage identified as ‘self’ was compared across two modalities using a paired-t test. Furthermore, the morph level at which the shift occurs from the category of ‘self ’to ‘other’ for both modalities across all participants was calculated and paired t-test was run. The analysis for maximum self-response and category shift data was performed to have an indication of how self-responses varied between the two modalities.

Individual differences analysis:

Atypical self-other distinction is observed in ASD and for the correlation analyses with autistic traits, the slope variable was chosen as the slope can give the best estimate of self-other distinction in the two modalities (See Section 1.2.1).

Performing Shapiro-Wilk tests revealed neither of the slope variables (for faces and voices) showed a normal distribution (Shapiro-Wilk test $p < .001$).

In line with the second aim of the study, Kendall rank correlation was conducted to investigate the association between the slope of self-recognition curves between the visual and auditory modalities.

In line with the third aim of the study, Kendall rank correlation was computed between the slope of self-face recognition responses and autistic traits as measured by AQ scores. Similarly, Kendall rank correlation was computed between the slope of self-voice recognition responses and AQ scores.

2.2.4 Results

Modality (mean (SD); range)	Maximum self-response (%)	Minimum self-response (%)	Morph level for self to other shift (%)	Slope
Face	97.05 (8.73);100 - 62.5	0	44.12 (12.09)	7.63 ± 0.36
Voice	87.87 (14.9); 100 - 62.5	18.94 (17.01); 50 -0	27.12 (14.14)	7.23 ± 1.25

Table 2.1 Distribution of self-response (%) parameters for face and voice morphs and slopes of the corresponding psychometric functions for study 1. The spread of maximum and minimum self-responses provides an estimate of the range of self-identification for both modalities.

2.2.4.1 Does morph level for category boundary from ‘self’ to ‘other’ differ between the two modalities tested for self-recognition?

A paired t-test revealed that the morph percentage for category boundary from ‘self’ to ‘other’ was at a significantly higher morph level (containing higher self-related information) for visual self-recognition compared to auditory self-recognition ($t(32) = 5.28, p<.001$, d =

1.30; See Fig. 2.3). A paired t-test revealed that maximum self-identification was also significantly higher for visual compared to auditory modality (t (33) = 3.2, *p*< .001, *d* = .8).

2.2.4.2 Does individual differences in slope for self-recognition associate between the visual and auditory modalities?

Kendall rank correlation analysis revealed no significant association between the slopes of self-recognition between the visual and auditory modalities (τ (35) = −.2, *p* = .1; See Fig. 2.4). A partial Kendall correlation coefficient was calculated controlling for gender (to account for the unequal male to female ratio). This analysis did not alter the results (face slope and voice slope: τ = −.2, *p* = .35).

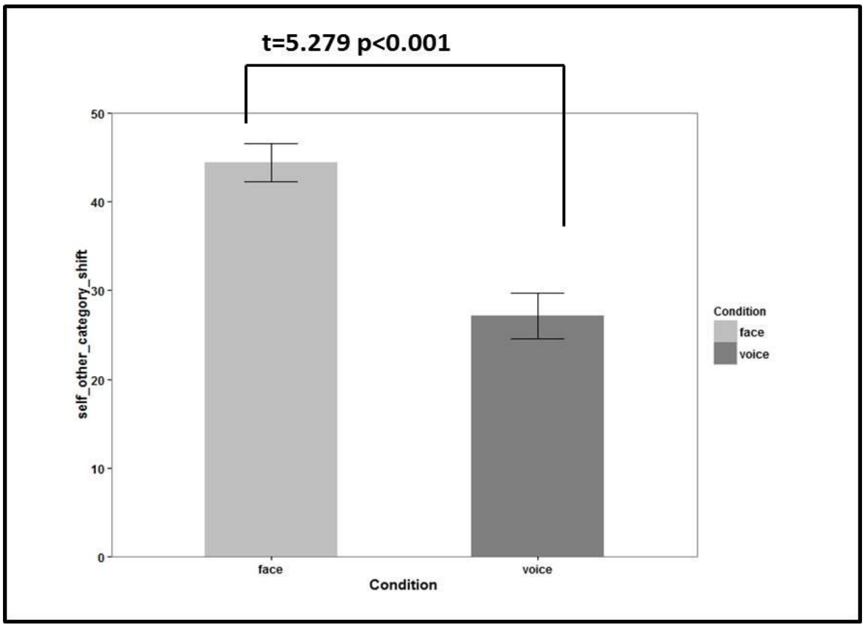

Fig. 2.3 Morph percentage at the group level (mean ± within-subject SEM), at which the ‘self’ identification reaches a minimum percentage indicating the identification shift to ‘other’ category for the self-face and self-voice recognition tasks for study 1.

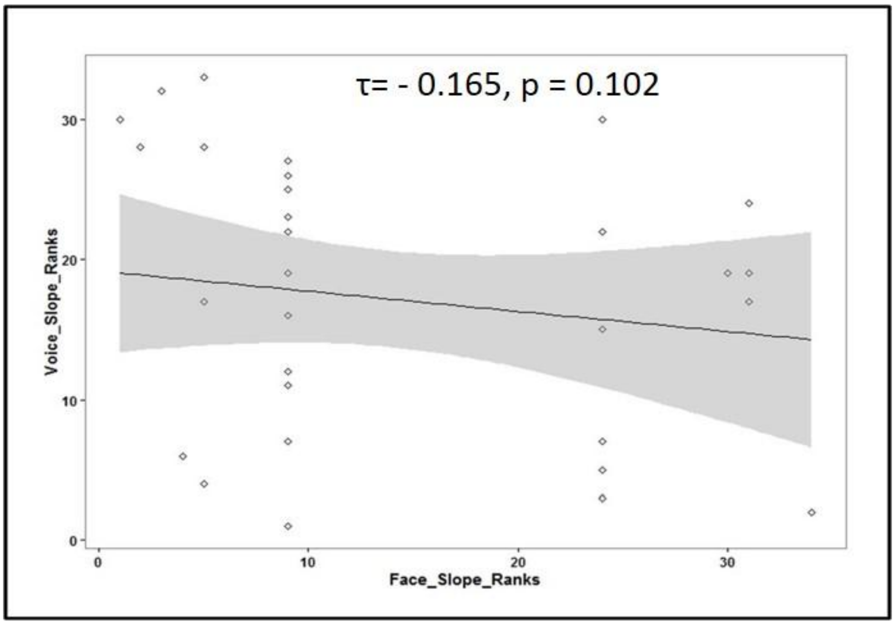

Fig. 2.4 Rank scatterplot representing the association between the slopes for self-voice recognition (y-axis) and for self-face recognition (x-axis) for study 1. The shaded portion represents the 95% confidence region interval for the slope of the regression line.

2.2.4.3 Are autistic traits (AQ) associated with individual differences in slope for self-recognition in the visual and auditory modalities?

The group level autistic score had a mean value of18.6 and SD of ±7.6.To investigate whether autistic traits were associated with individual differences in self-other overlap, AQ was correlated with the slopes for the auditory and visual modalities. Kendall rank correlation analysis revealed slope of visual self-recognition was not significantly correlated with AQ scores (τ (35) = −.02, p = .88).

However, autistic traits were associated with auditory self-recognition; Kendall rank correlation analysis revealed slope of auditory self-recognition was significantly correlated with AQ scores (τ (35) = .3, p = .04; See Fig. 2.5). The data was further analysed with gender as a covariate (accounting for the unequal male to female ratio). This analysis revealed a very similar pattern of results to those reported above (face slope and AQ: τ = −.01,p = .1, 2-tailed; voice slope and AQ: τ = .3,p = .04, 2-tailed).

Steiger's z test did not find a significant difference between the two correlation coefficients (face_slope and AQ & voice_slope and AQ; Z = -1.2, p = .23).

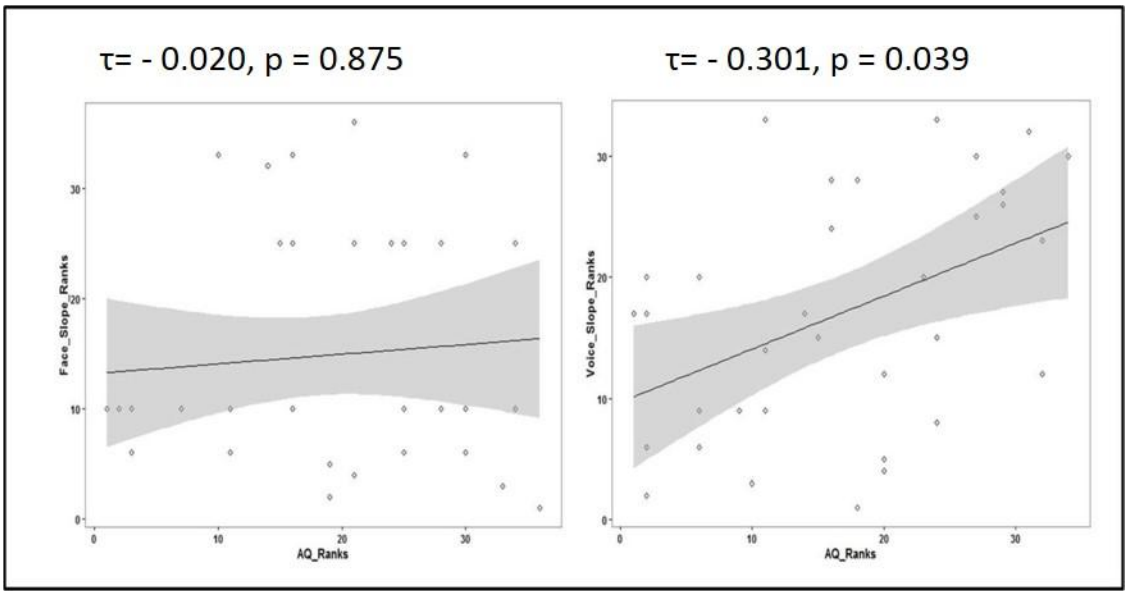

Fig. 2.5 Rank scatterplots representing the association between the slopes for self-face/self-voice recognition (y-axis) and for AQ scores (x-axis) for study 1. The shaded portion represents the 95% confidence region interval for the slope of the regression line.

To check if the pattern of response was biased by specific 'other' faces/voices (since two 'other' faces/voices were used), t statistics were computed using a paired sample t-test for percentage self-response between two unfamiliar faces and two unfamiliar voices for each participant. This analysis revealed no significant differences (faces: t = 0.35,*p* = .73, d = .05; voices: t = 1.61,*p* = .11, *d* = .25).

Modality_Variables	Mean (SD)
Unfamiliar face 1	1.32(1.55)
Unfamiliar face 1	1.33(1.55)
Unfamiliar voice 1	1.9(1.41)
Unfamiliar voice 2	2.05(1.41)

Table 2.2 Mean and SD for each of the two unfamiliar faces and voices.

2.3 Study 2: Self-recognition across sensory modalities in an Indian sample

2.3.1 Aims

The aim of this study was to replicate study 1 in a different cultural context. For this purpose, the participant sample pool was recruited from the Indian subcontinent. Study 2 tested the same aims as study 1 with the overreaching aim to characterize physical self-representation and its relationship to autistic traits within a different cultural context. For this purpose, the same morphing paradigm as study 1 was implemented for study 2 and the 'unfamiliar' faces and voices were chosen to be culture specific.

2.3.2 Predictions

People everywhere develop the concept of the physical self as distinct from others (Hallowell, 1955). Physical self has been proposed as a universal schema for body-representation that acts as a reference point in space and across time (Head, 1922). The development of this physical awareness which is hypothesized to be similar universally is rooted in physiological feedback systems of sensory and motor signals. However, there is evidence of perceptual differences across culture in regards to the processing of physical self-related information. The reduced self-face advantage in the form of slower reaction times to self-face was observed among Chinese participants (Sui et al., 2009). Viewing of self-face resulted in the better processing of interoceptive signals in westerners but not in East Asians with low baseline interoceptive sensitivity. Self-face was also found to evoke a higher level of self-awareness in westerners but not East Asians allowing for better processing of internal bodily signals (Maister & Tsakiris, 2014). Chinese participants showed a 'boss effect' and lost the self-face advantage in the presence of their supervisor's face indicating higher salience for a superior's face compared to self-face in Chinese individuals (Liew, Ma, Han, & Aziz-Zadeh, 2011; Ma & Han, 2009). However, this effect was not observed in European-American students who retained the self-face advantage. The results indicate cultural affiliations moderate self-face recognition advantage. However, self-concept threat priming eliminated self-face advantage effect in both Chinese and American participants, indicating some level of universality in self-face advantage (Ma & Han., 2010).

Although East Asian cultures mainly refer to Chinese, Japanese and Korean nations, previous work on cultural affiliations of nations has categorized Indian culture as possessing interdependent self-construal where self-schema is inclusive of close others (Hofstede, 1980; H. R. Markus & Kitayama, 1991; Shweder & Bourne, 1982; Triandis, 1989). However, there are no reports on any experimental psychology studies of physical self-representation involving the Indian population.

Considering the universal nature of physical self-representation, in the current study, it was predicted that at the behavioural level physical self-recognition across and between modalities and in relationship to autistic traits will exhibit similar patterns as was observed in study 1.

2.3.3 Methods

2.3.3.1 Participants

Thirty-Eight Indian students from the National Brain Research Centre, outside of New Delhi, India aged 25 to 35 years were recruited in the study (13 males, 25 females, age=25.87±2.68 years). All participants were right-handed and had normal or corrected to normal vision and normal hearing. Participants were drawn from different geographical zones of the country. The first languages of participants were different but all participants had English as their second language of education. Maternal education level was recorded as a measure of socio-economic status. All participants completed a two-part experiment. The parts were spaced one to three days apart from each other. All participants also completed the Autism Spectrum Quotient (AQ) questionnaire online after the second part.Thirty-three participants were included in the final analysis. Morph level for category boundary from 'self' to 'other' couldn't be computed for four participants due to a lack of a distinct category boundary (See section 2.3.4.1).The study was approved by the National Brain Research Centre Ethics Committee.

2.3.3.2 Task Design&2.3.3.3 Data Analysis

Protocols for stimuli preparation, task design, and data analysis were identical to study 1. All analyses were one-tailed as similar patterns of results to study 1 were predicted.

2.3.4 Results

Modality (mean (SD); range)	Maximum self-response (%)	Minimum self-response (%)	Morph level for self to other shift (%)	Slope
Face	100	0	40.76(9.53)	14.3±10.67
Voice	93.56(14.02); 100 – 50	7.2(11.2); 37.5 – 0	33.5(11.3)	7.47±.04

Table 2.3 Distribution of self-response (%) parameters for face and voice morphs and slopes of the corresponding psychometric functions for study 2. The spread of maximum and minimum self-response identification provides an estimate of the range of self-identification for both modalities.

2.3.4.1 Does morph level for category boundary from 'self' to 'other' differ between the two modalities tested for self-recognition?

Paired t-test analysis revealed that the morph percentage for category boundary from 'self' to 'other' was at a significantly higher morph level (containing higher self-related information) for visual self-recognition compared to auditory self-recognition ($t(28)=2.2$, $p=.02$, $d = .57$; See Fig. 2.6). In other words, participants identified a face as their own at higher levels of self-related information and switched from 'self' to 'other' category at higher percentages of self-other face morphs. In comparison, category shift for self-other voice morphs occurred at the lower level of self-related information. The maximum self-identification was also found to be significantly higher for visual compared to auditory modality ($t(32) = 2.7$, $p< .01$, $d = .7$).

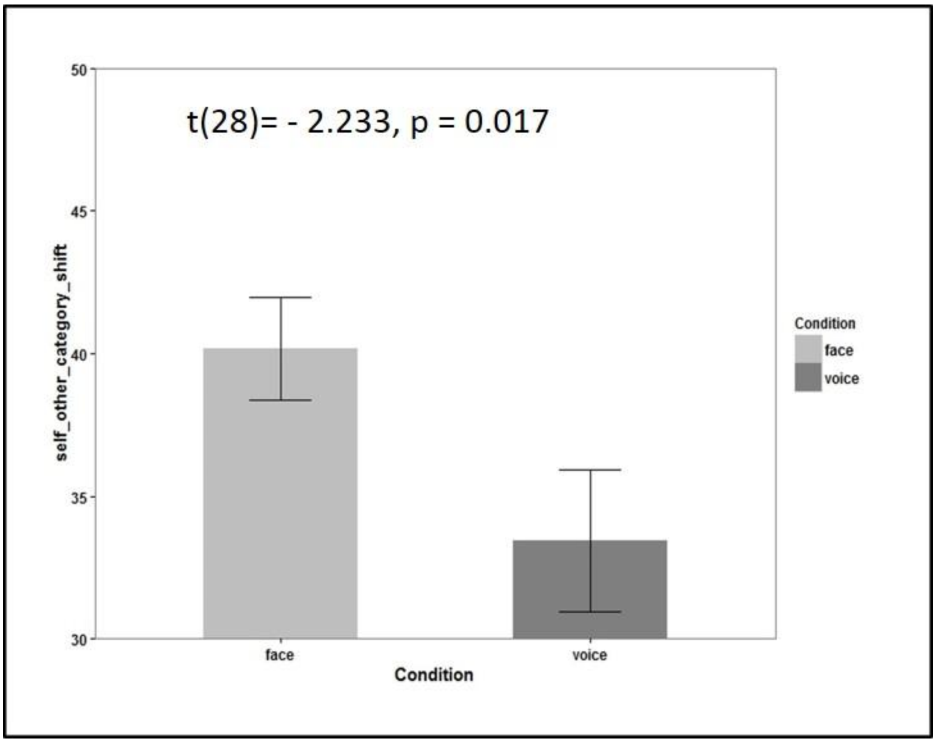

Fig. 2.6 Graph representing the morph percentage at the group level (mean ± within-subject SEM) (Cousineau, 2005) for the threshold for category boundary from 'self' to 'other' across two modalities.

2.3.4.2 Do individual differences in slope for self-recognition correlate between the visual and auditory modalities?

To test if the overlap between self and other representation in the two sensory domains exhibited any relationship, a Kendall rank correlation coefficient was computed between the slopes of face and voice self-representation. The choice of the test was made as both datasets did not show a normal distribution (Shapiro–Wilk test p<0.01) and the ranks were tied for many scores. This analysis included only the participants who completed both auditory and visual tasks (N = 33). There was no significant correlation between the self-recognition slope of visual and auditory modalities (τ (32) = .11, p=.2; See Fig. 2.7).

2.3.4.3 Are autistic traits (AQ) associated with individual differences in slope for self-recognition in the visual and auditory modalities?

The group level autistic score had a mean of 20.95; SD = ± 6.9. Kendall rank correlation coefficient revealed visual self-representation did not correlate significantly with AQ scores (τ (33) = .15, p=.12; See Fig. 2.8).

Kendall rank correlation coefficient revealed auditory self-representation was significantly correlated with AQ scores (τ (32) = .2, p=.05; See Fig. 2.9). Steiger's z test found no significant difference between the two correlation coefficient (Z = 0.24,p= .41; See Fig. 2.8).

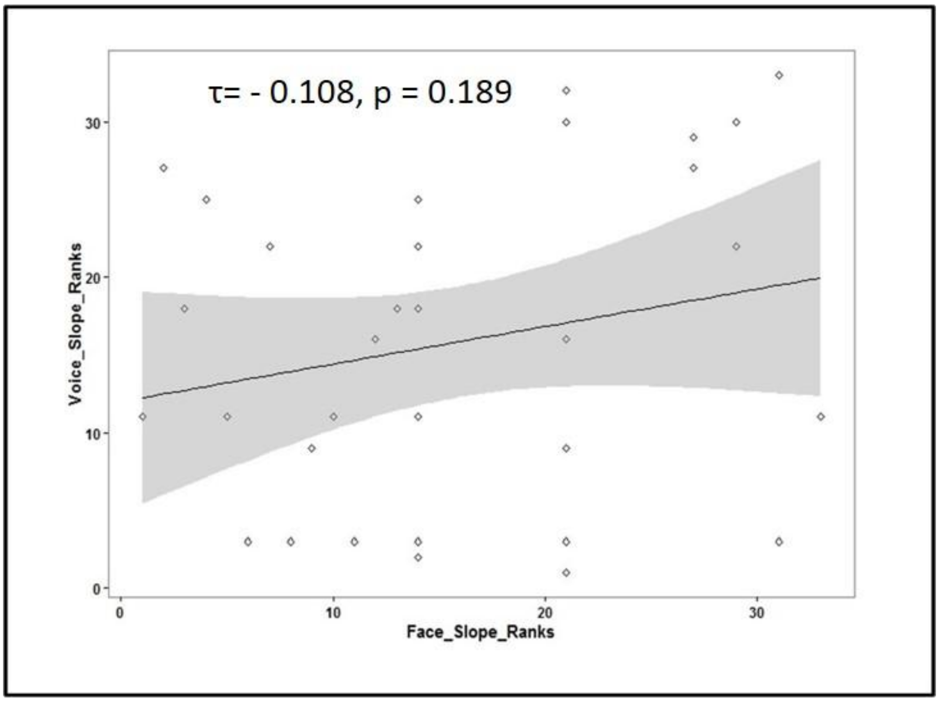

Fig. 2.7 Rank scatterplot representing the association between the slopes for self-voice recognition (y-axis) and for self-face recognition (x-axis) for study 2. The shaded portion represents the 95% confidence interval for the slope of the regression line.

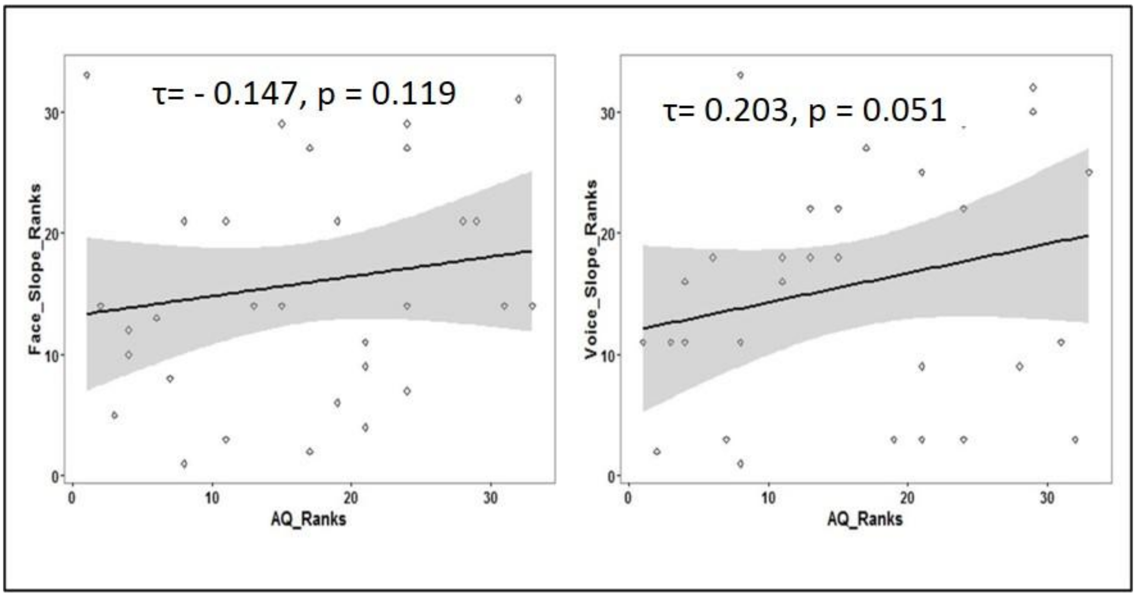

Fig. 2.8 Rank scatterplot representing the association between the slopes for self-face/self-voice recognition (y-axis) and for AQ scores (x-axis) for study 2. The shaded portion represents the 95% confidence interval for the slope of the regression line.

2.4 Discussion

Study 1 and study 2 tested in Western European Caucasian and Indian samples respectively, (a) if physical self-representation is comparable between visual and auditory modalities and (b) if autistic traits are associated with sensory modality specific self-representation.

Results from both the samples revealed that individuals shift category from 'self' to 'other' at higher levels of self-related information in the visual modality when compared to the auditory modality. This is primarily because visual self-representation presents less subjective ambiguity, possibly due to higher levels of familiarity for self-face compared to self-voice. This inference is further supported by the observation that at group level the percentage of trials identified as 'self' was close to hundred-percent for self-other face morphs that spanned the morphing continuum with highest levels of self-face information (100 % - 85% morph levels). However, self-identification for self-other voice morphs was comparably lower at ninety to sixty percent at the self-end of the self-other voice continuum. For both participant groups, the maximum percentage of trials identified as 'self' was significantly higher for self-face identification (Western European: 97.05% ± 8.03; Indian: 100%) compared to voice (Western European: 87.87±14.9; Indian: 93.56 ±14.02).

Self-face recognition is found to have greater accuracy compared to self-voice (Hughes & Nicholson, 2010). The current sample for study 2 was recruited from urban settlements and participants had high levels of education. It is possible that a different pattern of results could be obtained with lower levels of percentage self-face identification for individuals from a rural settlement in India possibly due to reduced familiarity for self-face (e.g. through less exposure to photographs and 'selfies'). Although self-face advantage is seen in both western (Keenan et al., 1999; Tong & Nakayama, 1999) and East Asian cultures (Sui & Han, 2007; Sui, Zhu, & Han, 2006), there is evidence of differences in face processing strategies across cultures. In westerners, face processing involves a triangular fixation pattern over eyes and mouth regions of the face. However, East Asians have been found to focus more on the central region of the face as a process to extract features in face categorization and recognition task (Blais, Jack, Scheepers, Fiset, & Caldara, 2008). Furthermore, easterners sample faces extrafoveally and are inflexible in changing gaze patterns when presented with blindspots (Blais et al., 2008). However, westerners, when presented with blind spots become more extrafoveally oriented in their gaze processing strategy similar to that of easterners. This indicates westerners show flexible strategies for face processing when presented with restricted visual information (Jack, Garrod, Yu, Caldara, & Schyns, 2012). Thus, face processing may not be culturally universal and behavioural representation with the current paradigm cannot discount for underlying differences in face processing strategies between participants of study 1 and study 2. Further studies using eyetracking methodology should be used to probe underlying gaze scanning strategies for self-other face morphs in individuals from the two cultures tested here.

In the current study, the slope of self-face recognition was used as a metric for self-other overlap in the physical domain. Available physical self-related information was manipulated in both visual and auditory domains by creating degrees of morphs with differing percentages of self-related information. The steepness of the slope, calculated from the self-recognition responses across the different degrees of morphs, provided a measure of stimulus range over which the participant shifted between the self and other categories. A steeper slope indicates a narrower range and a reduced overlap between self and other.

This metric was then compared between the modalities and with autistic traits. Results from study 1 and study 2 show that physical self-representation across the auditory and visual domains do not correlate with each other. This suggests that individuals with a narrower self-other overlap in visual domain (or more distinct self-face representation) did not show a correspondingly narrow self-other overlap in the auditory domain. This observation suggests that physical self-representation is not unitary across sensory modalities and is in line with the theories of domain-specific/non-unitary nature of self-representations (Gillihan & Farah, 2005; Neisser, 1988; Williams, 2010). While common brain regions such as the inferior frontal gyrus (IFG) might be involved in responding to both self-face and self-voice (Kaplan et al., 2008), this result suggests that the bias to self-related signals in the different sensory modalities might be sufficiently distinct. However, these differences in self-recognition across sensory modalities do not invalidate the possibility that physical self-related information may be processed in an integrated multisensory manner (Gallup, 1982; Platek et al., 2004).

Results from study 1 and study 2 also revealed that individuals with high autistic traits show narrower self-other overlap in the auditory domain. The steeper slopes in the auditory domain for individuals high in autistic trait indicates that the modality specific nature of the stimuli allowed such individuals to shift categories (from 'self' to 'other') with a smaller shift in the intensity of self-related information. This suggests that a narrow representation of self-voice (or a more distinct representation of self-voice) is associated with higher autistic traits. One interpretation of this result is that individuals high in autistic traits have a 'narrower' physical self-representation. This narrow physical self-representation can be interpreted such that any deviation from it is perceived to be an 'other', making it difficult to simulate others. This is particularly interesting since the flexibility of self-representation can be useful in order to put oneself in another person's shoes (that is, simulate them). One potential mechanism through which a more distinct physical self-representation can be instantiated is through heightened attention to interoceptive cues, as has been noted by a recent study in individuals with ASD (Schauder, Mash, Bryant, & Cascio, 2015). However, although this relationship of high autistic traits and narrower physical self-representation was seen for self-voice stimuli in both Caucasian and Indian population, the same was not observed for self-face in both the populations.

In follow-up experiments (See sections 4.5.3) the lack of association between autistic traits and self-face recognition in Caucasian population was further replicated. Since the relationship of autistic traits and narrower physical self-representation is only seen for self-voice and not for self-face, an alternative explanation based on the sensory characteristics of self-face and self-voice stimuli is offered here. In contrast to faces, our familiarity with our own voices as it sounds to others is usually lower. This is because we hear our own voices through bone conduction, which sounds different from recorded self-voice that we hear through air conduction. Previous reports have suggested that individuals focus on the grammar, syntax, and psychological characteristics of other speakers, while they focus on the tonal qualities when hearing their own voice (Holzman et al., 1966).The nature of the voice stimuli in the experiments was also devoid of any semantic information, a feature that makes recognition of self-voice further pitch dependent. The tonal qualities of a voice are more pitch dependent, and higher abilities in pitch discrimination are reported in ASD (Bonnel, Mottron, Peretz, Trudel, & Gallun, 2003). It is, therefore, possible that the higher perceptual functioning in the auditory domain, often seen in ASD individuals, may underlie the better recognition of self in the auditory domain by individuals with high autistic traits.

It should be noted that the current study sample was not balanced for gender and did not have sufficient power for the analyses to be stratified by gender. Notwithstanding this limitation, controlling for gender in separate correlation analyses did not change the reported results. However, in view of a female advantage in self-face recognition suggested in an early study based on polaroid photographs of self-faces (Yarmey & Johnson, 1982), future work should further test the role of gender in self-face and extend it to self-voice recognition.

Specifically for self-voice recognition, future experiments should test the competing explanations of the results presented in this study, by testing if the better discrimination of pitch in unrelated control sounds can account for this observed positive correlation of self-voice recognition bias and autistic traits. Self-representation in the psychological domain has been investigated widely in recent behavioural and neuroimaging studies (Han & Northoff, 2008; Northoff et al., 2006). It will be of interest to test the brain-behaviour relationship of physical self-representation with self-representation in the psychological domain using behavioural and neuroimaging techniques. In addition, cultural differences in different domains of self-representation and how these are altered in psychopathological conditions such as ASD need to be addressed by future studies. Chapter 5 will investigate the relationship between the physical and psychological self-representation and its relationship with autistic traits.

2.5 Conclusion

Studies from this chapter found evidence from samples within two different cultures suggesting that self-face compared to self-voice is a more familiar stimulus with a stronger mental representation. Further, the results suggest that the recognition for physical self-representation across the visual and auditory domain is not a unitary or correlated phenomenon. Considering evidence from these two different cultures, it can be reasonably inferred that the self-face and self-voice representation are perhaps behaviourally distinct, and unrelated to each other. It is possible that these representations depend strongly on the exposure to self-related stimuli from early on in development. It was also found that recognition for self-voice is correlated with autistic traits, such that individuals with high autistic traits show a narrow self-other overlap. Future experiments should include non-voice stimuli to test between competing interpretations suggested in this report and extend the paradigm to other cultures as well as individuals with ASD. Following the investigation of behavioural representation of the physical self across two modalities, the next chapter will outline an investigation into the role of task specificity (explicit vs. implicit processing) on the behavioural representation of the physical self in the visual modality.

3. Physical self-representation: Evidence for task specificity

In the domain of the physical self-representation, the main investigative focus has been on explicit self-recognition primarily in the visual modality. Chapter 2 of this thesis outlined an investigation into explicit physical self-recognition in two different sensory modalities and in two different cultural contexts. The current chapter outlines an investigation into the role of 'task-specificity' in self-face recognition response. The study investigates how different task instructions and stimulus manipulation affects the physical self-representation in the visual domain. The differences in task-specific response patterns are discussed in relation to explicit recognition and implicit evaluation of self-face. This study also investigates how familiarity with facial identities influences recognition of a face. Overall, the study elucidates that familiarity levels and task specificity (explicit and implicit levels of self-processing) influence representation and recognition of faces.

3.1 Introduction

In Chapter 2, physical self-recognition was investigated using explicit self-face and self-voice recognition tasks. In daily life, physical self-appraisal can be evoked through the explicit presentation of the physical self. However, individuals could also access the physical self in an implicit and automatic manner while making social judgments about others (Rameson, Satpute, & Lieberman, 2010). In the absence of any explicit self-recognition task and with no prior knowledge regarding self-similarities, participants judged faces that looked like themselves (in terms of physical information present in them) to be more trustworthy. This result indicates that the similarity of the face was implicitly compared to self-face and those outcomes with a closer match resulted in a higher positive appraisal of the presented face (Verosky & Todorov, 2010). An fMRI task investigated activation in the amygdala to faces that resembled self-face in both same-race and other-race groups (Platek & Krill, 2009). It was observed that there is a nonlinear and heightened response for self-resembling faces (in the same race group) in the amygdala. Furthermore, the correlation between racial biases (as measured by implicit attitude test) was attenuated for self-resembling faces in the other race group. It was argued that in the absence of overt appraisal of the self-face, faces resembling the self were implicitly matched to the visual features of self-face and closer matches influenced social judgments. There is an inherent social importance of faces resembling self-face in relation to self-reference frame, and such appraisals in daily life may often happen implicitly/in an automatic manner (Platek, Keenan, & Mohamed, 2005). There is certain consensus on the behavioural and neural correlates of self-face recognition primarily using tasks that required explicit processing of self-face (Keenan et al., 2000; Keenan et al., 1999; Keenan, Wheeler, et al., 2003; Kircher et al., 2001; Platek, Wathne, Tierney, & Thomson, 2008). However, differences in these response patterns using different task designs have indicated self-face processing can be partly influenced by task-specificity i.e., dependent on the demands of the task even when the tasks involved are explicit self-recognition tasks (See section 1.2.1) for an overview of behavioural and neural correlates of self-face recognition).

It has been found that implicit and explicit self-related information processing are weakly related to each other indicating that self-advantage may work differently for explicit and implicit evaluation of the self(Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005). Implicit self-processing (in the absence of overt self-referential processing) involves processes of self-related evaluation that are primarily automatic in nature. It has been found that measures of implicit and explicit self-processing differently predict the impact of behavioural traits like anxiety and shyness associated with implicit and explicit levels of self-esteem (Asendorpf, Banse, & Mücke, 2002; Spalding & Hardin, 1999). The true mechanisms which govern these differences are unknown but it is theorized that implicit self-processing evokes underlying belief and value systems whereas explicit self-evaluation evokes appraisal of self-representations and social expectations (Fazio, Jackson, Dunton, & Williams, 1995; Greenwald, McGhee, & Schwartz, 1998). Self-bias is also observed in the form of increased allocation of attention to self-face and self-name (Devue, Van der Stigchel, Brédart, & Theeuwes, 2009; Geng, Zhang, Li, Tao, & Xu, 2012; Ma & Han, 2010) which is primarily automatic. It can be hypothesized that behavioural responses to self-face will differ when the self-face is explicitly evaluated and recognized as ‘self’ compared to implicit evaluation of self-face. However, visual self-representation is mostly studied as explicit self-recognition and little is known regarding the differences in self-face processing for both explicit and implicit conditions.

Studies investigating implicit self-processing have often used traits/personal information like text describing personality traits rather than pictorial self-schemas like self-face to evoke implicit self-processing. In an fMRI oddball task textual stimuli in reference to self or non-self relevance levels were manipulated (Moran, Heatherton, & Kelley, 2009). In the absence of any overt self-other judgments the cortical midline structures (medial prefrontal and anterior cingulate cortices), previously shown to be engaged in explicit self-processing (Northoff & Bermpohl, 2004), were activated during implicit evaluation of self-related information processing. In the domain of psychological self, both explicit self-evaluation of personality traits and spatial location judgment of the presented traits showed the emergence of self-recognition effect in memory for personality traits (Turk, Cunningham, & Macrae, 2008). Thus, deep encoding associated with self-referential information can be evoked both explicitly and incidentally. To investigate explicit vs. implicit self-processing, participants were tested using fMRI as they performed an intentional self-evaluation task (self-relatedness of traits) and an incidental task (physical attributes of traits) arranged without participants' knowledge, in self and non-self related blocks (Kircher et al., 2002). Behavioural data revealed reaction time advantages for both self-related encodings in intentional and incidental conditions indicating self-advantage for both explicit and implicit levels of self-processing. At the neural level, common areas (left superior parietal lobule and areas adjacent to the lateral prefrontal cortex) were activated for both tasks along with distinct task specific areas of activation (intentional self-processing: precuneus and incidental self-processing: right middle temporal gyrus). Consistent with these neural findings of common activations associated with passive and active self-processing, both passive (no explicit discrimination, judgment on the orientation of the face) and active recognition of self-face (explicit self-other discrimination) were shown to increase skin conductance indicating heightened physiological arousal (Sugiura et al., 2000). Furthermore, in the same study, using fMRI for active and passive self-recognition, the higher involvement of right hemisphere for active self-recognition but not for passive self-recognition was observed.These results indicate that the right hemispheric advantage in the explicit or active processing of the self may not hold true when self-processing takes place in an implicit and automatic manner suggesting that self-processing may occur through different cognitive routes for specific processing levels of self-related information.

In an event-related potential study, pictorial self-schemas were used to investigate responses to self-face in attended and unattended condition (Sui et al., 2006). The attended condition required explicit recognition of facial identity. The unattended condition required the judgment of head orientation of the presented facial stimuli. The Increase in the baseline amplitude of brain potential between 500-700 ms window was observed in the frontocentral region for self-face and a familiar face in the attended condition. However, in the unattended condition where no explicit evaluation/recognition of facial identity was required this increase in amplitude was observed only for self-face. It was argued that this peak in amplitude indicate increased attention to the presented stimuli. This increase in attention observed for self-face was high for both attended and unattended conditions indicating high salience for self-face during both explicit and implicit self-face processing.

An fMRI study of self-other face recognition found that manipulating background information (like priming) can influence levels of self-other distinction in the perception of self-face (Sui & Han, 2007). In the study outlined in this chapter, a similar design using pictorial self-schema (self-face) was used to evoke different levels (explicit and implicit) of self-processing. Using a self-other face morphing paradigm, the current study manipulated the familiarity levels of the 'other' face to study changes in the behavioural representation of the self-face.

Previous reports using multisensory integration have shown that the representation of self-face can be implicitly modified and that the behavioural representation of self-face is flexible in nature (Tsakiris, 2008). The evidence that multisensory integration can update self-face representation like that of the body illustrates that there is inherent flexibility in this representation allowing for other related information to overlap with it. This flexibility in self-representation may be important in shared interaction and imitation where overlap in self and other representation is required(Keysers & Gazzola, 2007). Although self-face representation is generally stable certain components of this representation are found to be flexible (Sui & Humphreys, 2013). This study investigated the stable and flexible components of self-face representation through different task conditions to show differences in response distributions in time across tasks. However, major components of the self-face distribution were also found to be stable across tasks.

In the current study, physical self-representation is investigated in different task conditions to illustrate any observable task-specific response patterns in physical self-representation. The task conditions chosen are predicted to stimulate explicit and implicit levels of self-processing to different degrees resulting in differences in response patterns. In the condition predicted to evoke predominantly explicit levels of self-processing, participants judged morphed faces as self-face or an unfamiliar other face. In the condition predicted to evoke predominantly implicit levels of self-processing, participants judged if a morphed face was a previously memorized face without being explicitly aware of self-face being present in the morphed face. Thus, for the current study, implicit processing refers to the processing of self-face being unaware that self-face is present in the task condition.

Furthermore, face-representations were tested for faces with different degrees of familiarity - a highly familiar self-face, a newly learned/memorized face, and unfamiliar facial identities. Face morphing technique was used to achieve the above manipulation strategy for the identities used for the task. Self-face, when mixed with other face, is believed to influence the representation of both familiar and unfamiliar faces (Sui et al., 2006). The current study used different facial identities (including self-face) morphed with target faces and investigated changes in the behavioural representation of the target face with the change in the identity of the face with which it is morphed. This study aims at showing that physical self-representation is flexible in nature with task-specific response patterns and that both the nature of processing and the degrees of familiarity influence the behavioural representations of self and other faces.

3.2 Aims

The primary aim of the study was to investigate task-specific (explicit and implicit) response patterns in self-face recognition, a visual marker of physical self-awareness. Self-face was morphed with 'other' facial identities to manipulate the degree of self-resemblance, and the self-face recognition responses were measured in both explicit and implicit task conditions. To investigate the self-face recognition implicitly, participants had to memorize an unfamiliar face and recognise the memorized face from a self-other face morph series (implicit-self condition). Participants were not informed that the memorized face was morphed with their own face and hence it allowed the investigation of representation of the self-face at an implicit level.

The second aim of the study was to investigate face representation of different facial identities and how these representations were influenced by background information that varied in levels of familiarity. To implement this aim, the task required participants to recognise a previously memorized face from a morph series when the same was morphed with a highly familiar self-face (implicit-self condition) and when the memorized face was morphed with an unknown face (non-self condition). This allowed studying the difference between the representations of a newly memorized face when the background information varied in levels of familiarity.

3.3 Predictions

The following predictions were made for this study:

1. At the group level, there will be a difference between self-face recognition responses when self is explicitly labelled and when the self-face is processed implicitly thereby showing a task-specific response pattern. This prediction is based on the theory that implicit self-processing represents true beliefs, which are automatic, whilst explicit self-processing is influenced by social expectation and overt evaluation of self-representation (Fazio et al., 1995; Greenwald et al., 1998).
2. There will be a difference in representation of a newly learned/memorized face as measured by face recognition responses when the background information is varied in degrees of familiarity. The degree of familiarity is varied by including two different facial identities – the highly familiar self-face and an unfamiliar face. It is predicted that the representation of the newly learned face will depend on the familiarity of the face it is morphed with.

   The following assumption was made for this prediction: when a face is morphed with another face, there is explicit processing of the target face and implicit processing of the background face. In the two conditions, the background face varied in degrees of familiarity while the target face is constant. It is predicted that the highly familiar self-face has a more distinct representation in the visual memory compared to the unfamiliar face. Hence, the representation of the target (the newly learned face) will differ due to the implicit access to the different levels of representations of the background faces. Previous reports have shown that when self-face is mixed with other facial identities, the familiarity of the self-face influences the processing of these other facial identities (Caharel et al., 2002; Sui & Humphreys, 2013).
3. There will be a significant difference in the recognition response of a familiar face when morphed with an unfamiliar face, based on degrees of familiarity of the target face. In contrast to the conditions of prediction 2, in the present condition recognition response of two familiar target faces are compared. Both the target faces, in two different conditions are morphed with an unfamiliar identity. It is predicted that the degrees of familiarity with the target face itself will influence the

representation of that face. Self-face being highly familiar, when explicitly labelled will have a more distinct representation compared to the representation of a newly learned/memorized face. This result is predicted because familiarity has shown to influence face representation and the self-face advantage is observed in comparison to familiar faces in self-face and familiar face recognition tasks (Keenan et al., 1999; Klatzky & Forrest, 1984; Tong & Nakayama, 1999; Valentine & Bruce, 1986).

3.4 Method

3.4.1 Participants

40 white Caucasian participants aged between 18 and 40 years were recruited in a two-part study (8 males, 32 females, age = 20.36±5.09 years). Two sessions, the first where photographs of the participants were taken and the second where participants performed the task, were spaced one to three days apart. Only white Caucasian participants were chosen since the ‘unfamiliar’ faces used in this experiment were constant across participants and were of this ethnicity. All participants had normal or corrected to normal vision and hearing and were right handed. The study was approved by School of Psychology and Clinical Language Sciences Ethics Committee, University of Reading.

3.4.2 Stimulus Preparation

Stimuli were individually tailored for each participant. Each participant was photographed using a digital camera in identical conditions under artificial lighting. Six volunteers matched for race and age (3 males for male participants and 3 females for female participants) selected to serve as two ‘unfamiliar faces’ and one face as the ‘newly learned/memorized’ face for each gender was also photographed under the same conditions.Participants looked directly at the camera and were seated at a distance of 100 cm with a white background while holding a neutral expression. The photographs were then converted to grayscale and external features (hairline, jaw line, and ears) were removed. This photograph was then mounted on an oval frame and cropped to a dimension of 350 × 500 pixels using GIMP. Three sets of stimuli were created for each participant using Sqirlz Morph. (See Fig. 3.1)

1. Explicit-self condition: A 15 step morph continuum between participant's own face and an unfamiliar face was created for the condition in the following step sizes (100% self-face, 90%, 80%, 70%, 65%, 60%, 55%, 50%, 45%, 40%, 35%, 30%, 20%, 10%, 0%).

2. Implicit-self condition: A 15 step morph continuum between the unfamiliar face to be memorized and participant's own face was created for this condition starting from 100% memorized face using the following step sizes (100% self-face, 90%, 80%, 70%, 65%, 60%, 55%, 50%, 45%, 40%, 35%, 30%, 20%, 10%, 0%).

3. Non-self condition: A 15 step morph continuum between the face to be memorized and a second unfamiliar face was created for this condition starting from 100% memorized face using the following step sizes (100% self-face, 90%, 80%, 70%, 65%, 60%, 55%, 50%, 45%, 40%, 35%, 30%, 20%, 10%, 0%).

In the test phase, images were presented at a viewing distance of approximately 55 cm, on a 30.5 cm × 23 cm inch colour TFT active matrix XGA LCD monitor (1,024 × 768 pixels) run at 60 Hz by a PC.

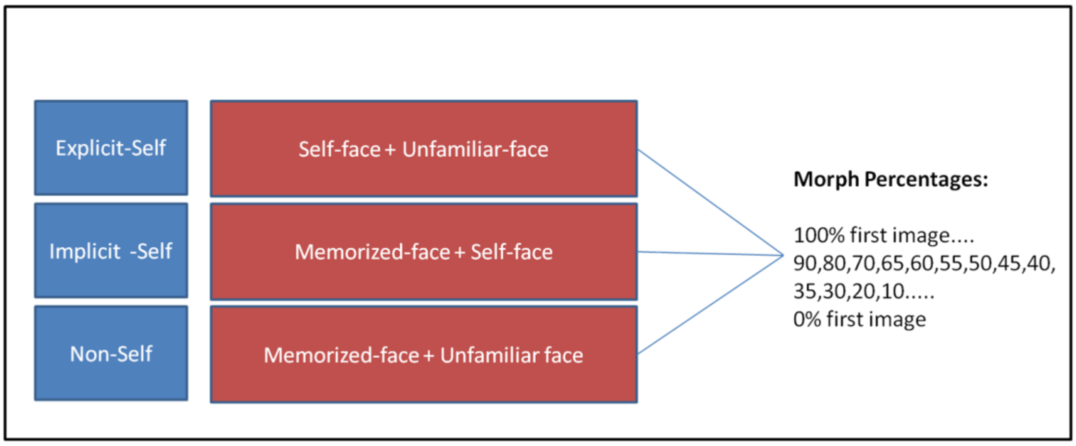

Fig. 3.1 Schematic representation of three task conditions and the corresponding face identities being morphed. Morph percentages represent the percentages at which the morphing was implemented for all conditions, starting at 100% image of the first identity of each morph series.

3.4.3 Task design

There were two parts in this study. In the first part, each participant was photographed using the technique detailed in the previous section (See Section 3.4.2). In the second part, the participants performed the experimental task. There were three conditions in the second part – explicit-self condition, implicit-self condition, and non-self condition (See Fig. 3.2). The three conditions were presented as separate runs and all conditions were counterbalanced across participants. All conditions had a 15 step face morph series (100%, to 0%). These step sizes were chosen as it was observed that individual differences in face labelling varied between the 70% and 30% morph levels in terms of the morph level for category shift between self and other category (See Table 2.1). Each morph in each condition was presented 24 times. Hence a total of (15x24) = 360 morphs was presented for each condition. Morphs were presented in a random order within each condition. All trials were preceded by a 500-millisecond cross-hair on a blank screen. Following which there was a single presentation of a face morph for 500 milliseconds followed by a 500-millisecond blank screen. Participants were asked to respond as quickly as possible in this 1000 millisecond time window. All conditions were run using E-Prime version 2.0.

Explicit-self condition

In the explicit-self condition, participants were asked to label each presented face as 'self' or 'other'. The task was a keyboard button press task with "1" to be pressed for 'self' face and "2" to be pressed for 'other' face. The presented morphs were from a 15-series morphing continuum between participant's face and a face unfamiliar to them.

Implicit-self condition

For the implicit-self condition participants were first presented with a face for 15 seconds and asked to memorize this face. Following this, participants were asked to label each presented face as 'memorized' or 'not-memorized'. The task was a keyboard button press task with "1" to be pressed for 'memorized' face and "2" to be pressed for 'non-memorized' face. The presented morphs were from a 15-series morphing continuum between the memorized face and participant's own face. Participants were unaware that the memorized face was morphed with their own face and had to respond to the faces with this information being accessed implicitly.

Non-self condition

For the non-self condition (where no self-related information was present) participants were first presented with the same face from the implicit-self condition for 15 seconds and were asked to memorize this. Following this, participants were asked to label each presented face as 'memorized' or 'not-memorized'. The task was a keyboard button press task with "1" to be pressed for 'memorized' face and "2" to be pressed for 'other' face. The presented morphs were from a 15-series morphing continuum between the memorized face and another unfamiliar face to which they were not previously exposed.

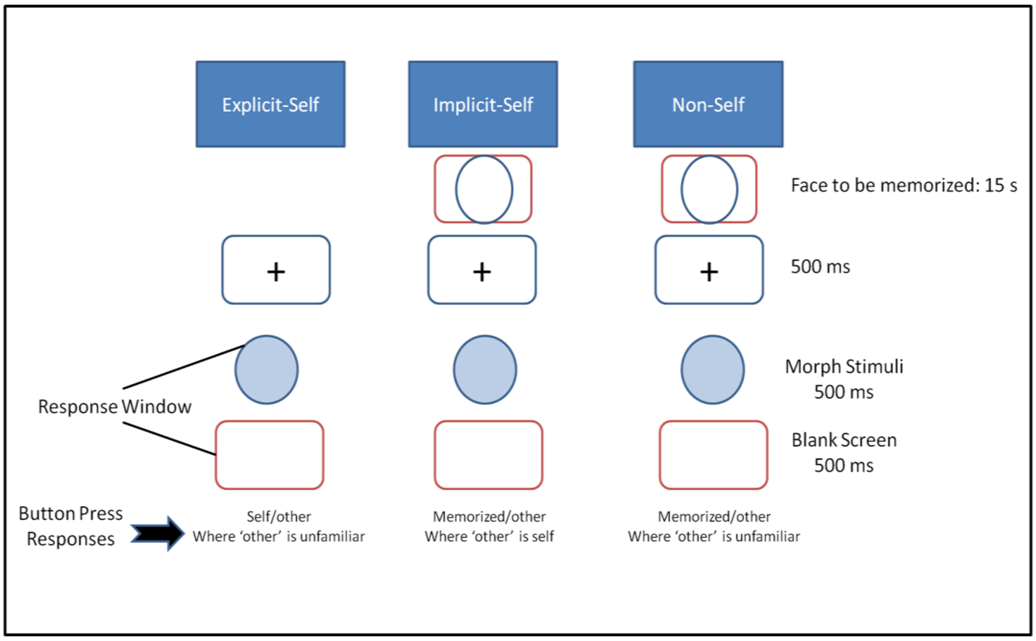

Fig. 3.2 Schematic representation of the trials in each condition. The face to be memorized is shown in the implicit self-condition and the non-self condition prior to any trials and not before each individual trial. Participants performed key presses for indicating identity response for each trial.

3.4.4 Data Analysis

Statistical tests and plots were generated using SPSS (SPSS Statistics for Windows, Version 22.0.Armonk, NY) and ggplot2 package (Wickham, 2009) implemented in R software. Unless reported otherwise, all test statistics presented in the results section are one-tailed (main effects analysis) due to the directional nature of the predictions.

For each condition, at each level of morph, the following responses (that is, how often was a given morph labelled as 'self'/'memorized face') were recorded and a response curve was generated.

a) percentage self-response (explicit-self) and (implicit-self) or
b) memorized-face response (implicit-self & non-self)

A logistic psychometric function fitted for maximum likelihood estimation for Weibull distribution was used to compute the slope variable. Maximum likelihood estimation is a standard adaptive method in psychophysical experiments (See Section 1.2.1 for choosing the slope of the self-response curve as the variable of interest). The slope variable gives an estimation of self-other overlap, where a steep slope theoretically represents a narrow self-other overlap and a more distinct physical self-representation and a shallow slope represents a wider self-other overlap and a less distinct physical self-representation.

Main Effects Analysis:

Outlier removal was performed using a (Q3-Q1) *1.5 formula (where Q3 and Q1 are third and first quartiles of the data set respectively) to define lower and upper bounds for outlier marking. The outliers were identified because high levels of noise in the data resulted in erroneous values of the slope variable. Following outlier removal, a total of thirty-three participants were analysed for slope variable.

Normality of the data was checked for slope values for all three conditions. As Shapiro-Wilk's test was significant (p <.001) for the slope of recognition response for all three conditions showing the non-normal distribution of data, Friedman test as a non-parametric alternative to analysis of variance (appropriate for data violating assumptions of normality) was conducted for dependent variables slope for all three conditions. The following posthoc Wilcoxon signed-rank posthoc tests were conducted to test predictions 1 and 2 for slope variables (see section 3.3):

1) Slope of self-face response recognition curves for explicit-self condition and implicit-self condition

The slope for the *implicit-self condition* (test 1) was calculated with the responses for 100% self-face taken as the start point of the response curve giving the estimate of the slope response for implicit processing of self-face. In other words, when self-face was 100%, the percentage of the face labelled as non-target/non-memorized (and not the memorized face) was calculated. This analysis directly tests the how the slopes of the recognition response curve differed between the explicit and implicit processing of self-face.

2) Slope of memorized-face response recognition curves for implicit-self condition and non-self condition

The slope for the *implicit-self condition* (test 2) was also used to calculate the responses for 100% memorized-face taken as the start point of the response curve giving the estimate of the slope responses for memorized face-familiar self-face morphs. In other words, when memorized-face was 100%, the percentage of the face labelled as the memorized face was calculated. This analysis directly tests the how the slopes of the recognition response curve were influenced by the background familiarity i.e., how the responses differed between the processing of memorized face when morphed with the familiar self-face (implicit-self condition) compared to when it is morphed with an unfamiliar face (non-self condition).

3) Slope of self and memorized-face recognition curves respectively for explicit-self condition and non-self condition

Alpha levels were adjusted for multiple testing (three comparisons) to $p=.017$ significance testing.

3.5 Results

Friedman's test showed a significant difference across the three conditions for slope variable (X2 (2, N = 36) = 17.4, $p <.001$, Fisher's $Z_r = 0.86$). Further simple effect analysis with Wilcoxon signed-rank test revealed the following results.

3.5.1 Does self-face recognition (as measured by self-face recognition response curve) differ when processed explicitly and implicitly?

To test this directly, a Wilcoxon signed-rank test was conducted between the slope values for the self to other direction for both explicit-self and implicit-self conditions. In the implicit-self condition, the self was not explicitly judged. The memorized-face was morphed with self-face and participants judged if the presented face was the memorized face or the non-target/non-memorized face. This was performed without any explicit knowledge that the non-target/non-memorized face is participant's own face. It thus served the purpose of testing directly whether self-representation differs when labelled explicitly or implicitly and if there is a difference in response pattern depending on the task instructions.

In line with prediction 1, this test showed a significant difference between the slope of self-face recognition response curves of the explicit-self and implicit-self conditions (Ws = 46, z = -4.2, $p < .001$, r = .73) however with higher mean rank of slope for explicit self-face compared to implicit self-face recognition (See Fig. 3.3).

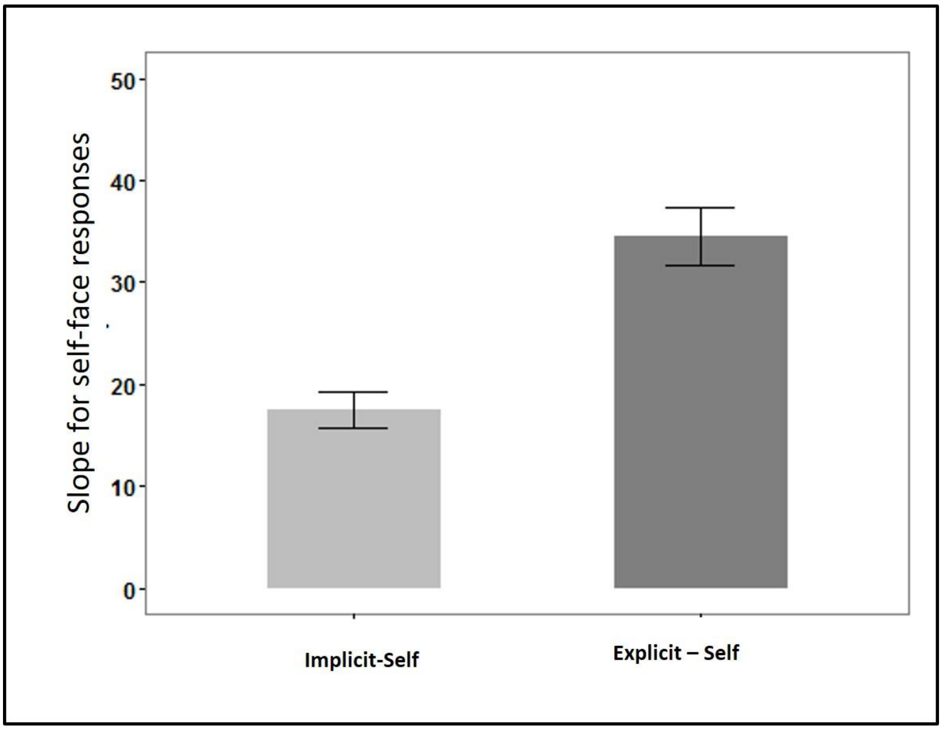

Fig. 3.3 Graph representing slope for self-recognition in explicit-self condition and implicit-self condition (responses calculated from the self-face to the memorized face end). In the explicit condition, self-face was explicitly labelled from morphs of self and unfamiliar other. In the implicit condition, the self was labelled as non-target/non-memorized face without any explicit instruction or knowledge that self-face was morphed into the memorized face. Results show a significantly steeper slope for self-recognition in the explicit condition compared to the implicit condition. The graph includes within-subject error bars of 1 SE (Cousineau, 2005).

3.5.2 Does slope of the recognition response curves for newly memorized face differ between Implicit-self and non-self conditions?

In both implicit-self and non-self conditions, participants memorized a previously unfamiliar face and judged from a morphing continuum if the presented face was the 'memorized face' or non-target/non-memorized face. The memorized face was morphed with a highly familiar 'self-face' (serving as the non-target face) for the implicit-self condition and an unfamiliar face for the non-self condition. In line with prediction 2, a Wilcoxon signed-rank test revealed a significantly lower slope for memorized faces for implicit-self condition compared to non-self condition (Ws = 120, z = -2.72, *p* = .007, r = .47; See Fig. 3.4).

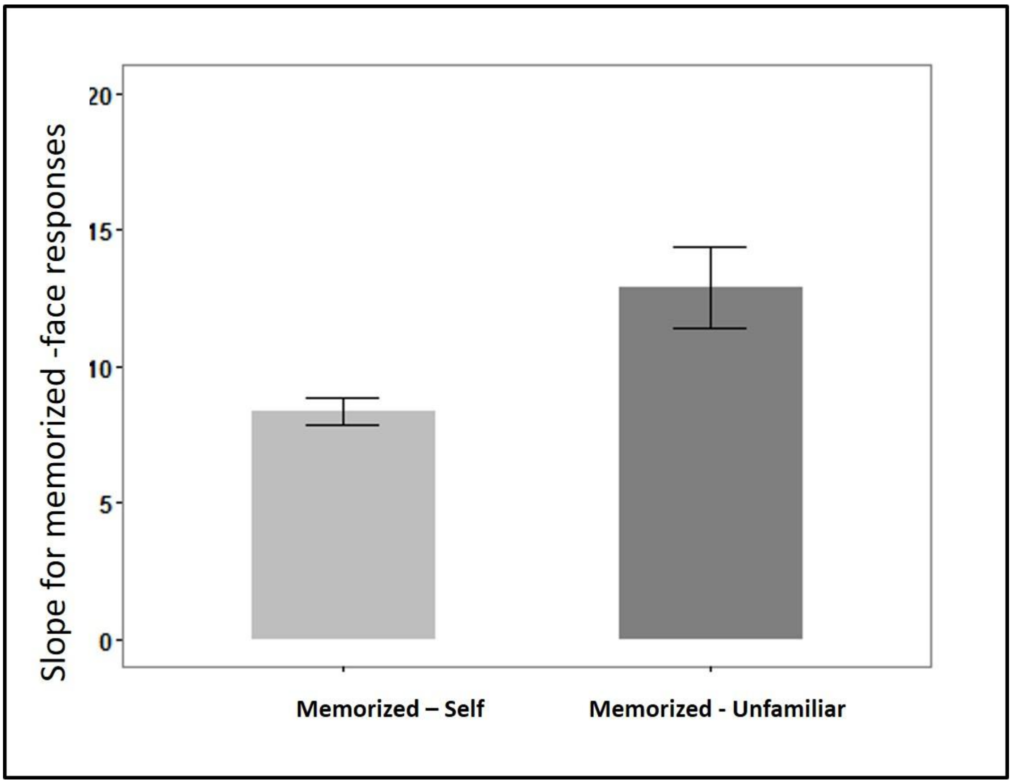

Fig. 3.4 Graph representing slope for memorized face recognition in implicit-self and non-self conditions. Results indicate significantly steeper slope for recognition of memorized face when morphed with the unfamiliar face (labelled memorized-unfamiliar) compared to when morphed with the familiar self-face (labelled memorized-self, responses calculated from the memorized face to self-face end in implicit self-condition). The graph includes within-subject error bars of 1 SE.

3.5.3 Does slope variable differ between explicit-self and non-self conditions?

In explicit-self and non-self conditions, labelling was performed between a familiar face (explicit 1 – self-face; non-self – memorized-face) and an unfamiliar face. In line with prediction 3, a Wilcoxon signed-rank test revealed significantly higher slope for explicit-self condition compared to the non-self condition (Ws = 124, z = -2.54, p = .01, r = .44) (See Fig. 3.5).

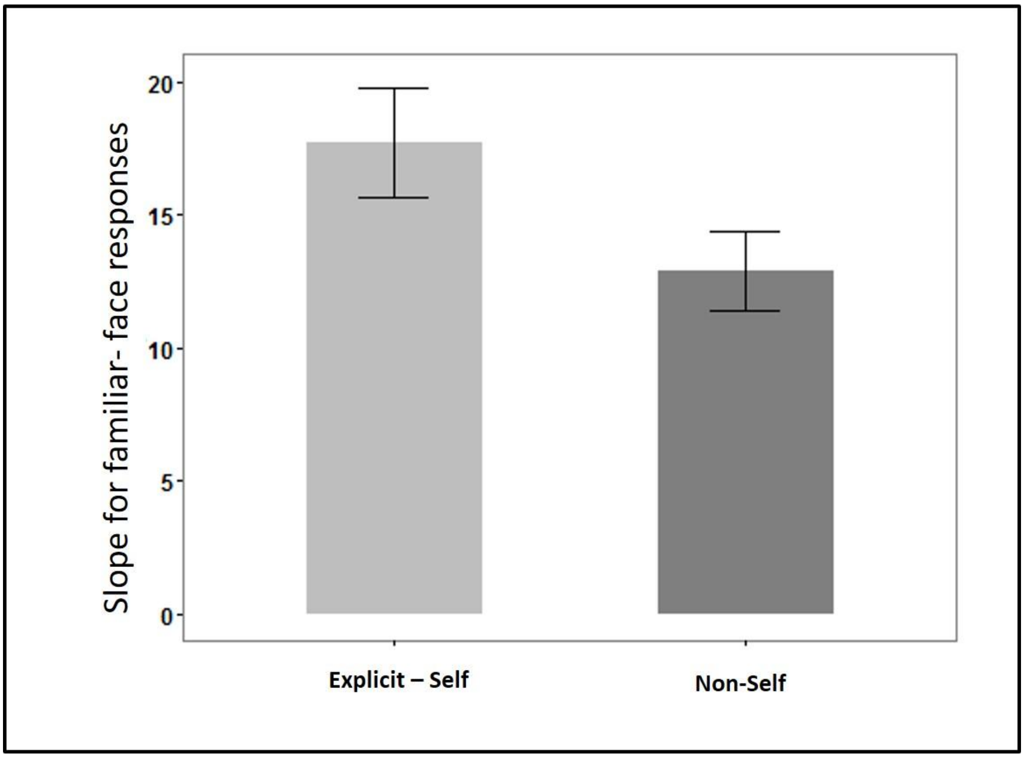

Fig. 3.5 Graph representing slope for recognition of self-face in explicit-self and memorized-face for non-self conditions respectively. Results indicate significantly steeper slope for explicit self-face recognition compared to explicit recognition of a memorized (newly learned) face when both are morphed with an unfamiliar face. The graph includes within-subject error bars of 1 SE (Cousineau, 2005).

Summary of results:

1. Behavioural self-face representation differed between explicit-self and implicit-self condition. Explicit self-face processing resulted in a more distinct self-face representation compared to implicit self-face processing (See Fig. 3.6).
2. Behavioural representation of a newly learned/memorized face differed when it was morphed with the highly familiar self-face (implicit-self condition) compared to an unfamiliar face (non-self condition). Behavioural representation of the newly learned/memorized face was more distinct when morphed with an unfamiliar face compared to the self-face (See Fig. 3.6).
3. Behavioural representation of a familiar face (Self-face vs. newly learned face) differed between each other. Self-face representation was more distinct compared to the representation of the newly-learned face when both were morphed with an unfamiliar face (See Fig. 3.6).

Fig. 3.6 Schematic representation of the main findings from the study

3.6 Discussion

This study investigated task-specific (explicit and implicit) response patterns in recognition of self-face. Recognition responses for self-face were studied using a self-other morphing paradigm which allowed experimental manipulation of the degree of self-face resemblance. For the explicit-self condition, participants labelled a face as 'self' or 'other' from a self-unfamiliar morphing continuum. For the implicit-self condition, participants labelled the 'self-face' as the 'non-target' (non-memorized face) from a memorized-face-self-face morphing continuum. For the implicit-self condition, participants were not aware of the presence of self-face related information in the presented morphs and hence no overt appraisal of self-face was expected. The slope of the recognition response curve gave an estimate of the distinctness of self-face representation in the explicit and implicit conditions.

The results show that the slope of the self-recognition response curve for explicit self-processing was steeper compared to self-recognition response curve when self-face was labelled as the non-memorized face. One possible interpretation of this result is that there is a more distinct self-face representation when processed on an explicit level compared to a background automatic self-face processing. Individuals showed a narrow self-face representation with self to other category change at a higher percentage of self-related information(Fazio et al., 1995; Greenwald et al., 1998).

Participants (without any explicit instruction or labelling of self-face) showed increased bias for labelling self-face when morphed with familiar faces (Keenan et al., 2000). The Similar direction of this bias was observed in the current study. In the current study, it was observed that participants showed a more distinct self-face representation when judging self-faces explicitly whereas the distinction was less in the implicit condition indicating participants showed a greater bias to label a morphed as self implicitly when it was morphed with a familiar, in this case newly memorized, face. The result is in line with evidence that at the behavioural level how self-face is processed can influence self-face representation (Sugiura et al., 2000).

One limitation of the current study is that the conditions - explicit-self and implicit-self varied in identities with which the self-face was morphed. The difference in identities can exert different self-face-other-face overlap behaviourally. The current study did not compare the results for self-face representation with the representation of other highly familiar face. However, previous studies have demonstrated that self-face is processed differently compared to other familiar faces (Keenan et al., 1999; Klatzky & Forrest, 1984; Tong & Nakayama, 1999; Valentine & Bruce, 1986) and it can be argued that the result observed in the current study is self-face specific. Additionally, with any implicit self-processing task design it is possible that there was an explicit recall of self-referential information (Rameson et al., 2010); one can only comment that there was a relatively less explicit recall due to no prior knowledge of the presence of self in the implicit- condition.

The current study also investigated if the representation of a newly memorized face was influenced by background information that varied in levels of familiarity. In the implicit-self condition, the background face was the highly familiar self-face whereas in the non-self condition the background face was unfamiliar. The results from the current study suggest that the familiarity of the background face influenced the representation of a newly memorized face. A more distinct representation for the memorized face is observed when the background face is an unfamiliar one compared to the highly familiar self-face.

Familiar faces have been found to be categorized differently depending on the direction of the morphs (Rotshtein, Henson, Treves, Driver, & Dolan, 2005). Faces are perceived as categories (Beale & Keil, 1995), and it is likely that differences in familiarity change these category boundaries in a way that influences the recognition task. Since in the implicit-self condition the self-face and the newly learned/memorized face were both familiar, participants had higher levels of self-other overlap resulting in less distinct representation. Categorical perception of faces has been demonstrated between familiar and newly learned faces (Beale & Keil, 1995; Kircher et al., 2001). Furthermore, processing differences exist between over learned faces and other categories of faces with faster recognition of highly familiar faces. The face processing units process visual features faster for familiar faces resulting in faster reaction times in identification tasks (Bruce & Young, 1986). Differences in processing of the background face (highly familiar self-face) and the unfamiliar face are believed to influence the behavioural representation of the newly memorized face observed here.

Comparing representation of two familiar faces, i.e. self in explicit and memorized in non-self conditions, it was observed that degrees of familiarity of the target face itself influenced representation. In both the explicit-self and non-self conditions, the background morphed face was unfamiliar. The representation of self-face, when appraised explicitly, was significantly more distinct compared to the representation of the newly memorized face. This result confirms that the familiarity of the target face in a morphing continuum influences the representation of faces when judged from a morphing continuum.

Findings from this study have a bearing on psychopathological disorders as negative implicit self-evaluation is often linked to depression, bulimia and anxiety (Egenolf et al., 2013; Franck, De Raedt, & De Houwer, 2007; Orth, Robins, & Meier, 2009). Implicit processing of the physical self as implemented in the current paradigm should be studied in relation to traits that measure negative self-esteem, mood and anxiety levels. This may provide insight as to how implicit beliefs about the physical self are related to personality traits.

3.7 Conclusion

The current study observed differences in behavioural representation of self-face between explicit and implicit self-face processing. A narrower self-representation, as evident from more distinct self-representation, was observed for explicit processing of self-face compared to implicit processing of self-face. Furthermore, the behavioural representation of a newly familiar face varied with the familiarity of the face with which it was morphed. The representation of the memorized face was more distinct when morphed with an unfamiliar face compared to the highly familiar self-face. Finally, it was observed that face representation was not only influenced by the familiarity of the non-target face but the familiarity of the target face itself. When explicitly processed, highly familiar self-face showed more distinct representation compared to a newly learned face. This study demonstrates task-specificity, as well as familiarity with facial identities influence, face representation generally, including representation of self-face. Following the studies on the behavioural representation of physical self, the next chapter describes a study investigating visual processing strategies involved in physical self-recognition using eye tracking methodologies and how these visual strategies are associated with the behavioural representation of physical self.

4. Visual processing strategies in physical self-representation: Evidence from eye tracking

This chapter describes a study investigating eye gaze strategies in the recognition of self-other face morphs. The chapter briefly reviews eye gaze patterns used to identify and categorize familiar and unfamiliar faces. The relationship between ASD and atypical face processing is also discussed. The chapter then describes the investigation of eye gaze processing of faces identified as ‘self’ and ‘other’ from self-other face morphs. The results of the relationship between the viewing strategies and the behavioural representation of the self-face are also presented. Finally, the relationship between autistic traits and self-other face viewing strategy is discussed. The results of the current chapter shade light into the visual processing strategies specifically for the highly familiar and salient self-face. The chapter also discusses the relationship of visual processing of self-face with the behavioural representation of the self-face and the influence of autistic traits on visual processing of self-other face morphs.

4.1 Introduction

Self-awareness is proposed to be one of the highest manifestations of human cognition. Self-awareness is theorized to be a prerequisite for understanding mental states of 'self' and 'others' (Gallup, 1970; Keenan, Ganis, Freund, & Pascual-Leone, 2000) and visual self-recognition is considered to be a marker of a higher-order of self-awareness. Self-face viewing is associated with greater attention to and faster recall of the self-face compared to other faces (Devue, Van der Stigchel, Brédart, & Theeuwes, 2009; Tong & Nakayama, 1999). Identification of self-face requires orientation towards the self from a decentralized position and indicates high salience for self-related stimuli (Heinisch, Dinse, Tegenthoff, Juckel, & Brüne, 2011). The self-related salience is observed as increased positive component (P300-a measure indexing attention allocation) to self-name (Gray, Ambady, Lowenthal, & Deldin, 2004). In regards to self-related stimuli (like self-face and self-name), the salience is relational and is specific to the individual. In other words, in comparison to an unfamiliar face, the salience of the self-face will be higher as it is personally significant. This relational salience is distinct from salience associated with low-level visual features of the presented stimulus which are similar across individuals. The relational salience of a face varies with the degree of familiarity, e.g., self-face has high relational salience, resulting in immediate attention orientation to the self-face. The salience of self-face was observed in a study investigating effects of self-face on the processing of temporally presented primes (Pannese & Hirsch, 2011). Presentation of self-face resulted in increased attention to the particular spatial location, leading to increased processing speed for temporally adjacent stimuli of subliminal facial primes. The presence of self-face is shown to interfere with cognitive tasks (Brédart, Delchambre, & Laureys, 2006) where the presentation of self-face resulted in increased attention to the self-face thus interfering with task performance. Additionally, it was observed that self-face was identified faster among other faces even where faces were presented in non-upright conditions (Tong & Nakayama, 1999). Alternatively, participants in another study did not find the self-face with faster reaction times (Devue et al., 2009). However once found, self-face was difficult to disengage from and interfered with task performance. The study concluded that self-face facilitates sustained attention (social maintenance) similar to that observed for other rewarding social stimuli rather than 'social seeking' and may possess higher reward value.

Most studies investigating physical self-representation have focussed on the investigation of the behavioural and neural basis of self-face recognition (See Section 1.2.1). Relatively little is known about visual processing strategies and gaze behaviour employed when recognizing a face as 'self'. In the research area of physical self-awareness, this is particularly relevant as it allows addressing some yet unanswered questions: is gaze response pattern for a face recognized as 'self' different from one recognized as 'other'? If so is the difference driven by a self-specific gaze strategy or is it more in line with gaze response for a familiar face? Indeed the nature of 'self' as a special case or a template of a highly familiar 'other' is often discussed in current psychology and neuroscience literature (Gillihan & Farah, 2005). The study of eye gaze behaviour in self-face recognition allows for better understanding of bottom-up visual sensory processes that bring about self-awareness. It also answers the issue of whether there are indeed distinctions between self-face recognition from recognition of other faces.

Different gaze strategies are employed to discriminate between familiar and unfamiliar faces (Van Belle, Ramon, Lefèvre, & Rossion, 2010). Viewing strategies for an unfamiliar face involve more sampling from all regions of the face (Heisz & Shore, 2008). However, with an increase in familiarity, the gaze fixates more frequently in the eye region. However, increased sampling and exploration of local features were observed for familiar faces compared to unfamiliar faces (Van Belle et al., 2010). One reason for these seemingly opposite findings could be the possible nature of the task, i.e. recall vs. recognition. The first study showed less overall sampling and more eye-region sampling for familiar faces on a recall task. The second study observed that features of a familiar face were sampled more extensively from all areas of the face in a recognition task. The current study used a recognition task to investigate gaze response pattern for both 'self' and 'other' faces. Results from the current study can add additional evidence for differences in facial feature sampling for familiar and unfamiliar faces by confirming if the highly familiar self-face results in increased feature sampling from different regions of the face in a recognition task.

Numerous studies have shown that considering all facial features, eyes are the most attended and provide rich sources of information for identification of a face. This has been consistently observed across different tasks involving face perception (Henderson, Williams, & Falk, 2005;Itier, Alain, Sedore, & McIntosh, 2007;Janik, Wellens, Goldberg, & Dell'Osso, 1978;Laughery, Alexander, & Lane, 1971;Luria & Strauss, 2013;Schyns, Bonnar, & Gosselin, 2002). However, viewing of familiar faces is associated with both increased feature sampling from upper parts of the face including the eye region and lower parts of the face including the mouth region. Considering that the self-face is a highly familiar face, the first aim of this study was to investigate if gaze duration for upper parts of the face (including eye region) and for lower parts of the face (including mouth) differed between faces identified as the familiar self-face and the unfamiliar other face. ‘The two regions of interest were chosen to allow for computing the proportion of gaze duration to regions shown to be relevant in both face identification and in distinguishing between familiar and unfamiliar faces.

To study the first aim, a morphing paradigm was adapted where self-face was morphed with unfamiliar faces in a systematic manner. The present morphing paradigm also allowed studying the behavioural representation of self-face. Using a morphing paradigm previous reports have shown that gaze cueing effect was stronger for faces morphed with the self-face compared to unfamiliar faces (Hungr & Hunt, 2012). The results were interpreted as different processing strategies for self-similar versus dissimilar faces. However, this proposed difference in visual processing strategies of self and unfamiliar faces have not been linked to the behavioural representation of self and unfamiliar faces. At the neural level, one study exploring the association between gaze scanning strategies and hemodynamic responses when viewing self and unfamiliar face did not observe any association (Kita et al., 2010). The study observed increased hemodynamic activity in response to self-face viewing in the right IFG, however, gaze scanning strategy for self and unfamiliar faces were found to be similar. The authors concluded that visual information processing of self and unfamiliar faces do not predict neural processing of these faces. However, there is at current no study that has investigated how a distinct self-face representation at the behavioural level can be explained by gaze data for self-other face morphs. The second aim of the study was to investigate the association between individual differences in self-face representation at the behavioural level and gaze duration to faces identified as 'self' versus 'other'.

Due to reports of atypical gaze fixation to social stimuli (Klin, Jones, Schultz, Volkmar, & Cohen, 2002) and atypical self-processing in ASD (Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007;Lombardo, Chakrabarti, & Baron-Cohen, 2009;Lombardo et al., 2010;Uddin et al., 2008), the current study also investigated the association between autistic traits and gaze duration to self and other faces. Atypical gaze to faces is a well-documented feature in ASD and is believed to be one of the underlying causes of the social deficits observed in individuals with ASD. In particular, there are accounts of reduced fixation to the eye regions of the face in ASD (Dalton et al., 2005; Klin et al., 2002; Pelphrey et al., 2002). Eye-regions are used to extract socially relevant information about emotion and mental states of others and reduced attention to the eye regions may account for social deficits observed in ASD. However, it is also reported that there is reduced orientation to faces as a whole in ASD that may not be specific to eyes (Bird, Catmur, Silani, Frith, & Frith, 2006; Riby & Hancock, 2009). The two regions of interest, one focussing on the upper part of the face and the second focusing on lower parts of the face, thus also allow for computing proportion of gaze duration to 'self' and 'other' faces in feature specific manner. The current study investigated if there is an association between autistic traits and gaze duration to faces in general or if there is an association that is specific to facial identity and/or facial region.

The third aim of the current study was to explore associations between gaze duration to faces identified as 'self' or 'other' and autistic traits. It was predicted that autistic traits will correlate negatively with gaze duration to the upper portion of the face. This negative association between autistic traits and gaze duration to eye-region was predicted to be stronger for faces identified as 'other' compared to those identified as 'self'. The social motivation theory of ASD posits that reduced fixation and sampling of eye regions is driven by lower reward value associated with social stimuli like faces in individuals with ASD (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012). The reduced value may result in diminished social motivation to attend to social stimuli in ASD individuals (Dalton et al., 2005; Pelphrey et al., 2002). It is thus expected that the association of autistic traits with reduced gaze duration to eye region will be less severe for faces identified as 'self' due to the possibly rewarding nature of self-face (Devue et al., 2009).

4.2 Aims

The primary aim of the study was to investigate differences in the proportion of gaze duration to the upper and lower parts of faces identified as ‘self’ and ‘other’. The second aim of the study was to investigate individual differences in the association between gaze patterns for ‘self-face’ with self-face representation as measured using behavioural self-face recognition task. The third aim of the study was to investigate if gaze duration to the eye region of a face was associated with autistic traits and if the association was different when identifying a face as ‘self’ or when identifying it as ‘other’.

4.3 Predictions

The following predictions were made for this study:

1. Gaze duration to different parts of the face, for faces identified as ‘self’ and ‘other’, will be significantly different. It is predicted that this difference will be due to increased viewing of different facial features for faces participants identify as ‘self’ compared to ‘other’. Hence, the gaze duration to the lower parts of the face will be longer for a face identified as ‘self’ compared to ‘other’. This would be consistent with increased feature sampling different regions of the face for familiar faces compared to unfamiliar faces (van Veluw & Chance, 2014).
2. At the behavioural level, self-face representation as measured using self-face recognition is predicted to be positively associated with the proportion of gaze duration to upper parts of the morphed faces identified as ‘self’. This association is not predicted for faces identified as ‘other’. Individuals who spend more time extracting information from the eyes for faces identified as ‘self’ are predicted to have a more distinct self-face representation as measured by the slope of self-face recognition. They are expected to perform less local feature sampling of the mouth or other surrounding regions.
3. It was predicted that autistic traits will correlate negatively with gaze duration to the upper parts of the face. This negative association between autistic traits and eye

gaze to upper parts of the face is predicted to be stronger for faces identified as 'other' compared to those identified as 'self'. The social motivation theory of ASD posits that reduced fixation to eye region is driven by reduced reward values associated with social stimuli in ASD (Chevallier et al., 2012) with an increased preference for geometrical images compared with social images observed in children with ASD (Pierce, Conant, Hazin, Stoner, & Desmond, 2011; Pierce et al., 2016). As a result of the reduced reward value, attention allocation to social stimuli is not prioritized (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012; Sepeta et al., 2012). If this theory holds true it can be expected that the association between higher autistic traits with reduced gaze to eye regions to be less severe for faces identified as 'self'. This is predicted because self-face can be argued to be of higher reward value (Devue et al., 2009).

4.4 Methods

4.4.1 Participants

Thirty-three white Caucasian participants completed the current study (5 males; mean ± SD age = 20.67 ± 3.69 years). Ethical approval for the study was obtained from the Department of Psychology Research Ethics Committee of the University of Reading (reference no: 2012/117BC). All participants provided written informed consent. All participants were right-handed and had normal or corrected to normal vision. From the thirty-three participants, four participants were removed for correlation analysis of self-face recognition slope and gaze data due to the poor goodness of fit of the slope parameter (See section 4.5.2).

4.4.2 Stimulus Preparation

Stimuli were individually tailored for each participant. Each participant was photographed (Canon Power Shot SX700 HS digital camera) looking directly at the camera and holding a neutral expression. Participants were seated at a distance of 100 cm, under constant artificial lighting and with a white background. One unfamiliar 'other' identity for each gender and from the same race and age range was also photographed under these conditions. One unfamiliar identity was used instead of two as previous data showed no significant difference in response pattern for ‘self-other’ identification between morphing continua generated using two different unfamiliar identities (See Section 2.2.3).

Following this, each participant’s photograph was pre-processed and morphed using the same materials and in a similar process as described in Chapter 2 (See section 2.2.3*).* The following step sizes were used to create the morphing continuum from 100% 0% participant’s face (100, 90, 80, 70, 65, 60, 55, 50, 45, 40, 35, 30, 20, 10, and 0). Since the previous data showed that individual differences in self-other face category boundary lie within the morph range of 60 and 30 morph percentages for the self-face recognition task (See Table 2.1), the morph percentages were at 10% step sizes between 100 and 70 and 30 and 0 and 5% step sizes between 70 and 30.

Calibration and task presentation were controlled using E-prime 2.0 (Psychology Software Tools, PA, USA) on a Tobii T60 eye tracker. The stimuli were presented with a refresh rate of 60 Hz and resolution of 1024 × 768 pixels. Participants sat in chairs 50 cm from the monitor. They used a keyboard for their responses to the task. (See Fig. 4.1).

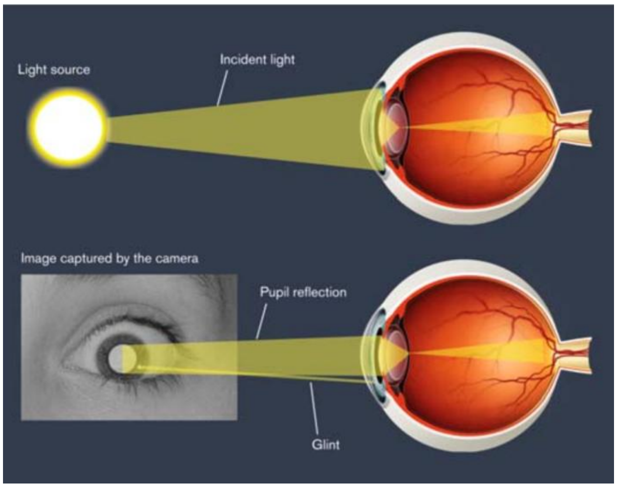

Fig. 4.1 Pictorial representation of the projected light source of Tobii T60 eye tracker and the light reflected off the pupil recorded by the cameras in the eye tracker. A near infrared light source from the tracker illuminates the eyes and the eye-tracker uses Pupil Centre Corneal Reflection to track eye movements with the cameras capturing the light reflected off the pupil and the cornea. 'Glint' in the figure refers to the corneal reflection and the angle between the glint and the pupillary reflection is used to calculate the gaze position with additional modelling of other physiological features of the eye. The above figure was taken from the tutorial for use of Tobii eye-tracker athttp://www.measuringbehavior.org/files/tutorials/Tobii_MB2010_tutorial_handouts.pdf

4.4.3 Task design

Before commencing the task, participants underwent a five-point calibration procedure. Participants were instructed to attend to and follow the travel path of a moving red circle. Following this, recorded eye positions with green lines representing saccades within and outside the perimeter of each of the five locations of the red circle were presented on screen. Calibrations were repeated if the saccades within the perimeter of the red circle for any of the locations were absent. Additionally, calibrations were repeated if the saccades were erratic or deviated exceedingly beyond the perimeter. Two regions of interest were pre-positioned over each morphed face for each individual participant. Region of interest 1 (*UPPER ROI*) was positioned to cover the upper portion of the face including the eyes. Region of interest 2 (*LOWER ROI*) was positioned to cover the lower portion of the face including the mouth. Gaze within these regions was recorded during this task (See Fig. 4.2).

Next, participants completed a self-face recognition task following a similar task design as detailed in Chapter 2 (See section 2.2.3*).* Each trial started with a 500 millisecond (ms) fixation cross followed by the stimulus for a duration of 500ms followed by a 1000ms blank screen (See Fig. 4.2). Participants were instructed to judge and identify a presented face as either 'self' or 'other'. There were two runs, one for a right handed and the other for a left-handed 'self' recognition response. Participants were asked to respond with the right or left hand in each run. Each run consisted of 15 distinct morphs presented ten times each, resulting in 150 trials per run. Any keyboard response in the 1500 ms window was recorded. All participants completed the AQ questionnaire online following the completion of the task.

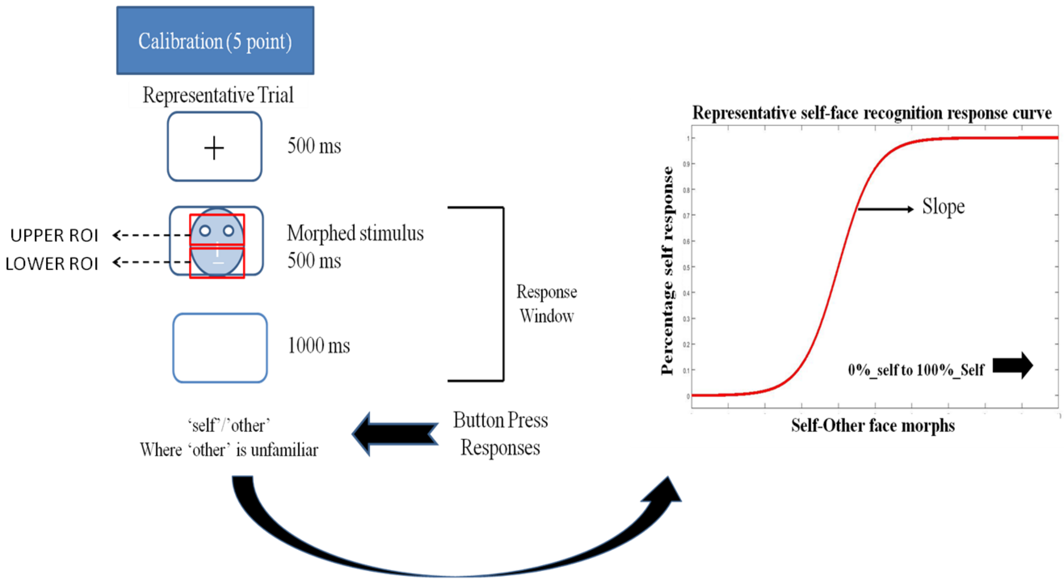

Fig. 4.2 Schematic representation of a trial in the eye tracking task. Participant's eye movements and gaze pattern were recorded during the 500ms stimulus presentation window and the behavioural response was recorded in the 500 +1000ms window. Participants pressed the 'a' key for identifying a face as 'self' and 'l' key for identifying a face as 'other' in the self left-hand response. These key responses were reversed for the self-right hand response. The schema also shows a representative self-face recognition response curve calculated from the 'self'/'other' face recognition data.

4.4.4 Data Analysis

Statistical tests and plots were generated using SPSS and R software using ggplot2 (Wickham, 2009) package.

Slope calculation for self-other recognition: 'Self' and 'other' responses for both runs were combined for each morph level to generate percentage response curves for self-face recognition response for each participant. The slope of the response curve was generated using the same procedure as described in Chapter 2 (see section *2.2.3.4)*.

Gaze duration analysis: gaze position as well as the regions of interest where gaze was on, was recorded using E-prime for each time stamp. Gaze position was determined by averaging the locations of both eyes. In the absence of one eye position during the time stamp, the eye position for the single recorded eye was used. The data were processed using MATLAB. The following criteria were used to identify fixations to be included in the analysis:

- Three successive time stamps within 35 pixels of the original time stamp. Each time stamp is approximately 16.6ms long, hence for a fixation to be included the eye position needed to be within the region of interest for a minimum of 50ms.
- If gaze was outside the range for one time stamp (possibly due to blinking) or was not recorded but the following time stamp was inside the range, the fixation was considered legitimate.

Following the gaze position analysis, the average gaze duration to ***UPPER ROI*** was calculated for each participant for all trials that the participant identified as 'self-face' (*Average_upper_duration_self*) and 'other-face' (*Average_upper_duration_other*). Similarly, the average gaze duration to ***LOWER ROI*** was calculated for each participant for all trial identified as 'self-face' (*Average_lower_duration_self*) and 'other-face' (*Average_lower_duration_other*).

Next, the proportion of gaze duration to *UPPER ROI* (*Upper_proportion_self*) was calculated for each participant for all trials identified as 'self-face' by dividing Average_upper_duration_self by the sum of Average_upper_duration_self and Average_lower_duration_self (See Box 4.1). Similarly, the proportion of gaze duration to *UPPER ROI* (*Upper_proportion_other*) was calculated for each participant for all trials identified as 'other-face' by dividing Average_upper_duration_other by the sum of Average_upper_duration_other and Average_lower_duration_other (See Box 4.1). The denominators in both instances were chosen to control for individual differences in total looking time to the different ROIs.

Upper_proportion_self:

Average_upper_duration_self/(Average_upper_duration_self + Average_lower_duration_self)

Upper_proportion_other:

Average_upper_duration_other/ (Average_upper_duration_other + Average_lower_duration_other)

Box 4.1 Formulae used to calculate metrics for gaze duration to *UPPER ROI* and *LOWER ROI* controlling for total gaze duration to both the ROI-s for all faces identified as 'self' and 'other' at the individual participant level.

Variables	Mean (SD)	Shapiro-Wilk Statistics
Upper_proportion_self	0.84(0.2)	$W = .8$, $p < .001^*$
Upper_proportion_other	0.86(0.2)	$W = .75$, $p < .001^*$
Slope of self-face recognition	14.9(7.2)	$W = .9$, $p = .002^*$
Average_upper_duration_self (ms)	282.47(93.3)	$W = .96$, $p = .3$
Average_upper_duration_other (ms)	286.88(91.2)	$W = .94$, $p = .05$
Average_lower_duration_self (ms)	47.88(52.8)	$W = .83$, $p < .001^*$
Average_lower_duration_other (ms)	40.28(43.3)	$W = .83$, $p < .001^*$
AQ	16.4 (6.34)	$W = .83$, $p = .83$

Table 4.1 Mean and SD for the computed variables. As shown above, multiple variables violated the assumption of normality. Statistical tests were chosen accordingly. In line with directional nature of the hypothesis, all tests were one-tailed unless specified otherwise.

Main effects analysis:

To investigate the difference in gaze duration to the upper parts of the face, for faces identified as 'self' and 'other' a related sample Wilcoxon signed-rank test was computed between Upper_proportion_self and Upper_proportion_other.

Individual differences analysis:

To investigate individual differences in the association between the slope of the self-recognition curve and gaze duration, Kendall rank correlations were computed between the slope of the self-face recognition response curve and a) the Upper_proportion_self and b) Upper_proportion_other.

To investigate individual differences in the association between AQ scores and eye gaze duration, Kendall rank correlations were computed between AQ and a) Upper_proportion_self and b) Upper_proportion_other.

4.5 Results

4.5.1Does gaze duration to the upper portion of the face differ between images identified as 'self' and 'other'?

There was a significantly greater proportion of gaze duration to *UPPER ROI* for morphed faces identified as 'other' compared to morphed faces identified as 'self' (Z= -2.385, *p* =.02,r = .42; See Fig. 4.3). This conversely illustrates the greater proportion of gaze duration to LOWER ROI for morphed faces identified as 'self' compared to morphed faces identified as 'other'.

It should be noted that the Average_upper_duration_self (Mean = 282.47; SD = 93.28) and Average_upper_duration_other (Mean = 286.88, SD = 91.19) did not differ significantly from each other. This indicates that while there was more gaze to *UPPER ROI* for faces identified as 'other' compared to faces identified as 'self', this gaze duration was not significantly different between the two categories (t (1, 32) = -1.36, *p* = .18, *d*: -.04). However, Average_lower_duration_self (Mean = 47.88, SD = 52.7) was significantly higher compared to Average_lower_duration_other (Mean = 40.3, SD = 43.3). This indicates there was longer gaze duration to *LOWER ROI* for faces identified as 'self' compared to 'other' (t (1, 32) = 3, *p* = 0.006, *d* = -.15).

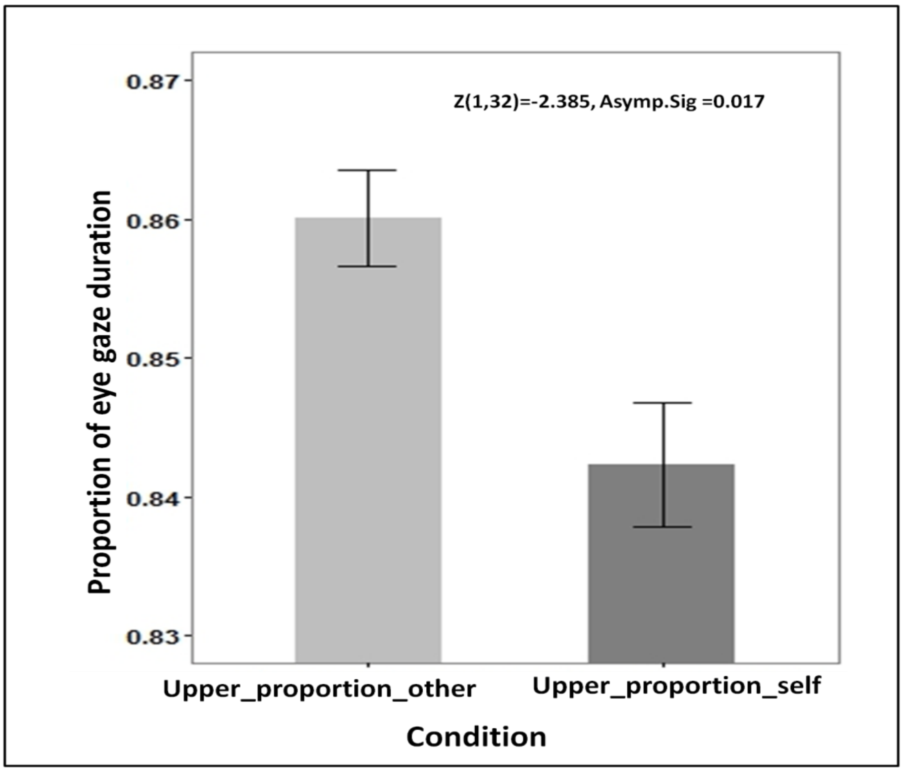

Fig. 4.3 Graph representing the proportion of gaze duration to upper parts of the face including eyes and surrounding region (Upper_proportion self/other) for faces identified as 'self' and 'other'. The graph includes within-subject error bars of 1 SE (Cousineau, 2005).

4.5.2 Is individual difference in behavioural representation of self –face associated with the proportion of gaze to the upper parts of the face for faces identified as 'self' in proportion to faces identified as 'other'?

It was predicted that individuals who have a more distinct self-face representation would gaze longer at the upper parts of faces identified as 'self' in proportion to faces identified as 'other'. One-tailed Kendall rank correlation found a significant positive correlation between the slope of self-face recognition with the ratio of Upper_proportion_self to Upper_proportion_other (τ=.227, *p*=.04, N = 29; See Fig. 4.4).

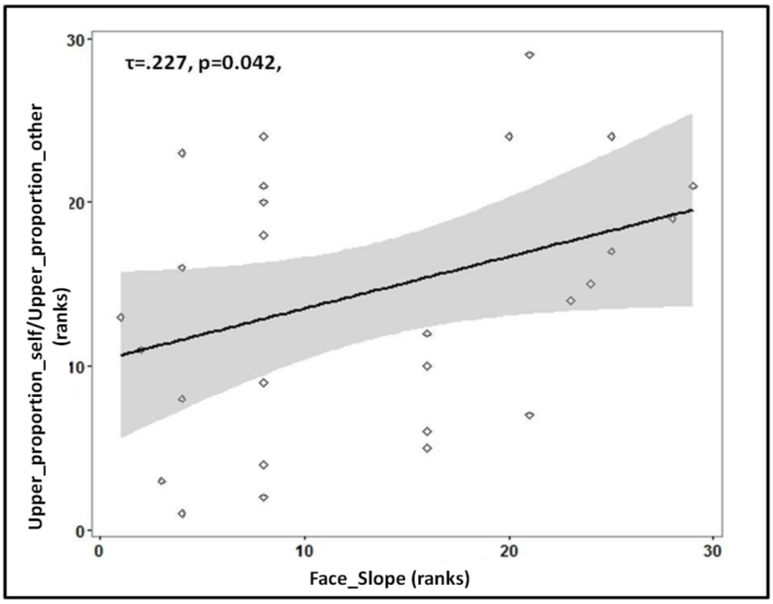

Fig. 4.4 Rank scatterplot representing the positive association between the slope for self-face recognition (x-axis) with the proportion of gaze duration (y-axis) to *UPPER ROI* (ratio_proportion (self: other)) for faces identified as 'self' compared to faces identifies as 'other'. The shaded portion represents the 95% confidence region of the slope of the regression line.

*4.5.3 Are autistic traits associated with the proportion gaze duration to UPPER ROI for faces identified as 'self' (*Upper_proportion _self) and for faces identified as 'other' (Upper_proportion_other)?

One-tailed Kendall rank correlation showed no significant association between autistic traits and proportion of eye gaze duration to *UPPER ROI* for faces identified as 'self' (Upper_proportion_self)(τ=-.008, p=.5, N = 33) or 'other' (Upper_proportion_other)(τ=.015, p=.5, N=33; See Fig. 4.5).

Following previous findings of reduced overall looking time to social stimuli (like faces) in individuals with ASD, further exploratory analysis was carried out to investigate if the overall looking time to faces (inclusive of both regions of interest) was associated with autistic traits. The total gaze duration (for each participant) was calculated for both faces identified as 'self' by summing Average_upper_duration_self and Average_lower_duration_self and for faces identified as 'other' by summing Average_upper_duration_other and Average_lower_duration_other. Two-tailed Kendall rank correlations revealed a significant negative correlation between autistic traits and total looking time for faces identified as 'self' (τ = -.305, p = .01, N = 33) as well as faces identified as 'other' (τ = -.286, p = .02, N = 33) (See Fig. 4.6).

Since the denominators (total looking time) in the ratios (Upper_proportion_self & Upper_proportion_other) were negatively correlated with autistic traits, this might have influenced the overall relation between the proportion of gaze duration and autistic traits. Hence Kendall rank correlations were performed between AQ and the average gaze duration for both ROIs and both face categories. A negative association trend was observed between autistic traits and average gaze duration to *UPPER ROI* for faces identified as 'self' and for faces identified as 'other' (τ =-.197, p=.05, N=33). No such trend was observed between autistic traits and average gaze duration to *LOWER ROI* for both faces identified as 'self' and faces identified as 'other' (τ =-.041, p=.4, N = 33).

Variables	Correlation Result
Upper_proportion_self & AQ	τ=-.008, *p*=.5, N = 33
Upper_proportion_other & AQ	τ=.015, *p*=.5, N=33
Total looking time - self (Average_upper_duration_self + Average_lower_duration_self)	τ = -.305, *p* =.01, N = 33
Total looking time - other (Average_upper_duration_other + Average_lower_duration_other)	τ = -.286, *p* = .02, N = 33
Average_upper_duration_self & AQ	τ =-.197, *p*=.05, N=33
Average_upper_duration_other & AQ	τ =-.197, *p*=.05, N=33
Average_lower_duration_self & AQ	τ =-.041, *p*=.4, N = 33
Average_lower_duration_other_& AQ	τ =-.041, *p*=0.4, N = 33

Table 4.2 Summary table of individual differences in the association between gaze pattern for faces identified as 'self' and 'other' and autistic traits.

In line with previous results (See Section 2.2.4), Kendall rank correlation did not show any significant association between the self-face recognition slope and autistic traits (N=33, τ =-.120, *p*=.2).

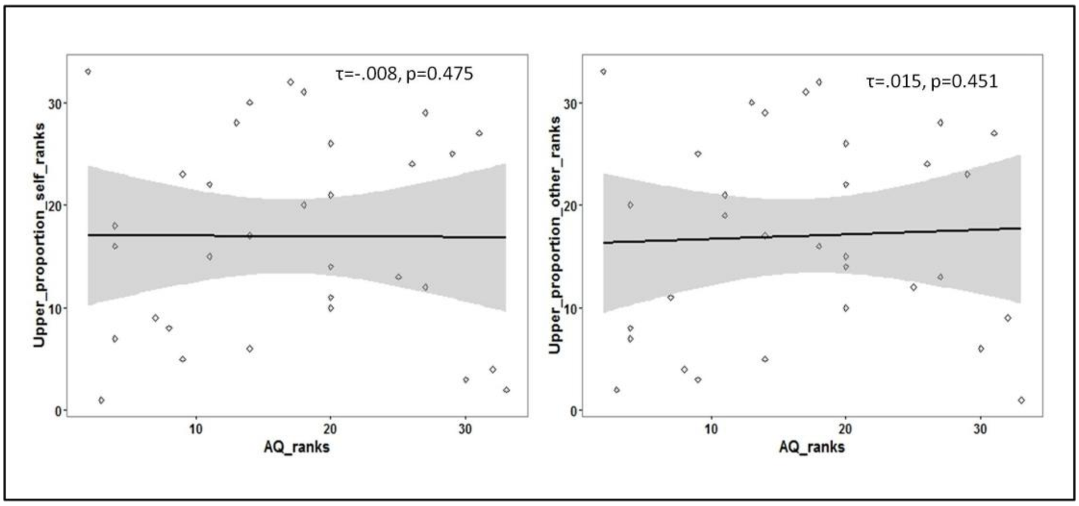

Fig. 4.5 Rank scatterplots representing the association between the AQ scores with the proportion of gaze duration to UPPER ROI (upper parts of the face including eyes and surrounding regions) for faces labelled as 'self' (left) and for faces labelled as 'other' (right). The shaded portion represents the 95% confidence region of the slope of the regression line.

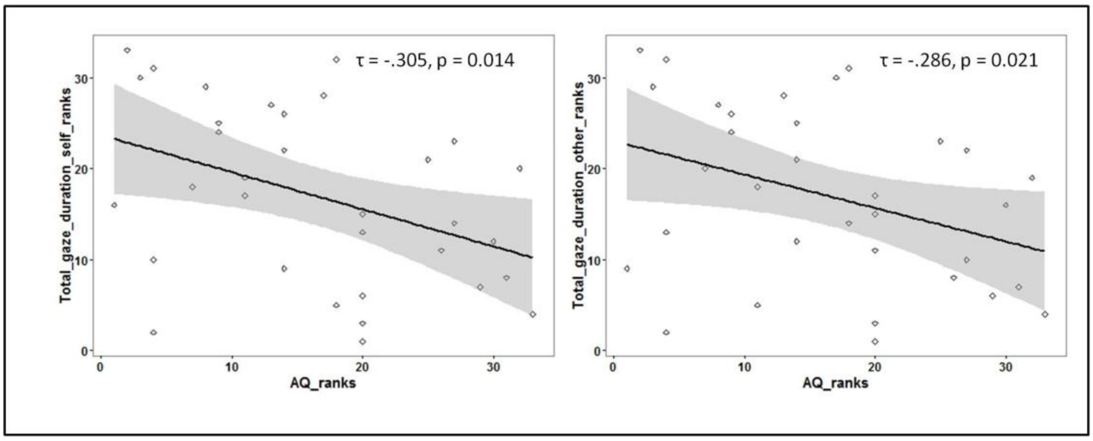

Fig. 4.6 Rank scatterplots representing the negative association between the AQ scores with the total gaze duration for faces identified as 'self' (left) and for faces identified as 'other' (right). The shaded portion represents the 95% confidence region of the slope of the regression line.

4.6 Discussion

The current study investigated differences in gaze pattern for faces identified as 'self' and 'other' from self-other face morphs. The study also investigated the association of these gaze patterns with the behaviour representation of self-face and autistic traits. In line with prediction 1, the study found a significant difference in gaze duration to different parts of a morphed face between faces identified as 'self' and those identified as 'other'. In line with prediction 2, the study found that a more distinct self-face representation behaviourally was associated with increased gaze duration to upper parts of morphed faces identified as 'self' in proportion to gaze duration to upper parts of faces identified as 'other'. Contrary to prediction 3, no significant association was observed between autistic traits and the proportion of gaze duration to upper parts of morphed faces for either face identified as 'self' or for faces identified as 'other'. However, the results found a negative association between autistic traits and total gaze duration to both faces identified as 'self' and as 'other'. The results are discussed in details in the following paragraphs.

Self-face has high relational salience (Brédart, Delchambre, & Laureys, 2006)to the individual and may possess high reward values (Devue et al., 2009). However, there is currently little understanding regarding visual processing strategies employed in self-face recognition. To understand the visual processing strategies employed in processing and recognition of self-face, the study investigated gaze duration to different parts of a face identified as 'self' compared to a face identified as 'other'. A self-other face morphing paradigm was used to test this aim. By studying gaze duration to different parts of self-other morphed faces, the study was also able to answer whether visual processing strategies involved in self-face recognition is similar to that of familiar faces. Using eye gaze monitoring a previous study found familiar faces are processed visually by increased feature sampling from the different parts of the face (Van Belle, Ramon, Lefèvre, & Rossion, 2010). In line with this result, the current study observed that faces identified as 'self' resulted in increased gaze duration to lower parts of the face (*LOWER ROI*) compared to faces identified as 'other'. However, the gaze duration to upper parts of the face (*UPPER ROI*) was not significantly different between the two identities. The increased overall gaze duration to faces labelled as 'self' (and also a report of increased feature sampling of other familiar faces) can be argued as the evidence for self-face (and other highly familiar faces) acting as a salient and rewarding stimulus. Previous work has found that when presented with self-face, individuals maintain sustained attention to the self-face which in turn interferes with task performance indicating high value associated with self-face (Devue et al., 2009).

This study also tested the association between behavioural performance on the self-face recognition task with the visual processing strategies for self and other face recognition. Using the present paradigm, a more distinct self-face representation was associated with increased proportion of gaze duration to the upper parts of morphed faces identified as 'self'. It can be argued that in individuals with a more distinct self-face representation the gaze duration was proportionately higher for upper parts of the self-face including eye regions compared to those with a less distinct self-face representation (or higher self-other overlap). It can be argued that behavioural representation of self-face is associated with visual processing strategies used in self-face recognition

The current study did not compare self-face with non-self familiar faces. Depending on the exposure level, a familiar face may also be of high salience and well represented mentally. Follow-up research should test if distinct behavioural representations of non-self familiar faces are associated with increased gaze duration to upper parts of these faces. Additionally, it needs to be investigated what possible trait features may lead to individual differences in self-face processing that results in a stronger representation of self-face. For example, do individuals who exhibit an exaggerated bias towards self-face exhibit preoccupation with body image?

The study also tested the association of autistic traits with a) self-face recognition and b) eye gaze processing strategies for faces identified as 'self' and 'other'. Replicating previous findings from Chapter 2, no relationship was observed between autistic traits and self-face representation at the behavioural level.

Within the domain of psychological self-representation, studies investigating self-referential cognition in individuals with ASD did not observe the preferential processing of self-related information that is typically observed in neurotypical adults (Lombardo et al., 2007; Toichi et al., 2002). Within the domain of physical self-representation, the current study investigating the association between autistic traits and visual processing strategies involved in self-face recognition did not observe any self-specific association between the two variables. However, for both faces identified as 'self' and 'other' higher autistic trait was negatively correlated to total gaze duration. There was a negative trend between gaze duration to the upper parts of morphed faces and autistic traits, but no relationship was observed between autistic traits and gaze duration to the lower parts of the morphed faces. The association between reduced looking time and autistic traits is in line with previous reports of reduced looking time for social images including faces in ASD individuals (Dalton et al., 2005; Pelphrey et al., 2002). This observation might be because social images possess lower reward value in individuals high in autistic traits resulting in reduced motivation for maintaining sustained attention to social stimuli (Chevallier et al., 2012). A previous study investigating self, familiar, and unfamiliar face viewing using eye tracking did not observe any difference in gaze fixation pattern to different categories of faces between control and ASD children. However, the association was observed between socio-communicative abilities and gaze patterns to self and unfamiliar faces (Gillespie-Smith, Doherty-Sneddon, Hancock, & Riby, 2014). The current study did not observe any self-specific association between gaze duration and autistic traits, however, an association between gaze patterns for both faces identified as self and unfamiliar other with autistic traits was observed indicating that autistic traits and symptoms may influence the gaze patterns to self and unfamiliar faces.

The findings from the current study show that despite reduced looking time to morphed faces, individuals with high autistic traits do not exhibit any association with the behavioural representation of self-face. It is possible that as the current task demands face identity recognition, the stimuli are themselves salient and attention grabbing and individuals with high autistic traits orient to the presented face to perform the task. However, once the face is identified as 'self' or 'other', individuals high in autistic traits no longer continue looking at the face. It could be inferred that the minimum looking time is sufficient to make an informed decision on self-other face categorization. Post-hoc analysis (unfortunately not with sufficient power) revealed there may be an association between reaction time responses to self-face and gaze duration moderated by autistic traits.

Results from the current study show autistic traits have a dissimilar influence on self-other face recognition behaviourally and at the level of visual processing employed in face recognition (See Fig 4.7 for a summary of results). Future work should explore other behavioural measures that can possibly capture the interaction between gaze patterns, autistic traits, and self-face representation.

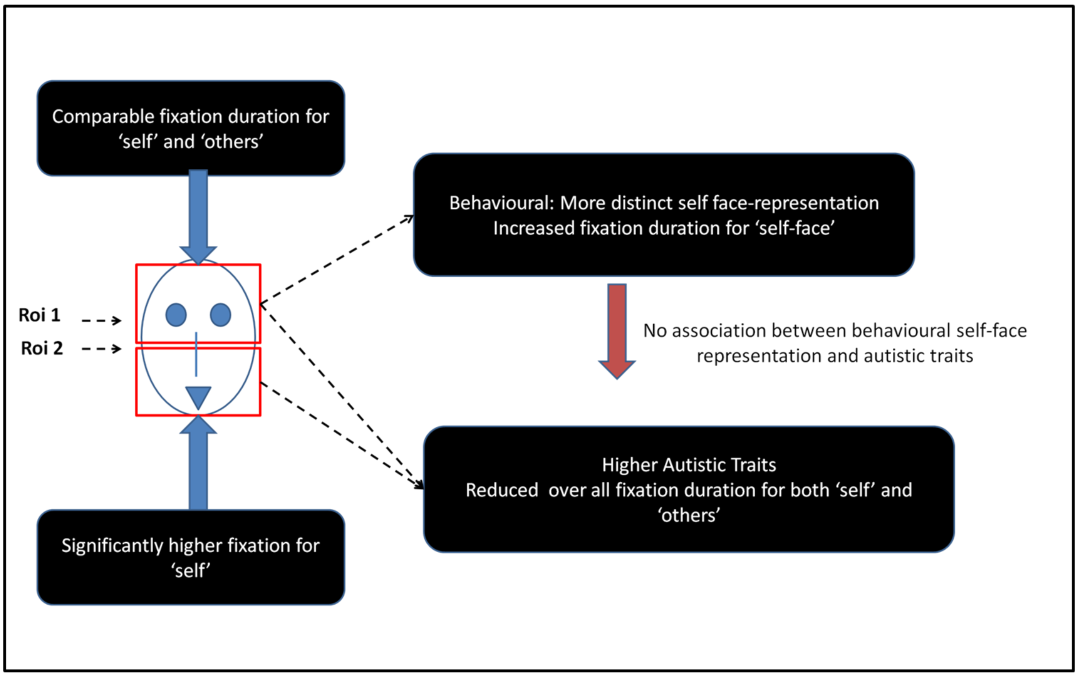

Fig. 4.7 Schematic representation of the main findings from the study.

4.7 Conclusion

Eye gaze behaviour differed between morphed faces identified as 'self' and 'other'. At the group level, gaze duration to lower parts of the face was higher for faces identified as 'self'. At an individual level, higher gaze duration to the upper part of morphed faces labelled as 'self' was associated with a more distinct self-face representation. It can be concluded that self-face viewing results in increased feature sampling from different regions of the face. However, individuals with a more distinct behavioural self-face representation had a higher proportion of gaze duration to the upper parts of faces identified as 'self' compared to individuals with less distinct self-face representation. Individuals with higher autistic traits looked at faces (irrespective of identity and region of interest) for a shorter duration. No relationship was observed between self-face representations at the behavioural level with autistic traits. This indicates that behavioural representation of self-face was not influenced by autistic traits. This study furthers the understanding of the visual processing of self-face and its relation to behavioural self-face representation and autistic traits. Following the studies of behavioural representation (previous chapters) and visual processing (current chapter) of the physical self, the next chapter will outline studies investigating individual differences in psychological self-representation and the association between physical and psychological domains of self-representation.

5. Self-representation across psychological and physical domains

This chapter describes a study investigating psychological self-representation in a sample recruited from the Indian population. It briefly reviews a commonly used depth of processing paradigm (self-reference effect in memory) as a measure of psychological self-representation. The role of self-construal traits and autistic traits in psychological self-representation is discussed. The chapter then outlines an investigation of psychological self-representation and its association to physical self-representation and relevant personality traits.

5.1 Introduction

Previous chapters of this thesis have focussed on the investigation of physical self-representation. There are existing theoretical accounts of association between physical and psychological self-representations (Gallup, 1982; Lewis & Ramsay, 2004; Russell & Hill, 2001) or lack thereof (Gillihan & Farah, 2005; Neisser, 1988; J. H. Williams, Whiten, & Singh, 2004). However, the direct relationship between the two domains has not been mapped to support the theories on the interdependent or the independent functioning of different domains of self-representation. Some form of physical self-representation is believed to be present at birth, with the ability to respond to motion with coordinated eye and head movements as well as differentiate between motions generated by self and others (Rochat, 2011). This initial minimal self-awareness of one's body develops into mirror self-recognition (MSR) by 18-24 months period (Gallup, 1982; Lewis & Ramsay, 2004). The emergence of MSR is followed by the 'sense of me' resulting in higher order self-awareness (Rochat, 2011). The domain of psychological self is a function of this higher order self-awareness.

Psychological self-representation constitutes autobiographical memory, first-person perspective, and knowledge about the self (Gillihan & Farah, 2005). The physical and psychological domains of self are hypothesized to interact and the psychological domain is theorized to be based on physical self-awareness (Lewis & Ramsay, 2004). For example, MSR is linked to personal pronoun use and pretend play in children (Lewis & Ramsay, 2004). This suggests a link between physical self-recognition and psychological aspects of self-processing that are involved in personal pronoun use and pretend play. However, self-awareness is also known to have different domains that at any given time can be accessed and retrieved independent of each other (D. Williams, 2010).

Domain specific self-awareness deficits are found in psychopathological conditions like ASD. Williams (2010) suggested that the association between the two domains of self can be tested by investigating the domain specific self-awareness deficits in ASD. Generally, intact physical self-recognition in ASD is observed across several studies (Dawson & McKissick, 1984; Ferrari & Matthews, 1983; Lind & Bowler, 2009; Neuman & Hill, 1978; Spiker & Ricks, 1984;Uddin, 2011). To further investigate physical self-representation in relation to ASD, Chapter 2 of this thesis investigated the association between physical self-representation and autistic traits. Results did not find an association between self-face representation and autistic traits in two different cultural settings. However, a positive association was observed between self-voice representation and autistic traits. In the psychological domain, there are behavioural and neurological reports of atypical self-processing in individuals with ASD (Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007; Lombardo et al., 2010; Toichi et al., 2002). The difference in the extent of self-processing deficits in the two domains of self-representation in ASD suggests that psychopathological conditions can disrupt self-processing in a domain specific manner with possible dissociation and independent functioning of the two domains.

These theoretical accounts of domain general and domain specific self-processing are yet to be tested empirically. This raises the question - Is awareness of one's own body as belonging to oneself associated with the development of the self-concept as a coherent psychological entity? In the absence of any previous report of direct empirical testing of the association between the two domains of self-representation, the first aim of this chapter was to test the inter-individual differences in the association between the physical and psychological domains of self-representation. In the current study, physical self-representation was measured using self-recognition tasks in the visual and auditory modality and psychological self-representation was measured using self-reference effect in memory.

One of the well-studied aspects of the psychological self is the mnemonic advantages of the self. Initially demonstrated by Rogers et al (1997) it is known as the self-reference effect (SRE) in memory (Rogers, Kuiper, & Kirker, 1977). The study showed that self-related information elicits better memory compared to other semantic information. SRE comprises a delayed recall/recognition task – in the first phase participants rate how well presented adjectives/personality traits describe 'self', a 'close-other' and/or a well-known personality. Participants also concurrently perform a semantic task (example - counting number of syllables in presented words). In the second phase of a recognition test, which typically takes place thirty to sixty minutes later, participants are presented with words from the previous phase as well as new words. Participants categorize presented words as 'old' (from the first phase) or 'new'. The current explanation of the SRE is that the self has an extensive and elaborate schema compared to other conceptual schemas. Hence, information coded in reference to self, evoke higher elaboration and/or organizational processing. This results in better recall in the second phase of the SRE task for traits that were coded in reference to self in the first phase.

Behavioural studies have demonstrated this effect in both Western and Chinese cultures (Jianli & Ying, 2002; Symons & Johnson, 1997; Zhu & Zhang, 2002). SRE is also studied in comparison to an 'other' condition where the 'other' has been a close person/familiar person/non-familiar person (Keenan, Golding, & Brown, 1992; Maki & McCaul, 1985; Wells, Hoffman, & Enzle, 1984). In Beijing undergraduate students, using an SRE task, priming with Chinese relevant primes resulted in comparable recall rates for self and mother referential information (Sui, Zhu, & Chiu, 2007), whilst, priming with American related primes resulted in better recall rates for self-referential information compared to the mother condition. The comparable memory sensitivity for 'self' and 'mother' in relation to collectivistic cultures (East Asian/Chinese) is termed as the 'mother reference effect'. The 'mother-reference effect' is also demonstrated at the neural level using functional neuroimaging; East Asians (Chinese participants) show activation in vmPFC (a region activated during self-processing (Macrae, Moran, Heatherton, Banfield, & Kelley, 2004)) while performing trait judgments in relation to both self and mother ((Ng, Han, Mao, & Lai, 2010; Sui & Han, 2007; Zhu, Zhang, Fan, & Han, 2007). In contrast, vmPFC activity is observed only in response to self (and not mother) related trait judgments in westerners. Using an SRE paradigm, higher recall rates for self-referential traits compared to close other referential traits was observed in European-Canadian participants (Wagar & Cohen, 2003). Asian-Canadian participants in comparison showed slower reaction time for recognizing self-related traits compared to close other related traits in the recognition phase of the SRE task. From these results, it can be argued that in East Asians self-related information processing in comparison to close other show reduced or equivalent bias.

East Asian cultures are proposed to be collectivistic in nature with similar schemas for self and close others (Hofstede, 1980; Hazel R Markus & Kitayama, 1991). Accordingly, participants from East Asian culture show similar self and close other related information processing. Western cultures are proposed to be individualistic in nature with more focused self-schema (Hofstede, 1980; Markus & Kitayama, 1991). Accordingly, participants from western culture show heightened self-related information processing in comparison to close other. Results from SRE and self-other trait judgment tasks have confirmed the notion of collectivistic and individualistic cultures developed through the earlier studies of social psychology and epidemiology. Thus, it is important that studies of experimental psychology in relation to self-representation are carried out on yet untested cultural settings to characterize self-representations in such populations.

One such cultural setting with a lack of empirical evidence on self-representation is the Indian subcontinent. Indian subcontinent represents an extensive and heterogeneous population. There is no evidence from experimental psychology studies of self-representation in India. Chapter 2 (See Section 2.3) investigated the physical self-representation in Indians. The present study investigates individual differences in psychological self-representation in a participant pool recruited from the India subcontinent. The conception of selfhood in Indian philosophy is detailed and complex (Bharati, 1985). However, it provides the basis from which the psychological self-representation in India could be theorized (Mascolo, Misra, & Rapisardi, 2004; Roland, 1991). A study of middle-classEnglish-speaking population from Boston, United States and New Delhi, India found that Indian participants used more relational attributes to describe self, indicating context dependent self-processing (associated with collectivist cultures (Kühnen, Hannover, & Schubert, 2001; Kühnen & Oyserman, 2002; Mascolo, Misra, & Rapisardi, 2004) . In contrast, American participants used more within-self attributes. Questionnaire-based studies have reported differences in self-concepts in Indian and American students. Indian students in comparison to American students responded in terms of social identity rather than self-identity indicating higher collectivistic cultural traits (Dhawan, Roseman, Naidu, Thapa, & Rettek, 1995). However, to the best of my knowledge, no experimental psychology studies have tested levels of psychological self-representation in India and how it fits the theories regarding cultural affiliation of Indians.

Accordingly, the second aim of the current study was to measure the SRE in memory in comparison to close other (best-friend) and semantic (syllable) conditions. If Indian culture is associated with population-level collectivistic affiliation, it can be hypothesized that the self-referential information would be coded similarly to a close other. If true, this result would indicate a similar representation in memory for self and close other referential information in the Indian population.

Cultural psychologists have studied the construal of ‘self’ as an extension of psychological self-representation in relation to cultural affiliations. Population level individualistic and collectivistic cultural traits emerge from individual-level differences in independent and interdependent self-construal (Markus & Kitayama, 1991). Independent self-construal refers to a focus on the psychological domain of self that is based on self-specific aims and goals. A population tends to be labelled individualistic if large numbers of individuals with affiliations to that culture exhibit a dominant independent self-construal. Interdependent self-construal refers to a focus on collective in-group aims and goals where the self is inclusive of close others (See Fig. 5.1). A population tends to be labelled collectivistic if large numbers of individuals with affiliations to that culture exhibit a dominant interdependent self-construal. However, within a particular cultural context that is commonly considered as being individualistic or collectivistic, individuals may exhibit varying degrees of independent or interdependent self-construal (Triandis, 1989).

This notion of collectivistic and individualistic culture was initially developed from differences observed in perceptions of self in relation to other and context specific self-perceptions (social comparison effect) in different cultures. Such studies also used questionnaires measuring psychological aspects of idiocentrism (attending and focussing on oneself) and allocentrism (focussing attention to others) to define self-construal levels in different cultures (Hofstede, 1980; Triandis, 1989). Subjective Likert-scales like the self-report questionnaire (self-construal scale –SCS (Singelis, 1994)) used in the present chapter, have based the questionnaire items on these initial study results. It is assumed that self-construal level of an individual indicates the values and beliefs they practice in relation to self and others and is interconnected to the behavioural and neural measures of self-processing (Han & Northoff, 2008; Markus & Kitayama, 1991). In order to investigate self-other processing in relation to self-construal traits, one neuroimaging study used the SCS to define the interdependent and independent self-construal of participants (Chiao et al., 2009). The results found that level of independent and interdependent self-construal traits predict activity in vmPFC, an area implicated in self-processing during self-trait judgments. The evidence supports the assumption that subjective self-construal levels are associated with behavioural and neural measures of self-processing. However, neuroimaging and behavioural studies on cultural differences in cognition use reverse inference to interpret results. The common view (individualistic/collectivistic) regarding the cultural affiliations of the participant sample is assumed from the onset. The obtained results are inferred based on how well they explain the presumed cultural affiliations.

Studies using questionnaire-based interviews on self-other related items (e.g., social distance and social identity) observed collectivistic values in Indian culture (Hofstede, 1980; Triandis, 1989). This has resulted in the common view that India can be termed as a collectivistic nation. Alternatively, Indian culture may represent a culture of coexisting collectivistic and individualistic values (Sinha & Tripathi, 1994). The third aim of the current study was to investigate the association of SRE (as a proxy measure of psychological self-representation) with the subjective self-construal levels of participants. The aim was to test how well the Indian population fits with the common view of the collectivistic culture (Hofstede, 1980) by studying the association between self-reported self-construal traits with implicit processing and retrieval of self and close other referential information.

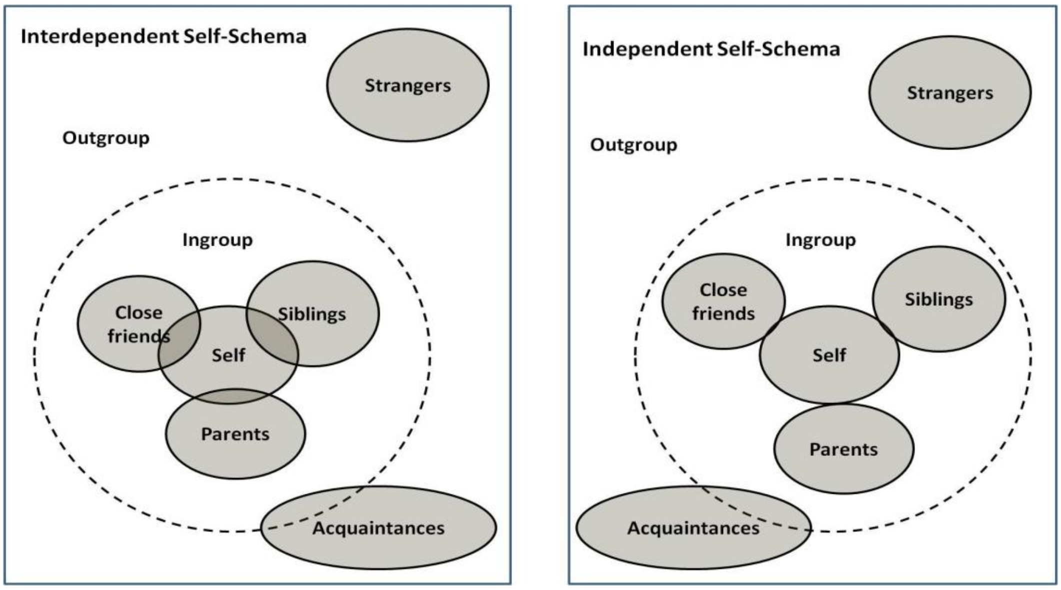

Fig. 5.1 Pictorial representation of Independent and Interdependent self-schema for ingroup and outgroup membership comprising close and distant social identities, adapted from Markus and Kitayama (2010).

Another dimension of interest regarding individual differences in psychological self-representation is that of autism-related traits. Behavioural and neuroimaging experiments in the domain of psychological self-representation have reported atypical self-processing in ASD. Using an SRE paradigm with conditions of self, semantic and phonological information processing, absent SRE was observed for the ASD group compared to controls (Toichi et al., 2002). The study found that in the ASD group, the recall rate for self and semantic information was comparable. In contrast, in the control group recall, rates for semantic information were lower in comparison to self-related information. In ASD it can be argued that self-related information coding per se is not affected. However, the mnemonic advantage of self is absent when compared to semantic information. Using an SRE paradigm, similar scores were observed for the social SRE (self-best friend) condition between control and ASD group (Lombardo et al., 2007). The difference reported was primarily observed in the recall rates for traits between self and famous other. The control group had significantly higher recall rates for information coded in reference to self compared to a famous character (Harry Potter), an effect absent in the ASD group (Lombardo et al., 2007). At a neural level, in comparison to the control group individuals with ASD showed reduced vmPFC activity while processing self-related traits. There was also a lack of differential response in vmPFC in self compared to other judgments (Lombardo et al., 2010). It can be argued that individuals with ASD lack typical levels of self-other distinction.

Considering that cultural affiliations influence psychological self-representation and in continuance with the previous aims of the current study, the fourth aim of the study was to investigate the association between the psychological self-representation and autistic traits in the Indian population. There is a lack of studies investigating the role of self as well as autistic traits in this population. Hence one generic aim of this study was to provide initial insights into the nature of psychological self-representation and test the influence of self-construal and autistic traits on self-representation in an Indian sample.

5.2 Aims

The first aim of the study was to investigate the association between the two domains of self-representation, namely physical and psychological. Physical self-recognition (in visual and auditory modalities) was used as a proxy measure of physical self-representation. SRE was used as a proxy measure of psychological self-representation. The second objective of this study was to characterize the psychological self-representation in an Indian sample. This was investigated as self-reference effect (SRE) in memory in relation to a close other (best friend) and a non-social (syllable) condition. The third aim of the study was to investigate the association between the subjective levels of self-construal traits with a proxy measure of psychological self i.e. the SRE in memory. The final aim of the study was to investigate how psychological self-representation maps onto autistic traits in the general Indian population.

The following predictions were made for this study:

1) In the absence of any directly relevant prior evidence, the study made no prediction on the directionality of the association between psychological and physical self-representation.
2) SRE will be comparable to the close-other reference effect in Indian sample. Additionally, self and close other reference effect will be significantly higher compared to the syllable condition. This prediction is driven by previous findings of similar recall rates for self and close other (mother) related trait judgments in collectivistic cultures.
3) Individual differences in the memory sensitivity between self and close other traits will be negatively associated with self-construal traits. Individuals showing similar memory sensitivity for self and close other conditions will have higher interdependent traits compared to independent traits. This prediction is driven by the theoretical view of dominant interdependent self-construal being associated with more elaborated self-schemas. In cases of more elaborate self-schema, evaluation and consequent recall of self and close other traits are predicted to be comparable.
4) Individual differences in SRE will correlate positively with autistic traits. To elaborate, individuals with higher memory sensitivity for self-traits compared to close other traits will exhibit higher autistic traits. This prediction is driven by the hypothesis that individuals high in autistic traits tend to exhibit heightened self-focus (Frith & De Vignemont, 2005; Lombardo & Baron-Cohen, 2010).

5.4 Methods

5.4.1 Participants

Thirty-eight participants recruited from students of the National Brain Research Centre, aged 25 to 35 years (13 males, 25 females, age=25.87±2.68 years) performed the SRE task. Ethical approval for the study was obtained from the internal ethics review committee of National Brain Research Centre. All participants gave informed written consent for the study. All participants completed the Autism-Spectrum Quotient (AQ) (Baron-Cohen et al, 2001) and the Self-Construal Scale (SCS) (Singelis, 1994) online after the lab-based tests. AQ provides a measure of autistic traits, while SCS measures an index of interdependent and independent self-construal as self-reported by participants. Four participants (N=34) were removed as outliers from the correlation analyses of SRE with self-construal traits and three participants (N=35) from autistic traits respectively (See Section 5.5.3 & 5.5.4).Thirty-three participants performed both runs of physical self-recognition tasks (face and voice) and the SRE task.

5.4.2 Stimuli Preparation

SRE task

The same trait adjectives were selected as Lombardo et al's (2007) study and the paradigm closely followed the paradigm used by the authors. These adjectives were drawn from a validated and experimentally used set of trait adjectives (Anderson, 1968). Half the adjectives in each condition were positively valenced (e.g., inventive) while the other half were negatively valenced (e.g., messy). Among all conditions, there were no differences in the number of characters, syllables, valence, or frequency of the adjectives. There was a total of 180 adjectives used; 90 target and 90 distractor adjectives (see Appendix 3). In a pilot study conducted with 14 participants, all participants confirmed being familiar with the trait adjectives. Following the main testing session, debriefing session with participants showed that participants were familiar with the meaning of the trait adjectives.

Self-recognition task

For both self-face and self-voice conditions, stimuli were prepared following the process detailed in Chapter 2 (See section 2.2.3.).

5.4.3 Task Design

SRE task

A depth-of-processing paradigm was used to assess the self-reference effect on memory. This paradigm is an established mode of accessing psychological self-representation (Rogers et al., 1977; Symons & Johnson, 1997). In the encoding phase, participants judged trait adjectives on three different conditions. In the 'self' condition, participants judged how well a particular adjective described them. In the 'close-other' social condition participants judged how well an adjective described their 'best friend'. All judgements were made on a 6-point scale where 1 indicated 'not at all descriptive' and 6 indicated 'very descriptive'. In the 'semantic' condition participants counted the number of syllables contained in the presented adjectives which ranged from 1 to 6. In the encoding phase, the three conditions were counterbalanced between participants.

30 minute after the encoding phase, the retrieval phase of the SRE task was conducted. During the 30-minute interval period, the photographing and voice recording sessions to be used in the physical self-recognition task were carried out. Participants were completely unaware that they have to perform a later retrieval phase of the SRE task during or after the encoding task. The retrieval phase of the SRE task involved performing a recognition memory test. 90 adjectives from the encoding phase (30 for each condition) and 90 new distracter adjectives were presented in a pseudorandom order. Participants did a confidence judgement on a 1-6 scale where 6 indicated 'definitely OLD' and 1 was 'definitely NEW' (See Fig. 5.2). In a pilot study (n=14), the ratings of 4 as 'Old but kind of unsure' and 3 as 'New but kind of unsure' were included. However, it was observed that participants mostly used options 1 and 6 and/or reported confusion over the additional options. Hence

for the final experiment participants were instructed only to respond with the 1 (NEW) and 6 (OLD) button press options.

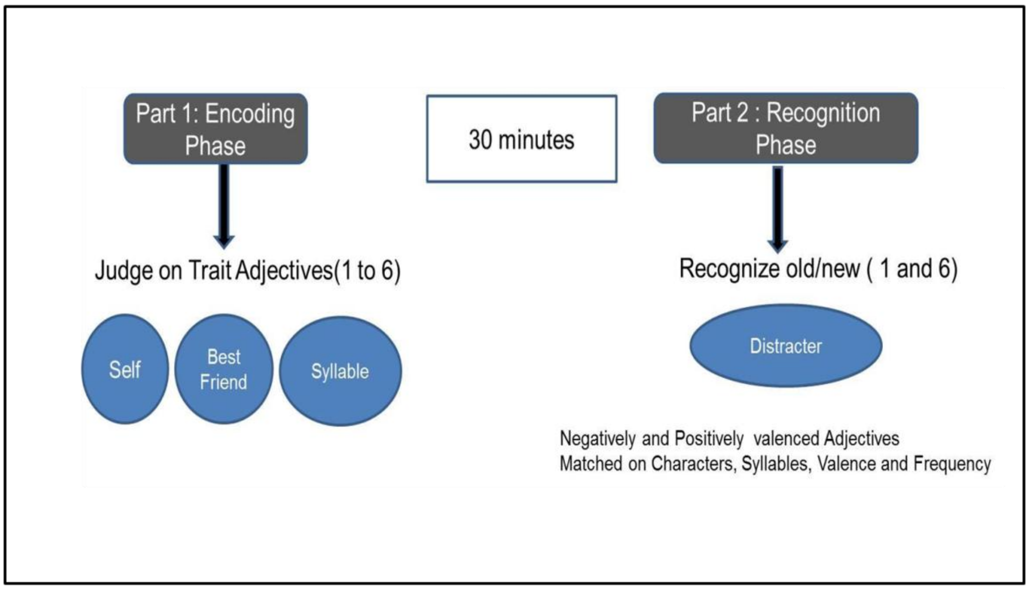

Fig. 5.2 Schematic representation of the SRE task.

5.4.4 Data Analysis

Statistical analyses were conducted using a combination of SPSS (IBM SPSS Statistics for Windows, Version 22.0.Armonk, NY) and ggplot2 package (Wickham, 2009) implemented in R software (R Development Core Team, 2012).

SRE: For each of the three conditions, a standard measure of memory sensitivity (d') was calculated as the standardized score of correctly remembered words minus the standardized score of false alarms (Macmillan & Creelman, 1991). Two SRE variables were computed namely the *social SRE* (d'_{self}-$d'_{best\ friend}$) and the *non-social SRE* (d'_{self}-$d'_{syllable}$) (See Table 5.1).

Self-construal Scale (SCS): SCS is a thirty-item questionnaire that has questions coding for both independent and interdependent self-construal (See Appendix 2B). The SCS subscales measure independent and interdependent self-construal, both of which are present to varying degrees in an individual. The questions used in SCS are answered on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). The dominance of one type of self-construal over another is measured as the *SCS index*. *SCS index* is computed as the difference in the mean scores of the interdependent and independent subscales (Chiao et al., 2009) (See Table 5.1).

Self-recognition: Metric of self-recognition for the face and voice modalities was identical to the analysis detailed in Chapter 2 (See section 2.2.3.4). For each individual participant, slopes of the percentage self-response for both modalities were used as the metric of self-recognition (a proxy measure of physical self-recognition; See Table 5.1).

Variables	**Description**	**Mean(SD)**
d'_{self}	The standard measure of memory sensitivity for self-referential traits. Higher values indicate higher recall rate for self-referential traits	1.7481(.66)
$d'_{best\ friend}$	The standard measure of memory sensitivity for close-other referential traits. Higher values indicate higher recall rate for close other referential traits	1.6685(.53)
$d'_{syllable}$	The standard measure of memory sensitivity for the semantic condition. Higher values indicate higher recall rate for semantic information	0.9550(.41)
social SRE (d'_{self}-$d'_{best\ friend}$)	The difference in memory sensitivity between self and close other condition. Higher values indicate higher recall rates for self compared close other referential information	0.0796(.44)
non-social SRE (d'_{self}-$d'_{syllable}$)	The difference in memory sensitivity between self and syllable condition. Higher values indicate higher recall rates for self compared semantic information	0.7932(.97)
SCS index	The difference in the mean of agreement between the interdependent and independent subscales of the SCS questionnaire. Higher values indicate higher levels of interdependent traits compared to independent traits	-.0162(.93)

AQ	A measure of the individual level of autistic traits. Higher values indicate higher levels of autistic traits.	20.74(7.3)
face_slope	The slope of psychometric function fitted to the percentage of self-responses for self-other face morphs. Higher values indicate steeper slope and a more distinct self-face representation	14.31(10.67)
voice_slope	The slope of psychometric function fitted to the percentage of self-responses for self-other voice morphs. Higher values indicate steeper slope and a more distinct self-voice representation	7.47(.04)

Table 5.1: Summary of different variables computed for the current study.

Main Effects Analysis:

A one-way repeated measures ANOVA was conducted with 3 conditions (Self, Best friend, and Syllable) as within subject levels and d' as the dependent variable. This analysis was performed to establish if the memory sensitivity (as measured by $d'_{self,}$ $d'_{bestfriend,}$and $d'_{syllable}$) for self, close-other and syllable condition significantly differed between each other. Post-hoc one-tailed paired samples t-tests were computed between all three condition pairs (alpha level corrected to 0.017 for significance testing). It was predicted that self-reference effect in memory will be comparable to the close-other reference effect and both will be significantly higher to the syllable condition.

Individual differences analysis:

A two-tailed Kendall rank correlations were computed between the domains of physical (self-face and self-voice recognition) and psychological (SRE) self-representations. This test was chosen following a Shapiro-Wilk test which revealed neither of the slope variables (for self-face and self-voice) showed a normal distribution (Shapiro-Wilk test: $p<.001$). The first correlation was between the slope of self-face recognition (face_slope) and memory sensitivity for self-traits in relation to another (*social SRE*). The second correlation analysis was between the slope of self-voice recognition (voice_slope) and memory sensitivity for self-traits in relation to another (*social SRE*).

A one-tailed Pearson product-moment correlation was computed between *social SRE* and *SCS index*. This analysis was performed to confirm the prediction that individuals with lower values of *social SRE* will have higher interdependent traits. This would indicate individuals with similar recall rates for self and close other traits would also have higher levels of interdependent self-construal.

A one-tailed Pearson product-moment correlation was computed between *social SRE*(d'_{self}-$d'_{best\ friend}$) and AQ. This analysis was performed to confirm the prediction that individuals with higher recall rates for self-referential information compared to close other would also exhibit higher levels of autistic traits.

5.5 Results

5.5.1 Is psychological self-representation as measured with SRE associated with physical self-representation?

A two-tailed Kendall rank correlation computed between SRE (d'_{self})and self-face slope did not reveal a significant association between the two (τ (33) =.08, p=.51; See Fig. 5.3). A two-tailed Kendall rank correlation computed between the SRE (d'_{self}) and slope for self-voice did not reveal a significant association between the two (τ(33) = -.002, p=.9; See Fig. 5.3).

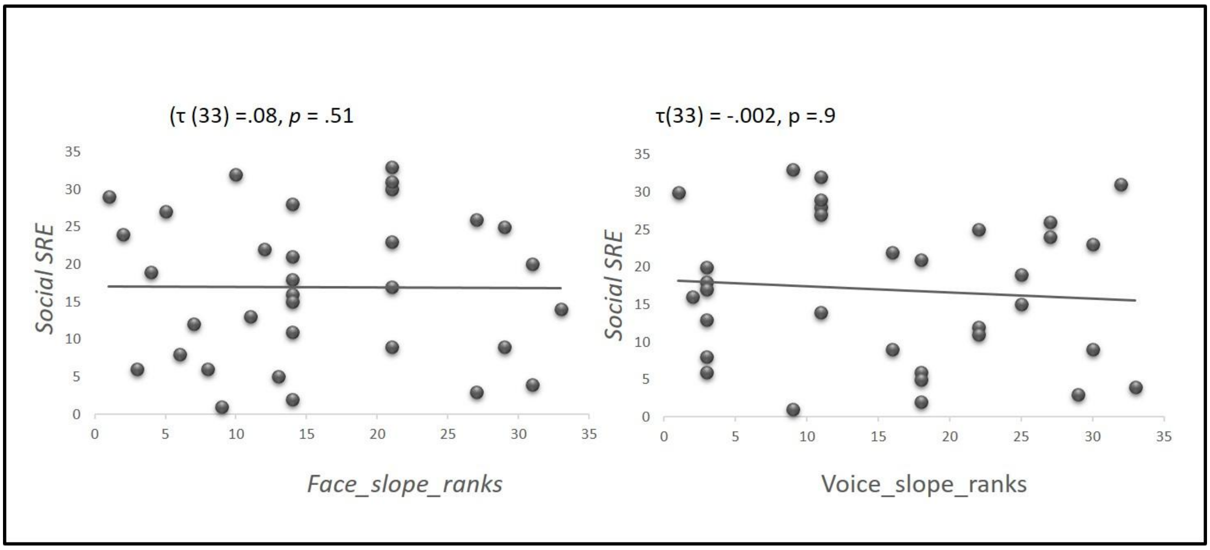

Fig. 5.3 Rank scatterplots representing the association between the slopes for self-face/self-voice recognition (y-axis) and for d'_{self} (x-axis). The shaded portion represents the 95% confidence region of the slope of the regression line.

5.5.2 Are self-reference effect and close other reference effect comparable to each other and significantly higher than the syllable condition?

A repeated measure ANOVA with a Greenhouse-Geisser correction showed that d' measures on memory performance significantly differed between conditions- self, close-other (best friend) and syllable ($F (1.612, 59.645) = 39.33$, $p<.001$, $\eta^2 = .03$). Post-hoc tests using Bonferroni correction revealed that memory sensitivity for self-referential information compared to close other referential information was not statistically significant ($d_{self} > d_{best\ friend}$: $t = 0.45$, $p=.3$, $d = .02$). However, memory performance of both self-referential as well as close other-referential information was significantly better compared to the syllable condition ($d'_{self} > d'_{syllable}$ $t= 7.53$, $p<0.001$, $d = 1.08$; $d'_{best\ friend} > d'_{syllable}$ $t=7.05$, $p<.01$, $d = 1.25$; See Fig.5.4).

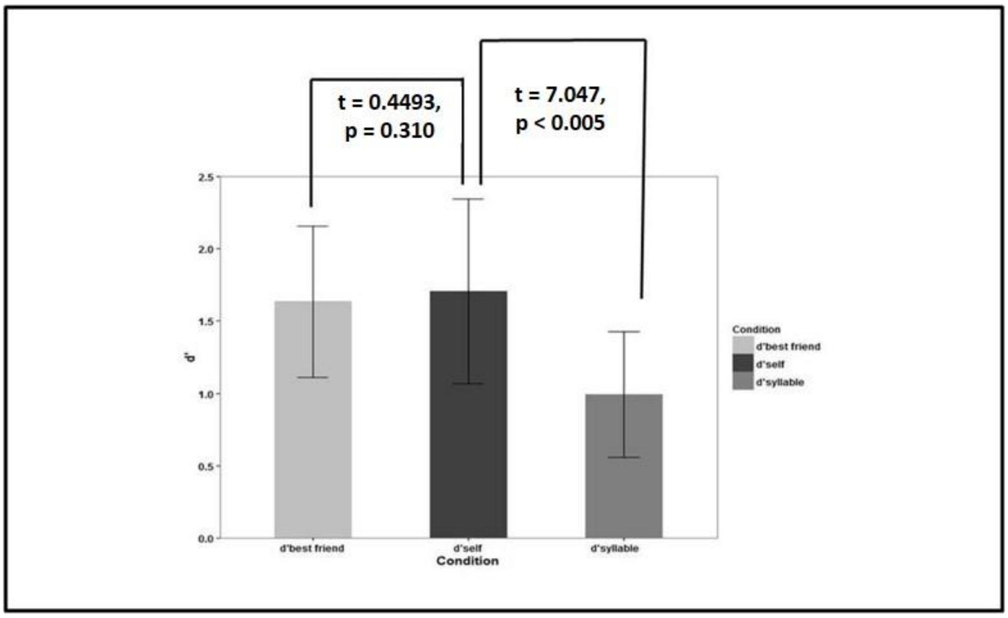

Fig. 5.4 Graph representing d' measures of memory recall for best friend, self and syllable conditions. Recall for self and close other trait adjectives were comparable and were both significantly higher than that of the syllable condition. Error bars indicate within-subject standard errors of the mean.

5.5.3 Do individuals with comparable self-representation to a social close-other (social SRE) also exhibit higher interdependent self-construal (SCS index)?

To investigate the relationship between individual differences in self-referential cognition and self-construal scores, a Pearson product-moment correlation was computed between *social SRE* and *SCS index*. As predicted, *social SRE* negatively correlated with *SCS index* (r (34) = -.358, *p*=.02). In other words, individuals showing a reduced difference between recall rates for self and close other had higher interdependent self-construal (See Fig.5.5).

5.5.4 Are autistic traits associated with individual differences in self-representations?

To investigate the relationship between individual differences in self-referential cognition and autistic traits, a one-tailed Pearson product-moment correlation was computed between *social SRE* and AQ scores. The analysis revealed that *social SRE* was positively correlated with autistic traits (r (35) = .399, *p*= .009), with individuals with higher autistic traits being better at recalling self-referential information compared to close other compared to individuals with low autistic traits (See Fig. 5.5).

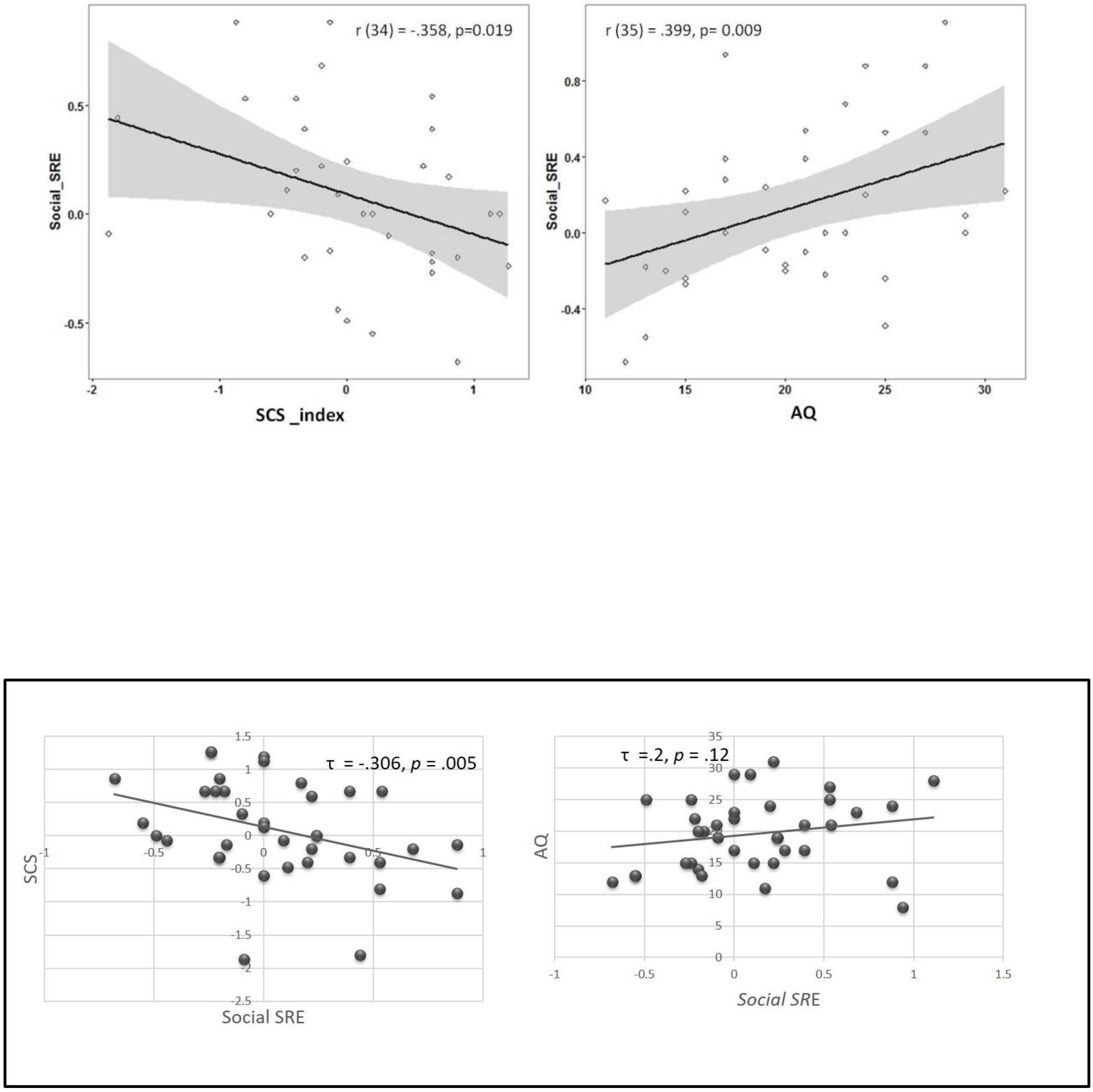

Fig. 5.5 Rank scatterplots representing the association between the *social SRE* and *SCS index* (left) and AQ (right) without (upper panel) and with (lower panel) outliers. The shaded portion represents the 95% confidence region of the slope of the regression line.

Aims	Predictions	Results
Association between psychological self (d'_{self}) and physical (face slope and voice slope)	No prediction was made regarding the directionality	No significant association was observed between psychological and physical self-representations.
Comparison between memory sensitivity for self, close-other and syllable conditions	There will be no difference between memory sensitivity (recall rates) for self and close other referential information. Memory sensitivity for both self and close other conditions will be higher compared to syllable condition	No significant difference was observed for memory sensitivity (recall rates) for self and close other referential information. Memory sensitivity for both self and close other conditions was significantly higher compared to syllable condition
Association between *social SRE* and *SCS index*	The two variables will be negatively correlated. Individuals with higher memory sensitivity for self compared to close other will exhibit higher levels of interdependent traits.	A significant negative correlation was observed between *social SRE* and *SCS index*
Association between *social SRE* and AQ	The two variables will be positively correlated. Individuals with higher memory sensitivity for self compared to close other will exhibit higher autistic traits.	Significant negative correlation was observed between *social SRE* and AQ

Table 5.2 Summary of primary predictions and results from the current study

5.6 Discussion

The current study tested the association between physical and psychological self-representation using measures of self-recognition and self-reference effect respectively. The study additionally tested individual differences in psychological self-representation in relation to self-report measures of self-construal and autistic traits. The results from the study found inconclusive evidence for an association between physical and psychological self-representation. Self-reference effect, which was used as a proxy measure for psychological self-representation was similar to close other reference effect. No significant difference was observed between recall rates for self and close other encoded information. The study also found that individuals with higher memory sensitivity for self-traits (when compared to close other) had a lower interdependent self-construal level. Lastly, the study found that individuals with higher memory sensitivity for self-traits (when compared to close other) also had higher levels of autistic traits.

Evaluation of the physical self is theorized to result in assessing one's own mental state and introspection indicating a possible link between the two domains (Lewis & Ramsay, 2004). However, there are no studies that have experimentally mapped the association between the two domains. The first aim of the study was to investigate the association between the psychological and physical domains of self-representation. The results did not show any statistically significant association between the two constructs. The results from the current study indicate that there may be a lack of direct association between the two domains in adulthood. However, it cannot be discounted that viewing one's own face can lead to introspection about one's self in the mind. It can be speculated that dependency in development and interaction in adulthood is most likely to be present between the two domains. Future studies should capture cognitive processes that directly engage the two domains in testing levels of interaction and inter-relationship between the two. However, the limitation of the research methodology used should be noted here. The current study used interindividual differences in two domains of self-representation to discuss the association/dissociation between the two domains. The extension of this interpretation from interindividual level to intraindividual level should be done cautiously and future studies should devise paradigms that can better probe the intraindividual differences in different domains of self-representation (See Molenar & Campbell, 2009 for critique).

The second aim of the study was to characterize the representation of self in the psychological domain in an Indian sample. This was investigated as self-reference effect (SRE) in memory in relation to a close other (best friend) and a non-social (syllable) condition. The results did not find a significant difference between memory sensitivity for self and close other referential information. The recall rates for self and close other traits were found to be higher compared to the syllable condition.

The similar memory sensitivity for self and close other referential information observed for the Indian sample in the current study is in line with previous reports of similar recall rates for self and mother in East Asian cultures (Chiao et al., 2009,2010;Sui, Liu, & Han, 2009;Sui et al., 2007). These studies found that in collectivistic East Asian cultures, self and close other is similarly encoded and retrieved from memory. Similar results from the current study provide a preliminary account of an experimental measure of psychological self-representation in India, suggesting a more elaborate self-schema inclusive of others. Using the same paradigm, a significant self-reference effect was found in comparison to close other in neurotypical and ASD participant pools (Lombardo et al., 2007). The study was conducted in western European Caucasian participants. The study observed SRE similar to that observed in western cultures indicating more focused self-related information processing. Using the same paradigm, in the current study, no significant difference in recall rates was observed between self and close other referential information. This indicates that this self-schema may be inclusive of close other in Indians. The results from this study are in line with previous findings of similar magnitude of self and close other (mother) reference effect in Chinese participants (Sui et al., 2007). Thus, this initial report of psychological self-representation in India is consistent with the pattern observed in collectivistic cultures where similar memory is observed for self and close other in comparison to semantic information.

The third aim of the study tested the association between psychological self-representation in memory and self-reports of self-construal traits. In the initial report of using SCS, participants from European-American (U.S), Asian-American and Chinese (Hong-Kong) population scored mean values of 5.63, 5.21 and 5 respectively for independent traits. This indicates a more dominant independent self-construal for European-Americans followed by Asian-American and Chinese individuals. In SCS subscale for interdependent traits, participants from European-American (U.S), Asian-American and Chinese (Hong-Kong) population scored mean values 5.27, 5. 67 and 5.67 respectively. This indicates more dominant interdependent self-construal for Asian-American and Chinese individuals compared to European-Americans (Singelis, 1994). In the current study, the average mean score of independent traits was 5.24 (±0.07SD) and the average mean score of interdependent traits was 5.17 (±0.12SD) and the mean difference between the two subscales did not show a significant difference. This indicates at the subjective level, individuals in the current sample showed overall similar levels of independent and interdependent traits.

In the current sample, the independent measure of 5.24 most closely matched that of Asian-Americans (5.21) and the interdependent measure of 5.17 most closely matched that of Euro-Americans (5.27) indicating co-existence of independent and interdependent self-construal in Indian participants as previously commented (Sinha & Tripathi, 1994). However, results from the current study for psychological self-representation as measured using SRE and the association between SRE and self-construal traits (discussed next) is consistent with the notion of a collectivistic Indian culture. The participant pool tested in the current study was an urban and educated student sample. It is likely that in such a sample self-reported independent and interdependent trait alone may not reflect the underlying self-schema of the tested participants.

Although interdependent and independent subscales of self-construal did not differ from each other, individual difference analyses revealed a negative association between *social SRE* and *SCS index*. Participants who had similar recall rates (lower *social SRE*) between self and close other condition had higher interdependent traits suggesting that when the psychological representation of self and close other was similar there was a reportedly higher level of interdependent self-construal for that participant. This is an interesting finding, showing that although self-reported independent and interdependent traits were similar, underlying psychological measures showed more elaborate schema for self and close other. Additionally, psychological self-representation associated with individual level self-report traits in a manner predicted for a collectivist culture where individuals with higher levels of interdependent traits had similar recall rates for self and close other. SCS scale was previously used to group individual participants into an individualistic or a collectivistic group based on a higher agreement with interdependent and independent traits respectively (Chiao et al., 2009). Using, this grouping mechanism, *SCS index* predicted the level of neural activity in vmPFC an area implicated in self-other processing. This previous study illustrates that *SCS index* can be reliably used to characterize individuals on independent and interdependent traits and can be used to predict culture-specific behaviour.

The fourth aim of the study was to test the association between different domains of self-representation with autistic traits. One of the underlying causes of social dysfunctions observed in ASD has often been attributed to atypical self-representation (Frith & De Vignemont, 2005; Frith & Happé, 1999; Lombardo & Baron-Cohen, 2010). However, there are no previous reports investigating the association between self-representation and autism-related symptoms in the Indian population. Regarding the association between SRE and autistic traits, the current study observed higher memory sensitivity for self (in comparison to close others) in individuals with high autistic traits. On further analysis, this was shown to be an effect of lower recall rates for close-other referential information in individuals higher in autistic traits.

In contrast to this finding, Lombardo et al. (2007) did not observe a difference between the ASD and control groups for *social SRE* condition. Both ASD and control group showed higher recall rates for self compared to close other (Lombardo et al., 2007). The results from the current study indicate that in the current sample, individuals higher in autistic traits showed higher recall rates for self-referential information indicating the presence of intact SRE unlike the one observed in Lombardo et al (2007) study which was conducted on a Caucasian sample. However, they showed poorer recall rates for close-other compared to self-referential information. This association was only found to be a function in relation to autistic traits, overall mean scores of recall rates did not show any significant difference between self and close other. It can be theorized that in a collectivistic culture where socio-cultural contexts result in comparable schemes for self and close-other, individuals high in autistic traits might be lacking in self and close other integration.

The current study used experimental and subjective measures of psychological self-representation. Testing different dimensions of self-representation provided a more informed understanding of individual-level cultural affiliations and underlying self-schema in the current sample. It is thus important for future studies to test different aspects of self-representation to fully capture the complex pattern of interaction between cultural affiliations and self-representation.

5.7 Conclusion

This initial investigation into the nature of psychological self-representation in a participant sample recruited from the Indian subcontinent revealed the presence of an elaborated self-schema that encodes and retrieves close-other related information at a comparable level to that of self-referential information. This result was further supported by evidence that individuals with similar recall rates for self and close other related information also had higher interdependent self-construal traits compared to independent self-construal traits. A preliminary investigation into the nature of the association between the two domains of self-representations, namely psychological and physical, did not reveal an association between the two domains. However, this initial result needs to be tested further in different cultural settings and using different paradigms. Lastly, it was observed that individuals with higher autistic traits recalled self-related information better than close-other related information, indicating a focused self-schema with the reduced inclusion of close others. Following the findings observed in self-representation and autistic traits in the sub-clinical population, the next chapter will outline an investigation of individual and gender differences in physical self-representation in a clinically diagnosed ASD sample.

6. Physical self-representation across sensory modalities: Evidence from Autism Spectrum Disorder

This chapter describes a study investigating individual differences in physical self-representation in individuals clinically diagnosed with ASD. The chapter briefly reviews different aspects of self-representation in relation to ASD and discusses gender differences in the autism phenotype. It then outlines investigation of physical self-representation as measured by self-recognition in visual and auditory modalities. Investigation of individual and gender differences in physical self-representation in relation to autistic traits is also outlined. The results obtained are discussed in relation to physical self-representation across sensory modalities as outlined in Chapter 2.

6.1 Introduction

In continuation of the investigation of physical self-representation and its relation to autistic traits (Chapter 2 and 4) in sub-clinical samples, the current study investigated individual and gender differences in physical self-representation in a clinically diagnosed ASD sample.

Psychological self-representation is often disrupted in ASD individuals (Cygan, Tacikowski, Ostaszewski, Chojnicka, & Nowicka, 2014; Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007; Toichi et al., 2002). In self and close other distinction, there is reduced ability to separate self and other referential information in individuals with ASD. On the other hand**,** physical self-representation is argued to be intact in individuals with ASD (D. Williams, 2010), the study of which is mostly limited, and far fewer compared to neurotypical population, to self-face recognition (Uddin, 2011). The ability to recognise one's own face, however, cannot explain the entire mechanism of physical self-representation in ASD. Self-other overlaps, as well as self-other discrimination in the physical domain, are key processes involved in social functioning (Bird & Viding, 2014; Lombardo & Baron-Cohen, 2010). Social behaviour such as emotional contagion (Hatfield, Cacioppo, & Rapson, 1994;Laird et al., 1994), action imitation (Rizzolatti, Fogassi, & Gallese, 2001) and empathy (Decety & Jackson, 2006) are believed to be achieved through self-other interactions in the physical domain (Meltzoff & Brooks, 2001), all of which shows some form of disruption in ASD (Lombardo et al., 2007;D. Williams, 2010;J. H. Williams, Whiten, & Singh, 2004).

Results from the previous chapters suggest that higher autistic traits are associated with differences in self-representation in both physical and psychological domains. In relation to the physical domain, results from Chapter 2 found that higher autistic traits are associated with a more distinct (or a narrower self-other overlap) in the auditory modality. This result was observed in Western European Caucasian and Indian samples. No such association was observed for visual self-representation and autistic traits in the two cultures studied in Chapter 2. Results from Chapter 4 found that for self-other face morphs, individuals with ASD had shorter gaze duration to faces in general irrespective of the facial identity. In relation to the psychological domain, results from Chapter 5 found higher autistic traits are associated with focused self-representation in the Indian population. In a culture (India) where self and close other have similar representations in the psyche, it can be argued that individuals with high autistic traits possibly lack such integration. These results show that ASD can provide a model to study how differences in behavioural self-representation in physical and psychological domains emerge in psychopathological conditions.

The current study provides a more detailed investigation of physical self-representation in visual and auditory modalities in ASD. The study also tests if/how these representations are associated with symptomatic severity in ASD, as measured by self-reported autistic traits. The clinically diagnosed sample thus represents more enriched sampling at one end of the autistic trait continuum. Self-representation was examined using the same paradigm used in chapters 2 (See Section 2.2.3) and 4 (See Section 4.4.3). Previous findings from Chapter 2, which tested individuals from two different cultures, found significantly higher threshold for self to other category boundary for self-face compared to self-voice. Individuals required more other related information to shift from self to other category in the auditory modality compared to the visual modality. In the absence of any previous reports of bi-modal self-representation study in ASD, it is predicted that individuals with ASD will show a pattern similar to the typical adult samples with a significantly higher threshold for self to other category boundary for self-face compared to self-voice. This prediction is also based on studies that report typical self-face recognition in children with ASD (Dawson & McKissick, 1984; Neuman & Hill, 1978; Spiker & Ricks, 1984). It is assumed that self-face would be a more familiar stimulus compared to self-voice for individuals with ASD similar to that observed in the sub-clinical population.

In relation to autistic traits, both Chapter 2 and Chapter 4 did not observe any relation between autistic traits and self-face representation. This result is in line with reports of intact physical self-representation in relation to autistic symptoms (Uddin, 2011;D. Williams, 2010) and a similar result is predicted for the clinically diagnosed ASD population. In relation to self-voice representation, results from Western European and Indian samples (Chapter 2) observed a positive association between self-voice representation and autistic traits. This indicates individuals with higher autistic traits have a more distinct self-voice representation compared to those with lower autistic traits, possibly because of enhanced pitch discrimination abilities observed in relation to ASD (Bonnel, Mottron, Peretz, Trudel, & Gallun, 2003). Pitch discrimination is one of the fundamental processes that are involved in self-voice recognition (Hughes & Nicholson, 2010). A result similar to neurotypical adult samples is predicted regarding the association between self-voice representation and autistic traits in the clinically diagnosed sample. However, at the extreme end of the symptomatic distribution where individuals with ASD lie, the symptom profile may interact with self-face/voice representation differently. This interaction may produce a different outcome in the association between self-face/voice representation and autistic traits to that observed in neurotypical adults indicating non-linearity in the relationship between self-representation and autistic traits.

The current study also investigated gender differences in physical self-representation and its relation to autistic traits as sex/gender differences in ASD is currently a focal research point (Lai, Lombardo, Auyeung, Chakrabarti, & Baron-Cohen, 2015). There is a male bias in ASD that has been attributed to both diagnosis criteria and neuroanatomical differences in male and female brains in general and ASD in particular (Baron-Cohen et al., 2011; Lai et al., 2015). Hence, it is relevant to investigate gender/sex differences in any behavioural measure in the ASD population (Baron-Cohen, Knickmeyer, & Belmonte, 2005; Baron-Cohen et al., 2011). Gender differences are also observed in ASD symptoms with higher repetitive and stereotyped behaviour in ASD males compared to ASD females but no significant gender differences in social or communication deficits (Harrop et al., 2015; Mandy et al., 2012). Contrasting findings were observed in a study where ASD females had higher social communication impairment and lower repetitive behaviour compared to ASD males (Frazier, Georgiades, Bishop, & Hardan, 2014). It was observed that diagnostic criteria were not able to differentiate cognitive profiles of the diagnosed individuals based on sex. The study also reported gender differences in cognitive profiles of IQ, social communication, and restrictive interests. In the domain of social cognition, similar levels of deficits were observed in social behaviour (mentalizing and emotion perception) for both genders. However, in the domain of non-social cognition (attention to detail and executive functioning), ASD males performed below the level observed in neurotypical male participants whilst ASD female participants performed at the same level as neurotypical female participants (Lai et al., 2012). Additionally, females with high-functioning ASD are hypothesised to have developed compensatory social mechanism resulting in under diagnosis of high functioning ASD females using current diagnostic measures (Lai, Lombardo, Auyeung, Chakrabarti, & Baron-Cohen, 2015).This, in turn, may result in clinically diagnosed

ASD samples where female ASD participants have higher levels of autistic traits in comparison to their male counterparts resulting in different behavioural outcomes in the two sexes.

Gender differences are also observed in different aspects of self-representation that may underlie body-dissatisfactions. Unlike men, both adult, and adolescent women were found to show dissatisfaction in their current body size compared to their ideal body size (Tiggemann & Pennington, 1990). Gender, which is a social construct influence mental representation of physical self disproportionately for women compared to men resulting in higher attention to physical self-evaluation in women (Fredrickson, Roberts, Noll, Quinn, & Twenge, 1998). Increased investment and focus on the physical-self also result in higher incidence of body-image dysphoria in women (Muth & Cash, 1997). Considering that gender may influence self-representation and self-perceptions and the gender differences observed in ASD, the present study investigated gender differences in physical self-representation in individuals with ASD.

6.2 Aims

The first aim of this study was to systematically test multiple aspects of physical self-representation in a sample drawn from the clinically diagnosed ASD population. This line of inquiry tested how metrics of self-face and self-voice recognition compared across and within individuals diagnosed with ASD. The second aim of this study was to explore gender differences in physical self-representation in ASD individuals. The third aim of the study was to explore individual and gender differences in the associations between modality specific (visual vs. auditory) physical self-representation and autistic traits.

To investigate physical self-representation, a morphing paradigm similar to that outlined in Chapter 2 was used to study self-recognition in both visual (face) and auditory (voice) modalities. The third aim was implemented by measuring autistic traits using a self-reported questionnaire (Autism Spectrum Quotient – AQ; See section 1.2.4 & Appendix 1 for details on AQ) from the individual participant and testing how the autistic traits were related to the measures of physical self-representation.

6.2.2 Predictions

The following predictions were made in light of previous findings:

1. The morph level for self to other category boundary will be higher for self-face compared to self-voice. This prediction is based on similar results observed in neurotypical adults (See Section 2.2.4). The result is not predicted to be qualitatively different for the ASD population; similar to neurotypical adults, ASD adults will exhibit higher familiarity with self-face.

2. In the absence of any prior research on gender differences in self-recognition in ASD, no predictions are made regarding the directionality of gender differences, if present.

3. Similar to results from Chapter 2, no association is predicted between visual (self-face) representation and autistic traits. A positive association is predicted between auditory (self-voice) representation and autistic traits.

6.3 Methods

6.3.1 Participants

30 adults (14 males, 16 females, age = 41.143 ± 3.46) with a diagnosis of ASD were recruited through several autistic support groups and the research database held at the Berkshire Autism Research Network. All participants diagnosed with ASD completed the Standard Progressive Matrices (Raven & Court, 1998), a standard research tool for measuring general intelligence and reasoning ability. To gain an insight into the range and severity of autistic symptoms, Autism Diagnostic Observation Schedule (ADOS) was co-administered by the researcher for all participants. Ethical approval for the study was obtained from the Department of Psychology Research Ethics Committee of the University of Reading (reference no: 2012/117BC) and all participants provided written informed consent.

6.3.2 Stimuli Preparation

Face

Face stimuli were individually tailored for each participant following a photograph session (See section 2.2.3 for details on steps involved in photography session and pre-processing of face stimuli). A 15-step morph continuum between participant's own face and an unfamiliar face was created for the condition (See Section 4.4.2). In the test phase, images were presented at a viewing distance of approximately 55 cm, on a 30.5 cm × 23 cm inch colour TFT active matrix XGA LCD monitor (1,024 × 768 pixels) run at 60 Hz by a PC.

Voice

Voice stimuli were individually tailored for each participant following a short voice recording session. See Section2.2.3for details on steps involved in voice recording session and pre-processing of voice stimuli. Following pre-processing, a 15 step morph continuum was created between participant's own voice and an unfamiliar voice.

6.3.3 Task Design

The task was designed to have two runs – one each for the face and voice conditions counterbalanced across participants. Each run had two blocks alternating the key response for each hand. Each trial in each run was presented 20 times in two blocks. Hence a total of (15x20) = 300 morphs were presented for each run. Morphs within a block were presented randomly. All trials were preceded by a 500-millisecond cross-hair on a blank screen. Following which there was a single presentation of a face/voice morph for 500 milliseconds followed by a 1000 millisecond blank screen. Participants were asked to respond as quickly as possible in this 500 + 1000 millisecond time window using key presses for 'self' and 'other' (See Fig. 6.1). All conditions were run using E-Prime version 2.0. Testing was carried out on the same day as the photographing and recording sessions with a gap period of one to two hours approximately between the stimuli sessions and testing. Two runs were counterbalanced across all participants.

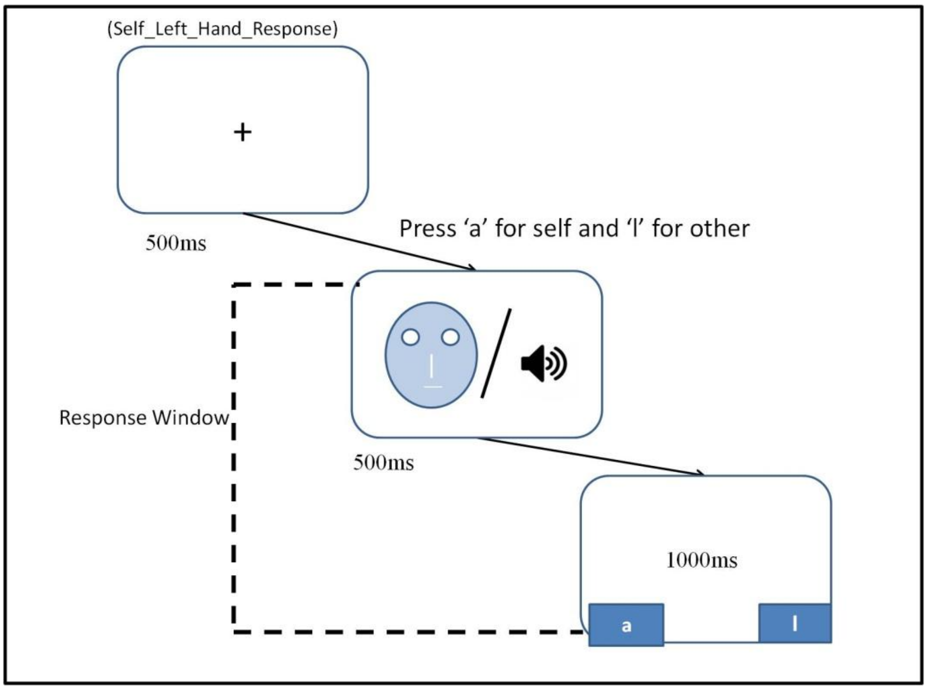

Fig. 6.1 Schematic representation of a trial in the self-recognition task. Participants pressed the 'a' key for labelling a presented face/voice morph as 'self' and 'l' key for labelling a face/voice morph as 'other' in the self left-hand response. These key responses were reversed for the self-right hand response.

6.3.4 Data Analysis

Statistical tests were performed using SPSS (SPSS Statistics for Windows, Version 22.0.Armonk, NY) and ggplot2 (Wickham, 2009) package implemented in R.

Unless reported otherwise, all test statistics presented in the results section are one-tailed, in keeping with the directional nature of the hypotheses.

The slope of self-recognition response across the morph continuum was calculated individually for face and voice runs for each participant (See Section 2.2.3.for details on slope calculation). The morph level (threshold) for self to other category boundary was also computed for the face and voice runs.

Main Effects Analysis:

Summary statistics for a measure of central tendency (mean) and a measure of spread (standard deviations) were calculated for morph levels for category boundary and slope of self-recognition responses for both modalities (See Tables 6.1 & 6.2). This was performed for all participants as a group as well as by gender. To test that category boundary for self-face would be higher than self-voice (prediction 1), paired t-tests were computed between the category boundary variable of the face and voice recognition.

To investigate gender differences mixed-ANOVAs were performed for category boundary and slope variables separately. Gender was used as the between-group factor and modality as the within-group factor. The assumption of sphericity was met with Greenhouse-Geisser correction ($\varepsilon = 1$).

Individual differences analysis:

To test prediction 2, Kendall rank correlation (Shapiro-Wilk test for normality for the slope variable was significant at $p < .001$) was performed between the self-recognition response slope for each modality and a) AQ scores and b) Raven's scores, with and without gender as a covariate.

6.4 Results

Modality	Morph level for self to other shift (%) – overall (mean ± SD)	Morph level for self to other shift (%) – males (mean ± SD)	Morph level for self to other shift (%) – females (mean ± SD)
Face	31.08 ± 16.14	31.43 ± 13.07	30.31 ± 20.53
Voice	28.86 ± 18.38	25 ± 14.72	40.71 ± 6.3

Table 6.1 Distribution of morph levels for self to other category boundary for face and voice modality for the full sample and for each gender

Modality	Slope – overall (mean ± SD)	Slope– males (mean ± SD)	Slope– females (mean ± SD)
Face	16.3 ± 12.32	17.1 ± 11.14	15.53 ± 13.67
Voice	21.19 ± 22.9	21.8± 28.23	20.7± 17.88

Table 6.2 Distribution of slope of self-recognition responses for face and voice modality for the full sample and for each gender

Trait-variables	Total sample (Mean ± SD)	Males	Females	Independent Sample t-test (Male vs. Female ASD participants)
AQ	33.71 ± 3.03	27.5 ± 6.42	31.21 ± 6.45	t = 1.525; *p* = .07
ADOS	8.7 ± 5	9.21 ± 4.9	8.142857 ± 6.95	t = .470; *p* = .32
Raven's	52 ± 6.32	51.85 ± 8.3	52 ± 4.6	t = -.055; *p* = .95

Table 6.3 Distribution of autistic traits and ADOS scores for the full sample and for each gender.

6.4.1 Does morph level for category boundary from self to other differ between the two modalities tested for self-recognition in individuals with ASD?

A paired t-test revealed that the morph level for category boundary from self to other did not differ significantly for visual self-recognition compared to auditory self-recognition (t (29) = 0.4, *p* = .3; *d* = .13; See Fig. 6.2).

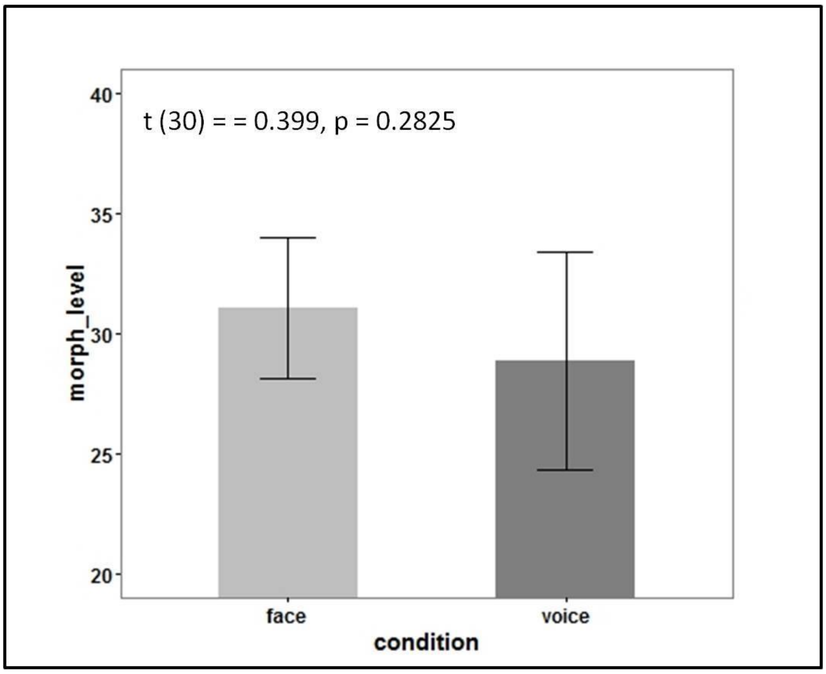

Fig. 6.2 Morph percentage at the group level (mean ± within subject SEM), at which the 'self' labelling reaches a minimum percentage indicating the labelling shift to 'other' category for the self-face and self-voice recognition tasks.

6.4.2 Are there gender differences in self-representation among individuals with ASD?

A mixed-ANOVA revealed no significant effect of modality or significant gender by modality interaction for category boundary from self to other in the ASD sample (main effects: modality, F (1, 27) = 1.534, *p* = .23; interaction: modality*group, F (1, 27) = 2.09, *p* = .16).

A mixed-ANOVA revealed no significant effect of modality or significant gender by modality interaction for slope of the psychometric function for self-recognition in the ASD sample (main effects: modality, 2-tailed, F (1, 27) = 1.09, *p* = .3; interaction: modality*group, 2-tailed, F (1, 27) = .018, *p* = .9).

6.4.3 Are autistic traits (AQ) associated with the slope for self-recognition in the visual and auditory modalities in individuals with ASD?

Kendall rank correlation analysis between slope of self-face recognition and AQ did not find any significant association between the two (τ (29) = -.112, *p* =.2; See Fig 6.3).Kendall rank-correlations on male and female participants separately did not show any significant correlation between slope of self-face recognition and AQ (males: τ (13) = 0.011, *p* = .48; females: τ (15) = -.15, *p* = .23).

A Kendall rank correlation between slope of self-voice recognition and AQ did not show a significant association (τ (29) = 0.038, *p* = .39; See Fig 6.3). Kendall rank correlation on male ASD participants showed a significant positive correlation between slope of self-voice recognition and AQ (males: τ (13) = 0.344, *p* = .04). Kendall rank correlation on female ASD participants showed a significant negative correlation between slope of self-voice recognition and AQ (females: τ (15) = -.366, *p* = .03; See Fig. 6.4). A two-tailed Fisher-z test between correlation coefficients for the slope of self-voice recognition and AQ for male ASD and female ASD participants showed a trend towards a significant difference between the two correlation coefficients (Z = 1.81, *p* = .07).

Variables	**Correlation Result: All ASD Participants**	**Correlation Result: Male ASD Participants**	**Correlation Result: Female ASD Participants**
Face Slope and AQ	τ (29) = -.112, *p* = .2	τ (13) = 0.011, *p* = .48	τ (15) = -.149, *p* = .3
Voice Slope and AQ	τ (29) = 0.038, *p* = .39	τ (13) = 0.344, *p* = .04*	τ (15) = -.366, *p* = .03*

Table 6.4 Summary table of individual and gender differences in the association between the slope of self-representation (visual and auditory) and autistic traits. *Significant at p<.05.

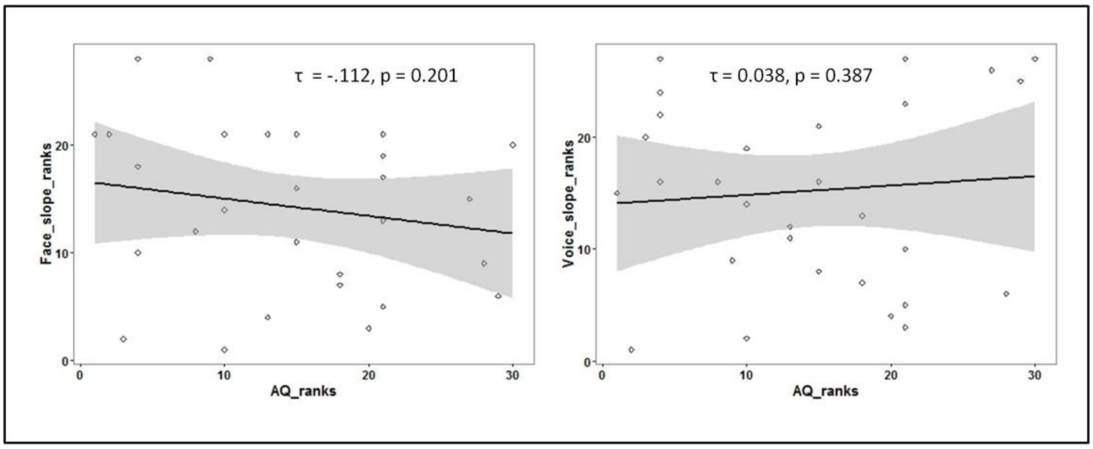

Fig. 6.3 Rank scatterplot representing the association between the self-face recognition slopes and AQ scores (left) and self-voice recognition slopes and AQ scores (right). The shaded portion represents the 95% confidence region interval for the slope of the regression line.

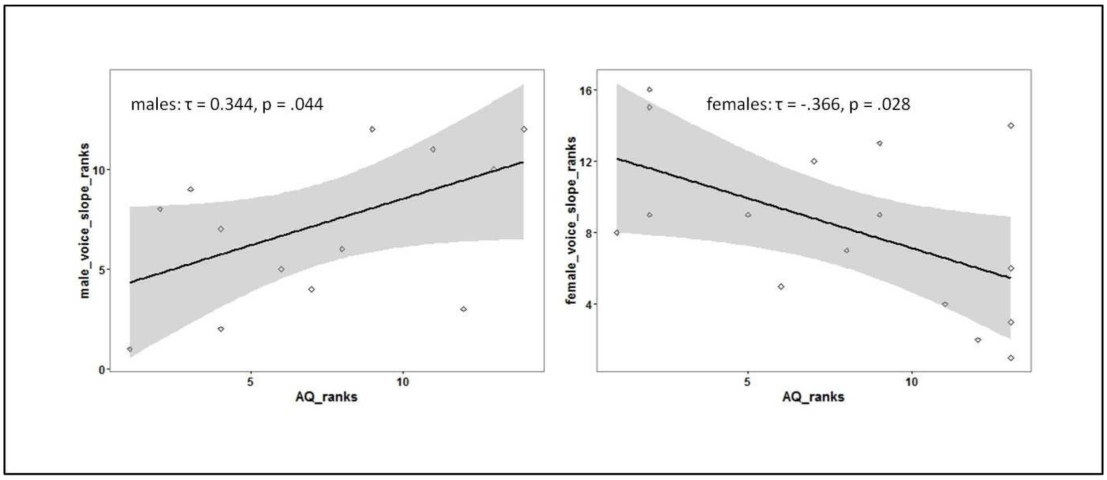

Fig. 6.4 Rank scatterplots representing the association between the self-voice recognition slopes (y-axis) and AQ scores (x-axis) for males (left) and females (right) autistic participants. The shaded portion represents the 95% confidence region interval for the slope of the regression line.

6.4. Are Raven's scores associated with the slope for self-recognition in the visual and auditory modalities in individuals with ASD?

Kendall rank correlation analysis between slope of self-face recognition and Raven's scores did not show any significant association (τ (30) = .003, *p* = .5). Kendall rank-correlations on male and female participants separately did not show any significant correlation between slope of self-face recognition and AQ (males: τ (13) = -0.04, p = .42; females: τ (15) = -.06, p = .38).

A Kendall rank correlation between slope of self-voice recognition and Raven's scores did not show a significant association (τ (29) = 0.04, p = .38). Kendall rank correlation on male ASD participants did not a significant correlation between slope of self-voice recognition and Raven's scores (males: τ (13) = 0.13, p = .48). Kendall rank correlation on female ASD participants showed a significant positive correlation between slope of self-voice recognition and Raven's scores (females: τ (15) = .39, p = .03; See Fig. 6.4).

6.5 Discussion

This study tested physical self-representation across sensory modalities, the relationship between physical self-representation with autistic traits and gender differences in self-representation in individuals with ASD.

The first aim of the study was to test differences in physical self-representation across the visual and auditory modalities in individuals with ASD. Results found no difference in the threshold for self to other category boundary between modalities. This result contrasts with the observations in neurotypical adults from Western Europe and India (See Section 2.2.4 and Table 6.5) which found the higher threshold for self to other category boundary for faces compared to voices. Qualitative comparisons showed that the self-face category boundary is at a lower morph level for ASD individuals in comparison to neurotypical participants from Western Europe and India (See Table 6.5). This shows that individuals with ASD switched from self-face to other-face category at morph levels closer to the other face end of the self-other morph continuum. Self-voice category boundary was similar for ASD individuals and neurotypical participant from Western Europe and comparatively higher for neurotypical participants from India (See Table 6.5). As evident from the above results, individuals with ASD required more other related information in the morphed face to switch from self to other category in comparison to neurotypical adults. However, qualitatively, category boundary for self-other voice morphs appears to be similar in ASD and neurotypical adult population.

Morph_level for self to other category shift (Mean ± SD)	Neurotypical: Western Europe	Neurotypical: India	ASD: Western Europe
Face	44.12 ± 12.09	40.76 ± 9.53	31.08 ±16.14
Voice	27.12 ± 14.14)	33.5 ± 11.3	28.86 ± 18.38

Table 6.5 Summary results of self to other category boundary for visual and auditory modalities from neurotypical adults and ASD adults.

Several ASD participants tested in the current study stated that they disliked looking at their own faces in the mirror or taking photographs. It is likely that self-face is a less rewarding stimulus for individuals with ASD and they spend less time inspecting self-face resulting in lesser degrees of familiarity. Viewing mirror reflection of the self is an important cultural norm often used for introspection (Lewis & Ramsay, 2004; Prinz, 2013). It is theorised that gazing and evaluating physical self-reflection allows one to have a clearer picture of the mental representation of self (Prinz, 2013). Viewing one's physical self also allows one the same view of self as observed by others. Considering individuals with ASD show atypical self-other distinction (Lombardo & Baron-Cohen, 2010;Lombardo et al., 2010)and reduced social motivation (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012), it can be argued that evaluation of self-face is of reduced significance in ASD as the social motivation associated with self-face evaluation and the relative social value of self-identity associated with self-face is lacking in ASD. This atypical self-face representation can be captured using a morphing paradigm which generates different levels of self-related information and tests how well one can discriminate it from being a self-face. Hence, although self-face recognition is intact in adults with ASD, the representation of self-face may be less well consolidated in the visual memory. The observed difference in the visual self-representation was not observed for auditory modality as the self-voice representation for the ASD participant pool was comparable to the sub-clinical population tested in Chapter 2.

It is important to note that in the absence of an age and sex matched control group in the current study, the comparisons with the neurotypical samples should be taken as qualitative observations only. As no statistical computations were performed between the neurotypical and ASD samples, the interpretations of the results from the current study in relation to the results from the neurotypical samples are made with caution. Face-representation for familiar and self-faces should be tested in individuals with ASD to investigate if the effect of less consolidated visual representation of familiar faces is specific to 'self'. A familiar face, a caregiver, friend or partner, requires increased viewing frequency of the face implicitly whilst one can avoid looking at the mirror or photographs of self-face. Hence there can be considerable differences in self compared to familiar face representations in individuals with ASD where self-face may act as a less familiar stimulus. Furthermore, the salience of self-face should be tested in individuals with ASD. Self-face in neurotypical adults has attention grabbing (Brédart, Delchambre, & Laureys, 2006; Gray, Ambady, Lowenthal, & Deldin, 2004; Pannese & Hirsch, 2011) as well as attention sustaining capacity (Devue, Van der Stigchel, Brédart, & Theeuwes, 2009). In Chapter 4, no self-specific relationship was observed between visual processing strategies employed in self-face recognition and autistic traits. Individuals with higher autistic traits had reduced gaze duration for faces in general compared to individuals with lower autistic traits. From these results, it can be argued that self-face advantage in terms of salience is reduced in individuals with ASD.

There are gender differences in body perception and women are shown to perform more evaluation of physical self (Fredrickson et al., 1998)and have a higher incidence of body image dysphoria compared to their male counterparts (Muth & Cash, 1997). In an early study based on Polaroid photographs, female participants were more accurate at self-face recognition than male participants (Yarmey & Johnson, 1982). Higher brain activations in females compared to males was also observed in right inferior frontal gyrus and superior temporal sulcus (areas involved in self-face processing) for self-related processing of facial expressions (Schulte-Rüther, Markowitsch, Shah, Fink, & Piefke, 2008). Considering evidence for gender differences in autism (Harrop et al., 2015), the second aim of the study tested if there are sex/gender differences in behavioural representation of the physical self in individuals with ASD. No such differences were observed for ASD individuals.

The third aim of the study was to test the relationship between autistic traits and physical self-representation. The results found no significant association between autistic traits and self-representation in either modality. However, opposite associations were observed for male and female participants between self-voice and autistic traits. Male ASD participants, like results from the general population (See Section 2.2.4), displayed a positive association between self-voice representation and autistic traits. Male ASD participants with higher autistic traits exhibited more distinct self-voice representation. Results from the previous chapters are mostly from neurotypical females who showed a similar positive association between self-voice representation and autistic traits. Considering atypical features in speech and vocal productions observed in ASD individuals, it is likely that the differences in vocal features were more distinct between the self – voice and unfamiliar voice in ASD participants resulting in more distinct self-voice representation or narrow overlap between self and other in the auditory domain. Female ASD participants showed a negative association between self-voice recognition and autistic traits, indicating a less distinct self-voice representation for female ASD participants with high AQ. However, the association was positive between the slope of self-voice recognition and Raven's score in female ASD participants. It is possible that ASD female participants with low Raven's score, a metric of nonverbal intelligence, found the voice recognition task more demanding resulting in less distinct representation. This could possibly drive the association between self-voice and autistic traits in the negative direction, unlike that observed for male ASD and neurotypical population. In summary, females with high autistic traits had less distinct self-representation in the auditory modality and this may be driven by task demands. Male ASD participants with higher autistic traits exhibited more distinct self-representation for auditory modality in comparison to male ASD participants with lower autistic traits.

Using larger sample size, future experiments should investigate self-face representation in ASD females. Right inferior frontal gyrus (IFG) is activated for self-face recognition (Platek, Wathne, Tierney, & Thomson, 2008) and is a part of the mirror network system of the brain (Molenberghs, Cunnington, & Mattingley, 2012). In comparison to male participants, female participants showed heightened activation of right IFG (and superior temporal sulcus) during self-processing related to facial expression (Schulte-Rüther et al., 2008). Considering atypical mirror network activity in ASD (Iacoboni & Dapretto, 2006), it is possible that ASD females with higher autistic traits show atypical physical self-representation because of a disrupted mirror system (particularly right IFG).

In the domain of psychological self-representation, both brain and behavioural observations have found a less distinct boundary between self and other in ASD (Lombardo et al., 2007;Toichi et al., 2002;D. Williams, 2010). In the domain of physical self-representation, observations from previous chapters and ASD literature did not find an association between physical self-representation in the visual domain and autistic traits. Results from the current study indicate a sex/gender difference in physical self-representation in relation to the association between autistic traits and self-voice representation in ASD. This result for the female ASD participants needs to be replicated in an independent study. If replicated, it can be concluded that there is a different outcome as to the association between the physical self-representation and autistic traits for female ASD population compared to the neurotypical and male ASD population. Interestingly, the female participants in the current sample had higher overall AQ scores (trend level) compared to males. However, the ADOS scores were comparable across both genders (See Table 6.3). There is an under-recognition of women with high-functioning ASD and the observed male bias in the form of higher diagnosis of men with high-functioning ASD is partly attributed to issues with diagnostic tools (Lai et al., 2015). In the current study using the self-report questionnaire (AQ), female ASD participants showed higher levels of autistic traits indicating gender differences in ASD symptoms may not be detected by diagnostic tools alone. It is possible that severity in the autistic symptoms can lead to a more atypical physical-self representation in individuals with ASD. It would be important to carry out a detailed analysis of symptom severity to study if the gender differences observed in the current study is contributed by symptom severity irrespective of gender. This may provide an understanding of how biological differences can result in different behavioural patterns in ASD which can account for heterogeneous results. The gender differences in the association between self-voice representation and AQ observed here also argue for the investigation of gender differences in physical self-representation in relation to autistic traits in the general population. However, since results from the current chapter did not show any significant main effect of gender on the slope or the category variables but only in association with autistic traits, there is less likely possibility to observe gender differences in the general population in the behavioural representation of the physical self.

6.6 Conclusion

In contrast to neurotypical adults, physical self-representation did not differ across sensory modalities for individuals with ASD indicating reduced familiarity with self-face and a less consolidated visual representation for self-face in ASD individuals. Self-advantage observed in relation to a higher category boundary for self-face in neurotypical adults is likely to be reduced in individuals with ASD due to less frequent evaluation and viewing of self-face in ASD individuals. This may indicate reduced salience for self-face which is an important component of self-identity. There was no observed main effect of gender for physical self-representation across sensory modalities. However, gender differences were observed for the association between self-representation and autistic traits, particularly in the auditory modality. Male ASD participants showed a similar pattern of result for auditory self-representation and its association with autistic traits as was observed in neurotypical adults. However, opposite effects were observed for female ASD participants indicating a less distinct physical self-representation in ASD females. Future studies should further explore the role of gender in cognitive profiles of individuals with ASD as well as how atypical self-representation in ASD females may result in dysfunctions in social behaviour. The next chapter will present general discussion based on the results from the empirical chapters outlined in this thesis and suggest future studies and experimental aims to complement and strengthen the findings from the current thesis.

7. General Discussion

The aim of this thesis was to characterize individual differences in physical self-representation in relation to different facets that may influence its representation. Firstly, physical self-representation was investigated across visual and auditory sensory modalities to investigate similarities and differences in perception of the physical self in different sensory modalities. Secondly, the association between two of the primary domains of the self was investigated i.e., the physical and psychological. Thirdly, physical self-representation was investigated in relation to culture as a social environmental factor influencing self-representation. Finally, physical self-representation was investigated in relation to a psychopathological condition relevant in the domain of self-representation i.e., autism spectrum disorder using the autism-spectrum quotient (Baron-Cohen et al., 2001) to elucidate the relationship between physical self-representation and autistic traits in subclinical and clinical populations. The study of physical self in the adult population has been largely limited to the investigation of the laterality effect i.e., right hemispheric dominance in physical self-recognition (Keenan, Ganis, Freund, & Pascual-Leone, 2000;Keenan et al., 1999;Keenan, Wheeler, & Ewers, 2003;Kircher et al., 2001). Physical self-representation is believed to be a developmental precursor of general self-awareness (Gallup, 1982) and is hypothesized to be implemented in understanding self and others through simulation and embodiment (Bird & Viding, 2014;Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992;Gallese, Fadiga, Fogassi, & Rizzolatti, 1996). Hence, understanding the representation of the physical self in its entirety is an important aspect of the cognitive construct of the 'self'. The behavioural representation of the physical self across modalities, domains, and contexts were explored in the following manner:

1) Physical self-representation
    - Across visual and auditory modalities in general population (See Section *2.2.4*)
    - In relation to autistic traits (See Section *2.2.4.*)
    - In two different cultural contexts (Western Europe and India)
2) Physical self-representation - the role of task specificity (explicit vs. implicit processing)
3) Physical self-representation - visual processing strategy of the physical self using eye-movement monitoring (See Section *4.5*)

4) Physical self-representation in relation to psychological self-representation
    - Association between physical and psychological self-representation (See Section *5.5*)
    - Psychological self-representation and association to autistic and self-construal traits (See Section *5.5*)
5) Physical self-representation in a psychopathological context
    - In visual and auditory modalities in clinically diagnosed ASD individuals (See Section *6.4*)

For the purpose of the above investigations in the domain of physical self, self-face and self-voice recognition responses to stimuli generated using self-other morphing technique were used as a measure of self-representation. The slope of the self-recognition response curve was computed from the self-recognition responses for the visual and auditory modalities where a shallower slope is associated with greater self-other overlap, while a steeper slope is associated with reduced self-other overlap and a more distinct self-representation. In the domain of psychological self (Chapter 5), the self-reference effect in memory was used as a measure of psychological self-representation. For all instances of measurement of autistic traits as a model of autistic symptoms in the general or clinically diagnosed population, the autism-spectrum quotient (AQ) was used.

In Chapter 2 behavioural representation of the physical self was investigated in two samples (Western European Caucasian and Indian) to explore the similarities and differences in self-representation in two different cultural contexts. First, it was tested if physical self-representation is comparable between visual and auditory modalities –using recognition response of self-face and self-voice respectively. Second, it was tested if self-representation in the two different modalities were associated with each other. Third, it was tested if there was an association between autistic traits and physical self-representation in visual and auditory modalities.

In Chapter 3 task-specific (explicit and implicit) response patterns in recognition of self-face were investigated. First, it was tested if task specificity, i.e. Explicit versus implicit self-recognition tasks, influenced the behavioural representation of the physical self in the visual domain. Second, it was tested how familiarity with the target face (self/newly memorized) influenced the behavioural representation of the target face.

In Chapter 4 the behavioural representation of the physical self in the visual domain was investigated in relation to the visual processing strategies employed to recognise self-face from self-other face morphs. First, it was tested if the gaze duration to different regions of a face recognised as self-face differed from a face recognised as other face, where the presented faces were morphs from self-other morph continuum. Second, it was tested if the slope of self-face recognition bears a relationship with the visual processing strategies used in the recognition of the self-face. Third, it was tested if autistic traits exhibit any association with visual processing strategies employed in self-face recognition.

In Chapter 5 self-representations in physical and psychological domains were tested in an Indian sample. This is a previously unexplored population with a complex cultural profile with coexisting collectivistic and individualistic traits (Sinha & Tripathi, 1994). Relatively little investigation has been done into how the cognitive construct of the 'self' is represented in the Indian population (Mascolo, Misra, & Rapisardi, 2004), in contrast to East Asian countries where there is considerably more data from (Blais, Jack, Scheepers, Fiset, & Caldara, 2008;Chiao et al., 2010;Han & Northoff, 2008;Hazel R Markus & Kitayama, 1991;Hazel Rose Markus & Kitayama, 2010;Sui & Han, 2007;Sui, Liu, & Han, 2009). To carry out this exploratory investigation, both psychological and physical domains of the self-representation were studied. First, it was tested if self-representation across the two domains were associated with each other. Second, it was tested if psychological self-representation as measured using the SRE paradigm followed the pattern of SRE observed in East Asian or western cultures. Third, it was tested if autistic traits and self-construal traits, relevant to self-representation differences in clinical and cultural contexts respectively, modulated with psychological self-representation in the Indian sample.

In Chapter 6 behavioural representation of physical self across sensory modalities and in relation to autistic traits was investigated in clinically diagnosed ASD individuals. First, it was tested if physical self-representation is comparable between visual and auditory modalities in individuals with ASD. Second, it was tested if autistic traits are associated with sensory modality specific (visual vs. auditory) self-representation in individuals with ASD. Third, it was tested if gender/sex differences influence the outcome of the association between autistic traits and physical self-representation.

Questions	Measure	Finding
Is physical self-representation different across sensory modalities?	Ch 2: Western European Caucasian sample: Threshold for category boundary between self-face and self-voice	Significantly higher threshold (morph level) for category boundary for self-face compared to self-voice
	Ch 2: Indian sample: Threshold for category boundary between self-face and self-voice	Significantly higher threshold (morph level) for category boundary for self-face compared to self-voice
	Ch 6: ASD sample: Threshold for category boundary between self-face and self-voice	No difference across sensory modalities approaching significance
Are physical self-representations between visual and auditory modalities significantly associated with each other?	Ch 2: Western European Caucasian sample: Slope of self-face recognition (visual modality) & Slope of self-voice recognition (auditory modality)	No association approaching significance
	Ch 2: Indian sample: Slope of self-face recognition & Slope of self-voice recognition	No association approaching significance
Is physical self-representation in the visual modality significantly associated with autistic traits?	Ch 2; Ch 4: Western European Caucasian sample –Slope of self-face recognition & AQ	No association approaching significance
	Ch 2: Indian sample –Slope of self-face recognition & AQ	No association approaching significance
	Ch 6: ASD Sample - Slope of self-face recognition & AQ	Trend of negative association
Is physical self-representation in the auditory	Ch 2: Western European Caucasian sample –Slope of self-voice recognition & AQ	Significant positive association

modality significantly associated with autistic traits?	Ch 2: Indian sample –Slope of self-voice recognition & AQ	Significant positive association
	Ch 6: ASD sample - Slope of self-voice recognition & AQ	Significant positive association observed for ASD males; Significant negative association observed for ASD females
Does physical self-representation vary between different task conditions (explicit & implicit tasks)?	Ch 3: Slope of self-face recognition in explicit recognition & implicit evaluation	Significantly more distinct (steeper slope) physical self-representation for the explicit task compared to implicit task
Is physical self-representation significantly associated with psychological self-representation?	Ch 5: Slope of self-face recognition & SRE	No association approaching significance
	Ch 5: Slope of self-voice recognition & SRE	No association approaching significance
Do visual processing strategies differ between self vs. other recognition, as used in tests of physical self - representation?	Ch 4: Slope of self-face recognition & proportion of gaze duration to upper parts of morphed faces (for faces identified as self compared to faces identified as others)	Significantly more positive association between behavioural self-face representation and gaze duration to upper portion of faces identified as self compared to faces identified as other
Is visual processing strategy for faces (self and other) significantly associated with autistic traits?	Ch 4: proportion of gaze duration to upper portion of face for faces identified as ‘self’ & AQ	No association approaching significance
	Ch 4: proportion of gaze duration to upper portion of face for faces identified as ‘other’ & AQ	No association approaching significance

	Ch 4: total gaze duration to faces identified as self & AQ	Significant negative association; Individuals with higher AQ spend less time looking at faces (irrespective of facial identity) in general
	Ch 4: total gaze duration to faces identified as other & AQ	

Table 7.1 A summary of studies (of physical self-representation) and their results as reported in previous chapters of this thesis.

7.1 Physical self-representation in western European Caucasian and Indian Population

This section discusses results from two different cultures (Western Europe and India) in relation to the representation of physical self. The results discussed focus on differences in physical self-representation in two different sensory modalities i.e., visual and auditory and on the presence/absence of any association between self-representations in the two modalities. Next, the section discusses the association between two domains of self-representation i.e., physical and psychological. Finally, the section discusses physical self-representation in clinical context i.e., the association between autistic traits and different modalities of physical self-representation.

7.1.1. *Is physical self-representation different across sensory modalities?*

Chapter 2 tested behavioural representation of physical self in visual and auditory modalities in Western European Caucasian and Indian participants. Observations from both cultural settings indicate that self-face has a more consolidated representation compared to self-voice. Compared to the auditory modality, participants shifted from the self to other category for the visual modality at higher morph levels, i.e. greater self-percentage. It can be argued that visual information about self had to deviate to a significantly lesser degree when compared to auditory information, for participants to identify a stimulus as no longer being self. This indicates that self-face compared to self-voice have a more consolidated mental representation and is in line with previous reports of higher accuracy rates for self-face compared to self-voice recognition (Hughes & Nicholson, 2010) , an effect that becomes reduced when the participants have higher familiarity with the self-voice - as in the case of professional radio presenters (Holzman, Rousey, & Snyder, 1966). The basic perceptual difference in processing between self-generated voice and the recording of one's own voice also possibly contributes to the reduced accuracy in the recognition of self-voice. This difference in representation between two modalities of the physical self indicates how different aspects of the self are experienced in everyday life with observable behavioural differences in physical self-recognition across modalities.

7.1.2. *Are physical self-representations between visual and auditory modalities significantly associated with each other?*

Physical self-representation in the visual and auditory modalities exhibited similar properties in Western European and Indian cultural settings. Evidence from both cultures indicates a lack of significant association between the behavioural representations of the physical self in the visual and auditory modalities. At the behavioural level, physical self-representation in one modality did not positively or negatively predict the representation in the other indicating independent representation and functioning of the visual and auditory modalities of self-representation. However, one functional neuroimaging study found some commonalities in self-recognition across both modalities showing right-hemisphere dominance as well as the involvement of inferior frontal gyrus in both (Rosa, Lassonde, Pinard, Keenan, & Belin, 2008). It is likely though that even if decision making in identifying a stimulus as self-specific may employ similar brain regions for both auditory and visual stimuli, these decisions are driven by low-level modality specific representational memory, possibly based on familiarity with the self-stimuli, resulting in behavioural differences in category boundaries observed in the current study.

Future studies should investigate individual differences in the association between the behavioural representation of the physical self and levels of activation in brain area/areas/network involved in self-recognition. Although the present study did not observe any behavioural association in self-representation between the two sensory modalities this should be followed up with neuroimaging studies to obtain further insights into the independent functioning of the two modalities.

7.1.3. *Is physical self-representation significantly associated with psychological self-representation?*

Chapter 5 tested the association between physical self-representation (as measured using self-face and self-voice recognition) and psychological self-representation (as measured using SRE). No association between the behavioural representations of the two domains of self were observed. The physical and psychological domains of self-representation are theorized to be co-dependent and the development of psychological self is believed to be dependent on the typical development of physical self (Lewis & Ramsay, 2004; Russell & Hill, 2001). However, there are existing theories that oppose the unitary self-construct which proposes that the well-established different dimensions of the self-construct can be experienced and stored independently (Gillihan & Farah, 2005; Neisser, 1988; Williams, 2010). It is possible that physical and psychological self-representation dissociate from each other in adulthood; further investigation into their developmental trajectory and how they interact with each other can lead to better understanding of how they associate with each other.

7.1.4. *Is physical self-representation in the visual and auditory modalities significantly associated with autistic traits?*

Chapter 2 tested the association between autistic traits with physical self-representation in the auditory and visual modalities in two different cultures. In both cultures, autistic traits correlated positively with the slope of the self-voice recognition response curve. Thus, a narrow self-other overlap (or a distinct self-representation) in the auditory modality was observed for individuals high in autistic traits. In the literature, ASD is often hypothesized to be a disorder of focused self-representation with reduced self-other overlap and difficulty in maintaining self-other representations (Frith & Happé, 1999; Iacoboni, 2006; Lombardo & Baron-Cohen, 2010; Williams, 2010). The results from the current study are consistent with this hypothesis for the auditory domain which was observed for both cultural settings. No significant association was observed between autistic traits and self-face recognition. Individuals high in autistic traits may process modality-specific stimuli differently. A previous study has found that individuals with ASD have enhanced pitch discrimination abilities (Bonnel, Mottron, Peretz, Trudel, & Gallun, 2003). It is likely that higher perceptual abilities in the auditory domain drive the distinct representation of voices for individuals high in autistic traits. However, in order to further investigate if self-voice is more distinctly represented in individuals with higher autistic traits as a result of better pitch discrimination abilities; future studies should use familiar voices as additional conditions. Identification of familiar identities from voices has been found to depend on aspects of the vocal features which are less dependent on low-level perceptual features; it could be hypothesized that the distinct representation of self-voice for individuals with high autistic traits may not generalize to other familiar voices (Holzman et al., 1966; Hughes & Nicholson, 2010). It is yet to be investigated if voices, in general, are better represented in memory for individuals high in autistic traits. It is possible that enhanced representation of voices may act as a compensatory mechanism developed to counter the lower focus and/or feature extraction from visually-social/facial stimuli (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012).

7.2 Physical self-representation: Task specificity

This section discusses results from explicit and implicit self-recognition tasks in relation to physical self-representation in the visual modality. The results discussed focus on differences in physical self-representation when the self is evaluated and identified in a tsk-specific manner evoking either higher levels of explicit or implicit self-processing. The section also discusses the result that the recognition of facial identity from morphed faces is dependent on the familiarity with the facial identities used in the morph continuum.

7.2.1. *Does physical self-representation vary between explicit & implicit tasks?*

Self-representation in any modality or domain can be implicitly evoked and appraised while making social judgments in daily life. The resemblance to the physical self has shown to implicitly evoke the representation of the self, resulting in a positive bias towards faces that resembled self-face to a greater extent (Platek & Krill, 2009; Verosky & Todorov, 2010). There are no studies that have investigated the behavioural representation of self-face in a morphing paradigm using explicit and implicit task conditions. In order to investigate how task-specific conditions of explicit recognition and implicit evaluation of self result in differences in behavioural representation of the self-face Chapter 3, implemented a novel task paradigm to investigate if self-face representation exhibits task-specific response patterns.

Evidence from Chapter 3 indicates a more distinct representation of the self-face is explicitly evaluated and recognised compared to when it is implicitly evoked (without prior knowledge of the presence of self-face in the task). In the current study, self-face was morphed with an unfamiliar face (in the explicit condition) and a newly memorized face (in the implicit condition). In the explicit condition participants explicitly judged if the presented morphed face is a self-face or an unfamiliar other face. In the implicit condition, participants judged if a presented morphed face is the memorized face or a non-memorized face. The non-memorized face in the implicit condition was participant's own face however they were not explicitly aware of this manipulation. It was observed that explicit self-face recognition resulted in a more distinct self-face representation compared to implicit self-face processing. Following this initial report, future studies should test the implicit representation of self-face and other highly familiar faces to investigate if the effect shows a graded response between the self, familiar, newly memorized and unfamiliar faces.

7.2.2. *Is there an effect of familiarity on face representation?*

Chapter 3 also investigated if the behavioural representation of a face is influenced by the degrees of familiarity of another face with which the face is morphed. For this purpose, a newly memorized (or learned) face was morphed with the highly familiar self-face for one run and an unfamiliar other face for the alternative run. The evidence suggests that level of familiarity of either face being morphed influences the representation of the memorized face. The memorized face had a more distinct representation when morphed with an unfamiliar face compared to when morphed with the highly familiar self-face.

Faces are perceived as categories, one example being familiar or unfamiliar (Beale & Keil, 1995; Rossion, Schiltz, Robaye, Pirenne, & Crommelinck, 2001), and it is likely that differences in familiarity change these category boundaries in a way that influences the recognition tasks involving the memorized face discussed above. Categorical perception of faces is observed between familiar and newly learned faces (Beale & Keil, 1995; Kircher et al., 2001). A previous study of face perception has found that depending on the direction in which the morphs are presented, familiar faces are categorized differently in different conditions (Rotshtein, Henson, Treves, Driver, & Dolan, 2005). It is possible that self-memorized face overlap is higher because of familiarity with both faces compared to the newly learned-unfamiliar face pair. In summary, the current study found that identity and familiarity levels of faces from morphed face continuum influences the behavioural representation of the identified faces in face recognition tasks.

7.3 Physical self-representation: Eye gaze

This section discusses results from experiments investigating visual processing strategies used in self-face recognition. The results discussed focus on differences in gaze duration to different parts of the face for faces identified as self compared to faces identified as an unfamiliar other. The section also discusses if visual processing strategies in the recognition of self-face show a positive association with self-face representation behaviourally. Finally, the section discusses the presence/absence of an association between autistic traits and visual processing strategies used in self-face recognition.

7.3.1. *Do visual processing strategies differ between self vs. other face recognition, as used in tests of physical self -representation?*

Chapter 4 tested if gaze duration patterns differed between faces identified as self and faces identified as other for self-other morphed faces. The gaze duration was calculated separately for two regions of interest for each presented face – one for the upper parts of the face including the eyes and the other for lower parts of the face including the mouth.

Individuals looked for a longer duration on the lower parts of the face for faces identified as self compared to faces identified as other. Since self-face is a familiar face with more consolidated visual representation in memory, less time is required to extract eye region related features to make the decision to label a face as self. This, in turn, may allow more time to sample internal features from rest of the face region. Previous results have shown that identification of other non-self familiar faces implements similar viewing strategies as was observed for self-face in the current study with more gaze duration to different parts of the face for identification of familiar faces compared to unfamiliar faces (Van Belle, Ramon, Lefèvre, & Rossion, 2010).

Evidence from Chapter 4 also found a link between self-face representation at the behavioural level and self-face viewing strategies. Individuals who exhibited a more distinct self-face representation at the behavioural level had longer gaze duration to upper parts of the face identified as self compared to faces identified as other. This is an interesting finding, indicating that distinctness in the behavioural representation of self-face is significantly associated with differences in viewing strategies employed in the identification of the presented face as 'self-face'. This is the first known report on how behavioural representation of the self-face is related to gaze duration.

Self-face is a highly familiar face and has high salience to the individual (Gray, Ambady, Lowenthal, & Deldin, 2004; Pannese & Hirsch, 2011). A familiar face may be of high salience and similarly well represented. It is of interest to observe if a distinct behavioural representation of a highly familiar face that is not self is associated with higher gaze duration to upper parts of the familiar face. Additionally, it needs to be investigated what trait features are associated with sampling features specific to self-face differently, resulting in a stronger representation of self-face. For example, do individuals who exhibit an exaggerated bias towards self-face also have a greater preoccupation with body image? Perceptual overestimation of body size (Garner & Garfinkel, 1982) and inflexibility in altered body perception is observed in eating disorders (Garfinkel, Moldofsky, Garner, Stancer, & Coscina, 1978). Furthermore, cognitive bias like attention or memory biases is observed in relation to body image disturbance in eating disorders (Williamson, 1996). Increased plasticity in body representation in the form of increased rubber hand illusion is observed in individuals with eating disorders, possibly due to heightened attention to visual information of the body and/or atypical somatosensory processing (Eshkevari, Rieger, Longo, Haggard, & Treasure, 2012). These studies show that altered perception of physical self may explain psychopathology of eating disorders. Studies investigating heightened perceptual bias to physical self can further the understanding of cognitive underpinnings of eating disorders.

7.3.2. *Does visual processing strategy for faces identified as self-face associated with autistic traits?*

Autistic traits did not show an association with gaze duration to any specific regions of interest on the face or facial identity. However, individuals with higher autistic traits had reduced total duration of looking time to faces when both regions of interest were combined. This is in line with social motivation theory of autism which suggests that individuals with ASD spend less time looking at social images possibly due to a lack of social motivation (Chevallier et al., 2012).

It appears that in individuals with high autistic traits, once the decision to identify the face is made, they do not continue looking at the face, indicating generally low reward value for faces. Considering that self-face is shown to sustain attention in neurotypical individuals indicating higher reward value (Devue, Van der Stigchel, Brédart, & Theeuwes, 2009), future studies should explore further if self-face lacks reward value in individuals with ASD, and thus fails to sustain attention due to reduced value.

7.4 Self-representation: Insights from an Indian sample

In Chapter 5, in a sample recruited from the Indian population, the SRE was tested in comparison to close other reference effect and semantic (syllable) condition. Memory sensitivity for self and close other referential information was higher compared to syllable condition. However, no significant difference in memory sensitivity was observed between self and close other referential information. This in line with reports from East Asian cultures, where both behavioural (Jianli & Ying, 2002;Sui, Zhu, & Chiu, 2007;Zhu & Zhang, 2002) and neuroimaging (Chiao et al., 2010;Zhang et al., 2006;Zhu, Zhang, Fan, & Han, 2007) results have demonstrated comparable memory sensitivity (or trait judgments) for self and close other referential information. This is argued to be the result of collectivistic values system of East Asian societies where close others are included within the self-schema. These results in similar levels of encoding and memory sensitivity for self and close other conditions in East Asians in the SRE paradigm. In contrast, European-American and Western European participants show higher memory sensitivity for self-referential compared to close other and syllable information (Lombardo, Barnes, Wheelwright, & Baron-Cohen, 2007; Rogers, Kuiper, & Kirker, 1977; Symons & Johnson, 1997). This is attributed to the individualistic value system of western societies where self-schema is focused and exclusive of close others. This result in the deeper encoding and SRE compared to close other condition in westerners.

The evidence from the current study is in line with the hypothesis of a collectivistic Indian culture (Mascolo et al., 2004; Sinha & Tripathi, 1994; Triandis, 1989) where self and close other are both presents in a similar schema in memory. This is a population-level phenomenon representing a cultural trait and does not discount the existence of individual differences within cultures.

Chapter 5 also tested the association between SRE and self-reports of self-construal traits in an Indian sample. The results found that Indians who have a more elaborate self-schema (inclusive of close-other), as evidenced by similar memory sensitivity for self and close-other, also have higher levels of interdependent self-construal traits. At the individual level, self-construal traits manifest as either independent or interdependent self, corresponding to overall cultural traits that are of individualistic or collectivistic nature respectively (Hazel R Markus & Kitayama, 1991). Using self-construal scale(Singelis, 1994) a functional neuroimaging study found activation in vMPFC, an area implicated in self-processing, associated with self-construal traits during general and contextual self-trait judgments task (Chiao et al., 2009). Using the same self-construal scale the current study observed that at the behavioural level, psychological self-representation in memory and self-construal traits are associated with each other such that individuals with a more elaborate self-schema in memory have higher self-reported interdependent traits. In the domain of psychological self-representation, there are reports of atypical self –representation in ASD involving aspects of self-reference effect in memory (Lombardo et al., 2007; Toichi et al., 2002). In Chapter 5 the association between psychological self-representation and autistic traits in the general Indian population was tested. Individuals with high autistic traits were found to have reduced memory sensitivity for close-other. Individuals higher in autistic traits showed poorer recall rates for close-other referential information but no association was observed for self-referential information. In western participants with ASD, SRE was found to be comparable to control participants (Lombardo et al., 2007). However, compared to controls, individuals with ASD showed a reduced difference between self and close other recall rates due to equivalent recall rates for both self and close other. This result was interpreted as a reduced capacity to differentiate self from other (Lombardo et al., 2007). However, results from Chapter 5 are in the opposite direction; individuals with high autistic traits show less elaborative schema for close-other and higher recall rates for self compared to close other.

In a collectivist culture where socio-cultural contexts result in comparable schemas for self and close-other, individuals high in autistic traits might be lacking in such integration.

7.5 Physical self-representation in individuals with clinically diagnosed ASD

In continuation to the discussion of physical self-representation in sub-clinical population, the next session discusses physical self-representation across modalities and in relation to autistic traits in individuals with clinical diagnosis of ASD.

7.5.1. *Is physical self-representation different across sensory modalities in ASD individuals?*

In individuals with clinically diagnosed ASD, there was no significant difference observed between self-face and self-voice representation. It can be interpreted that unlike the subclinical population, individuals with ASD do not have a more consolidated representation for self-face compared to self-voice, possibly due to reduced self-face examination from photos and videos as reported by several participants in the sample tested in the current study. In individuals with ASD reduced self-face examination may be because of reduced reward value associated with self-face similar to reduced reward value for social stimuli/faces in general (Chevallier et al., 2012). This is further supported by the results in Chapter 4; individuals with high autistic traits look at faces for a shorter duration than individuals with lower levels of autistic traits irrespective of whether the face is identified as self or other. There is no previous data investigating behavioural self-face representation using morphing paradigm in individuals with ASD. Future studies should explore the association between frequency of self-face examination and behavioural representation of self-face across general and ASD populations.

7.5.2. *Is physical self-representation significantly associated with autistic traits in ASD individuals?*

Similar to the general population, ASD males displayed a positive association between autistic traits and steepness of the slope of self-voice recognition. Thus a narrow self-other overlap (or a distinct self-representation) in the auditory modality was observed for ASD males with higher autistic traits. However, in ASD females, autistic traits were negatively associated with the slope of self-voice recognition indicating a less distinct self-representation in ASD females with higher autistic traits. This could indicate an atypical self-representation in the physical self domain with an inability to distinctly categorize self from other in ASD females. The current pattern of results comes from a small sample size and calls for larger studies of the role gender plays in the interaction between autistic traits and self-representation in ASD individuals. A similar result of reduced self-other distinction has been observed in autistic individuals in general in the domain of psychological self (Lombardo et al., 2007). Although the physical self-representation is generally intact in ASD males, in females with ASD this may not hold true and could be attributed to symptom severity.

7.6 General Conclusions

The results from the thesis show that physical self-representation differs between the visual and auditory modalities in neurotypical adults with a more consolidated mental representation of self-face compared to self-voice. Furthermore, results from two different cultural settings did not observe any association between physical self-representation in the visual and auditory modalities indicating distinct and independent self-representations in different modalities. The results also did not observe any association between the physical and psychological domains of self-representation. Taken together these results indicate that self-constructs can be processed at different levels independently and lends support to the theory that self-constructs have domain specific properties and can function independently where necessary. The results also found that depending on the nature of the task i.e., if the physical self is recognised explicitly or implicitly influences the representation of the physical self. In addition, the visual processing of faces identified as self differs from those identified as other with more gaze duration to different parts of the face for self-face compared to unfamiliar faces. This study showed that behavioural representation of self-face is associated with the visual processing of the self-face.

In a clinical context, the results found that autistic traits influence both domains of self-representation. In the domain of physical self, neurotypical adults with higher autistic traits exhibited a more distinct self-voice representation, an effect not observed for self-face representation. In ASD individuals, a gender difference was observed in physical self-representation with ASD males with higher autistic traits exhibiting a more distinct self-voice representation as observed in neurotypical adults. However, this pattern was reversed in ASD female participants, where higher autistic traits were associated with a less distinct self-voice representation. ASD female participants also showed a trend towards higher mean autistic traits compared to ASD male participants. This is an interesting finding outlining the importance of studying gender differences in cognitive tasks in the ASD population. The difference in physical self-representation between the visual and auditory modalities observed in the neurotypical adults was not observed in the ASD group. The ASD group did not show a significantly more consolidated mental representation of self-face compared to self-voice as was observed in neurotypical adults in two different cultural settings. Taken together these results indicate that autistic symptoms may interact in a non-linear manner with different constructs of self-representation depending on where in the autism spectrum the symptom severity of tested participant pool is positioned. In the domain of psychological self-representation, higher autistic traits were associated with a more focused self-representation with less inclusion of close-other in the self-schema. This result obtained from the Indian sample was in the opposite direction to previous reports of psychological self-representation in ASD individuals in a western culture which found less distinct self-representation in memory for individuals with ASD compared to neurotypical adults. This finding highlights the importance of investigating cognitive functioning in relation to autism in different cultural settings.

In conclusion, the current thesis provides evidence in support of multi-faceted nature of self-representation investigating associations between different modalities and domains of self-representation. The thesis also extends current understanding of physical self-representation in relation to ASD and autistic traits which were previously underexplored in the literature of ASD and self.

References

.Audacity® from http://audacity.sourceforge.net/

E-Prime® 2.0. from http://www.pstnet.com/eprime.cfm

.MathWorks - MATLAB and Simulink for Technical Computing. Fromhttp://www.mathworks.co.uk/

.Speech analysis, synthesis method STRAIGHT. from http://www.wakayamau.ac.jp/~kawahara/STRAIGHTadv/index_j.html

.GNU Image Manipulation Program. (2013), from http://www.gimp.org/

Ainley, V., Tajadura-Jiménez, A., Fotopoulou, A., & Tsakiris, M. (2012). Looking into myself: Changes in interoceptive sensitivity during mirror self-observation. *Psychophysiology*, 49(11), 1672-1676.

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (5th ed.)*.

Amsterdam, B. (1972). Mirror self-image reactions before age two. *Developmental Psychobiology*, 5(4), 297-305.

Anderson, J. R. (1984). The development of self-recognition: A review. *Developmental Psychobiology*, 17(1), 35-49.

Anderson, N. H. (1968). Likableness ratings of 555 personality-trait words. *Journal of*, 9(3), 272.

Apps, M. A., Tajadura-Jiménez, A., Turley, G., & Tsakiris, M. (2012). The different faces of one's self: an fMRI study into the recognition of current and past self-facial appearances. *Neuroimage*, 63(3), 1720-1729.

Asendorpf, J. B., Banse, R., & Mücke, D. (2002). Double dissociation between implicit and explicit personality self-concept: the case of shy behavior. *Journal of Personality and Social Psychology*, 83(2), 380.

Asperger, H. (1944). Die „Autistischen Psychopathen" im Kindesalter*. European Archives of Psychiatry and Clinical Neuroscience*, 117(1), 76-136.

Baron-Cohen, S. (2005). Autism–'autos': Literally, a total focus on the self. *The lost self: Pathologies of the Brain and Identity*, 166-180.

Baron-Cohen, S., Knickmeyer, R. C., & Belmonte, M. K. (2005). Sex differences in the brain: implications for explaining autism. *Science*, 310(5749), 819-823.

Baron-Cohen, S., Lombardo, M. V., Auyeung, B., Ashwin, E., Chakrabarti, B., & Knickmeyer, R. (2011). Why are autism spectrum conditions more prevalent in males? *PLoS Biol*, 9(6), e1001081.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, males and females, scientists and mathematicians*. Journal of Autism and Developmental Disorders*, 31(1), 5-17.

Barry, D. T. (2000). East Asians in America: Relationships between ethnic identity, self-construal, mental health, and acculturation patterns in East Asian immigrants in the United States. *ProQuest Information & Learning*.

Baumeister, R. F. (1986). Identity: Cultural change and the struggle for self: Oxford University Press.

Beale, J. M., & Keil, F. C. (1995). Categorical effects in the perception of faces. *Cognition*, 57(3), 217-239.

Bertenthal, B. I., & Fischer, K. W. (1978). Development of self-recognition in the infant. *Developmental Psychology*, 14(1), 44.

Bharati, A. (1985). The self in Hindu thought and action. In A. J. & G. D. Marsella, & E L. K. Hsu (Eds.), *Culture and Self* (pp. 185-230). New York: Tavistock Publications.

Bird, G., Catmur, C., Silani, G., Frith, C., & Frith, U. (2006). Attention does not modulate neural responses to social stimuli in autism spectrum disorders. *Neuroimage*, 31(4), 1614-1624.

Bird, G., & Viding, E. (2014). The self to other model of empathy: providing a new framework for understanding empathy impairments in psychopathy, autism, and alexithymia. *Neuroscience & Biobehavioral Reviews*, 47, 520-532.

Blais, C., Jack, R. E., Scheepers, C., Fiset, D., & Caldara, R. (2008). Culture shapes how we look at faces. *PloS one*, 3(8), e3022.

Blakemore, S.-J., & Frith, C. (2003). Self-awareness and action. *Current Opinion in Neurobiology*, 13(2), 219-224.

Blakemore, S.-J., Frith, C. D., & Wolpert, D. M. (1999). Spatio-temporal prediction modulates the perception of self-produced stimuli. *Journal of Cognitive Neuroscience*, 11(5), 551-559.

Bleuler, E. (1951). Autistic thinking.

Bohne, A., Keuthen, N. J., Wilhelm, S., Deckersbach, T., & Jenike, M. A. (2002). Prevalence of symptoms of body dysmorphic disorder and its correlates: a cross-cultural comparison. *Psychosomatics*, 43(6), 486-490.

Bonnel, A.-M., Mottron, L., Peretz, I., Trudel, M., & Gallun, E. (2003). Enhanced pitch sensitivity in individuals with autism: A signal detection analysis. *Journal of Cognitive Neuroscience,*, 15(2), 226-235.

Bourne, V. J. (2005). Lateralised processing of positive facial emotion: Sex differences in strength of hemispheric dominance. *Neuropsychologia*, 43(6), 953-956.

Bower, G. H., & Gilligan, S. G. (1979). Remembering information related to one's self. *Journal of Research in Personality*, 13(4), 420-432.

Brady, N., Campbell, M., & Flaherty, M. (2004). My left brain and me: a dissociation in the perception of self and others. *Neuropsychologia*, 42(9), 1156-1161.

Brédart, S., Delchambre, M., & Laureys, S. (2006). Short article one's own face is hard to ignore. *The Quarterly Journal of Experimental Psychology*, 59(1), 46-52.

Brewer, M. B. (1991). The social self: On being the same and different at the same time. Personality and Social Psychology Bulletin, 17(5), 475-482.

Brooks-Gunn, J., & Lewis, M. (1984). The development of early visual self-recognition. *Developmental Review*, 4(3), 215-239.

Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology*, 77(3), 305-327.

Buckner, R. L., & Carroll, D. C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences*, 11(2), 49-57.

Caharel, S., Poiroux, S., Bernard, C., Thibaut, F., Lalonde, R., & Rebai, M. (2002). ERPs associated with familiarity and degree of familiarity during face recognition. *International Journal of Neuroscience*, 112(12), 1499-1512.

Candini, M., Zamagni, E., Nuzzo, A., Ruotolo, F., Iachini, T., & Frassinetti, F. (2014). Who is speaking? Implicit and explicit self and other voice recognition. *Brain and Cognition*, 92, 112-117.

Carmody, D. P., & Lewis, M. (2012). Self representation in children with and without autism spectrum disorders. *Child Psychiatry & Human Development*, 43(2), 227-237.

Chakraborty, A., & Chakrabarti, B. (2015). Is it me? Self-recognition bias across sensory modalities and its relationship to autistic traits. *Molecular Autism*, 6(1), 1.

Chang, E. C., Elizabeth, A. Y., & Kahle, E. R. (2014). BMI, body discrepancy, and self-construal as predictors of eating disturbances in European and Asian American females. *Eating Behaviors*, 15(2), 328-330.

Cheon, B. K., Mathur, V. A., & Chiao, J. Y. (2010). Empathy as cultural process: insights from the cultural neuroscience of empathy. *World Cult Psychiatry Res Rev*, 5, 32-42.

Chevallier, C., Kohls, G., Troiani, V., Brodkin, E. S., & Schultz, R. T. (2012). The social motivation theory of autism. *Trends in Cognitive Sciences*, 16(4), 231-239.

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., . . . Iidaka, T. (2009). Neural basis of individualistic and collectivistic views of self. *Human Brain Mapping*, 30(9), 2813-2820.

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., . . . Iidaka, T. (2010). Dynamic cultural influences on neural representations of the self. *Journal of Cognitive Neuroscience*, 22(1), 1-11.

Constantino, J. N., & Gruber, C. P. (2007). Social responsiveness scale (SRS): Western Psychological Services Los Angeles, CA.

Constantino, J. N., & Todd, R. D. (2003). Autistic traits in the general population: a twin study. *Archives of General Psychiatry*, 60(5), 524-530.

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, 107(2), 261.

Conway, M. A., Singer, J. A., & Tagini, A. (2004). The self and autobiographical memory: Correspondence and coherence. *Social Cognition*, 22(5), 491.

Cooley, C. H. (1992). Human nature and the social order: Transaction Publishers. USA.

Cooley, C. H. H. N. (1902). The Social Order. New York: Charles Scribner's Sons. Corp, I. (2013). IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY.

Cousineau, D. (2005). Confidence intervals in within-subject designs: A simpler solution to Loftus and Masson’s method. *Tutorials in Quantitative Methods for Psychology*, 1(1), 42-45.

Cross, S. E., Bacon, P. L., & Morris, M. L. (2000). The relational-interdependent self-construal and relationships. *Journal of Personality and Social Psychology*, 78(4), 791.

Cross, S. E., Hardin, E. E., & Gercek-Swing, B. (2010). The what, how, why, and where of self-construal. *Personality and Social Psychology Review*.

Cygan, H. B., Tacikowski, P., Ostaszewski, P., Chojnicka, I., & Nowicka, A. (2014). Neural correlates of own name and own face detection in autism spectrum disorder. *PloS one*, 9(1), e86020.

Dalton, K. M., Nacewicz, B. M., Johnstone, T., Schaefer, H. S., Gernsbacher, M. A., Goldsmith, H., . . . Davidson, R. J. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience*, 8(4), 519-526.

Dawson, G., & McKissick, F. C. (1984). Self-recognition in autistic children. *Journal of Autism and Developmental Disorders*, 14(4), 383-394.

Decety, J., & Jackson, P. L. (2006). A social-neuroscience perspective on empathy. *Current Directions in Psychological Science*, 15(2), 54-58.

Decety, J., Perani, D., Jeannerod, M., Bettinardi, V., Tadary, B., Woods, R., . . . Fazio, F. (1994). Mapping motor representations with positron emission tomography. *Nature,* 371(6498), 600 – 602.

Devue, C., Van der Stigchel, S., Brédart, S., & Theeuwes, J. (2009). You do not find your own face faster; you just look at it longer. *Cognition,* 111(1), 114-122.

Dhawan, N., Roseman, I. J., Naidu, R., Thapa, K., & Rettek, S. I. (1995). Self-concepts across two cultures India and the United States. *Journal of Cross-Cultural Psychology*, 26(6), 606-621.

Di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding motor events: a neurophysiological study. *Experimental Brain Research*, 91(1), 176-180.

Dienes, Z. (2011). Bayesian versus orthodox statistics: Which side are you on*? Perspectives on Psychological Science*, 6(3), 274-290.

Dunphy-Lelii, S., & Wellman, H. M. (2012). Delayed self-recognition in autism: A unique difficulty? *Research in Autism Spectrum Disorders*, 6(1), 212-223.

Egenolf, Y., Stein, M., Koenig, T., Holtforth, M. G., Dierks, T., & Caspar, F. (2013). Tracking the implicit self using event-related potentials. *Cognitive, Affective, & Behavioral Neuroscience*, 13(4), 885-899.

Ehlers, S., Gillberg, C., & Wing, L. (1999). A screening questionnaire for Asperger syndrome and other high-functioning autism spectrum disorders in school age children. *Journal of Autism and Developmental Disorders*, 29(2), 129-141.

Ellis, H. D., Jones, D. M., & Mosdell, N. (1997). Intra-and inter-modal repetition priming of familiar faces and voices. *British Journal of Psychology*, 88(1), 143-156.

Eshkevari, E., Rieger, E., Longo, M. R., Haggard, P., & Treasure, J. (2012). Increased plasticityof the bodily self in eating disorders. *Psychological Medicine*, 42(04), 819-828.

Esposito, F., Bertolino, A., Scarabino, T., Latorre, V., Blasi, G., Popolizio, T., . . . Di Salle, F. (2006). Independent component model of the default-mode brain function: Assessing the impact of active thinking. *Brain Research Bulletin*, 70(4), 263-269.

Fazio, R. H., Jackson, J. R., Dunton, B. C., & Williams, C. J. (1995). Variability in automatic activation as an unobtrusive measure of racial attitudes: a bona fide pipeline? *Journal of Personality and Social Psychology*, 69(6), 1013.

Ferrari, M., & Matthews, W. S. (1983). Self-recognition deficits in autism: Syndrome-specific or general developmental delay*? Journal of Autism and Developmental Disorders*, 13(3), 317-324.

Fink, G. R., Markowitsch, H. J., Reinkemeier, M., Bruckbauer, T., Kessler, J., & Heiss, W.-D. (1996). Cerebral representation of one’s own past: neural networks involved in autobiographical memory. *The Journal of Neuroscience*, 16(13), 4275-4282.

Fourneret, P., & Jeannerod, M. (1998). Limited conscious monitoring of motor performance in normal subjects. *Neuropsychologia*, 36(11), 1133-1140.

Franck, E., De Raedt, R., & De Houwer, J. (2007). Implicit but not explicit self-esteem predicts future depressive symptomatology. *Behaviour Research and Therapy*, 45(10), 2448-2455.

Franck, N., Farrer, C., Georgieff, N., Marie-Cardine, M., Daléry, J., d'Amato, T., & Jeannerod, M. (2001). Defective recognition of one's own actions in patients with schizophrenia. *American Journal of Psychiatry*, 158(3), 454-459.

Fransson, P. (2006). How default is the default mode of brain function?: Further evidence from intrinsic BOLD signal fluctuations. *Neuropsychologia*, 44(14), 2836-2845.

Frazier, T. W., Georgiades, S., Bishop, S. L., & Hardan, A. Y. (2014). Behavioral and cognitive characteristics of females and males with autism in the Simons Simplex Collection. *Journal of the American Academy of Child & Adolescent Psychiatry*, 53(3), 329-340. e323.

Fredrickson, B. L., Roberts, T.-A., Noll, S. M., Quinn, D. M., & Twenge, J. M. (1998). That swimsuit becomes you: sex differences in self-objectification, restrained eating, and math performance. *Journal of Personality and Social Psychology*, 75(1), 269.

freeware, M.-m. Sqirlz Morph 2.1, from http://www.xiberpix.net/SqirlzMorph.html

Frith, C., & Frith, U. (2005). Theory of mind. *Current Biology*, 15(17), R644-R645.

Frith, U., & De Vignemont, F. (2005). Egocentrism, allocentrism, and Asperger syndrome. *Consciousness and Cognition*, 14(4), 719-738.

Frith, U., & Happé, F. (1999). Theory of mind and self-consciousness: What is it like to be autistic? *Mind & Language*, 14(1), 82-89.

Gallagher, S. (2000). Philosophical conceptions of the self: implications for cognitive science. *Trends in Cognitive Sciences*, 4(1), 14-21.

Gallese, V. (2007). Before and below 'theory of mind': embodied simulation and the neural correlates of social cognition. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 362(1480), 659-669.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, 119(2), 593-609.

Gallese, V., & Goldman, A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends in Cognitive Sciences*, 2(12), 493-501.

Gallup, G. G. (1970). Chimpanzees: self-recognition. *Science*, 167(3914), 86-87.

Gallup, G. G. (1982). Self-awareness and the emergence of mind in primates. *American Journal of Primatology*, 2(3), 237-248.

Gallup, G. G. (1998). Self-awareness and the evolution of social intelligence. *Behavioural Processes*, 42(2), 239-247.

Gallup Jr, G. G. (1983). Toward a comparative psychology of mind. *Animal Cognition and Behavior*, 473-510.

Gardner, W. L., Gabriel, S., & Dean, K. K. (2004). The individual as" melting pot": The flexibility of bicultural self-construals. Cahiers de Psychologie Cognitive/Current Psychology of Cognition.

Gardner, W. L., Gabriel, S., & Lee, A. Y. (1999). “I” value freedom, but “we” value relationships: Self-construal priming mirrors cultural differences in judgment. *Psychological Science*, 10(4), 321-326.

Garfinkel, P. E., Moldofsky, H., Garner, D. M., Stancer, H. C., & Coscina, D. V. (1978). Body awareness in anorexia nervosa: disturbances in" body image" and" satiety". *Psychosomatic Medicine*, 40(6), 487-498.

Garner, D. M., & Garfinkel, P. E. (1982). Body image in anorexia nervosa: Measurement, theory and clinical implications. *The International Journal of Psychiatry in Medicine*, 11(3), 263-284.

Geng, H., Zhang, S., Li, Q., Tao, R., & Xu, S. (2012). Dissociations of subliminal and supraliminal self-face from other-face processing: behavioral and ERP evidence. *Neuropsychologia,* 50(12), 2933-2942.

Geschwind, N., & Galaburda, A. M. (1985). Cerebral lateralization: Biological mechanisms, associations, and pathology: I. A hypothesis and a program for research. *Archives of Neurology*, 42(5), 428.

Gillespie-Smith, K., Doherty-Sneddon, G., Hancock, P. J., & Riby, D. M. (2014). That looks familiar: attention allocation to familiar and unfamiliar faces in children with autism spectrum disorder. *Cognitive Neuropsychiatry*, 19(6), 554-569.

Gillihan, S. J., & Farah, M. J. (2005). Is self special? A critical review of evidence from experimental psychology and cognitive neuroscience. *Psychological Bulletin*, 131(1), 76.

Goddard, L., Howlin, P., Dritschel, B., & Patel, T. (2007). Autobiographical memory and social problem-solving in Asperger syndrome. *Journal of Autism and Developmental Disorders*, 37(2), 291-300.

Graux, J., Gomot, M., Roux, S., Bonnet-Brilhault, F., & Bruneau, N. (2015). Is my voice just a familiar voice? An electrophysiological study. *Social Cognitive andA Neuroscience*, 10(1), 101-105.

Gray, H. M., Ambady, N., Lowenthal, W. T., & Deldin, P. (2004). P300 as an index of attention to self-relevant stimuli. *Journal of Experimental Social Psychology*, 40(2), 216-224.

Greenwald, A., & Pratkanis, A. (1984). The self. In R. S. Wyer & TK Srull. Handbook of Social Cognition, 1, 129-178.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test. *Journal of Personality and Social Psychology*, 74(6), 1464.

Gusnard, D. A., Akbudak, E., Shulman, G. L., & Raichle, M. E. (2001). Medial prefrontal cortex and self-referential mental activity: relation to a default mode of brain function. *Proceedings of the National Academy of Sciences*, 98(7), 4259-4264.

Gusnard, D. A., & Raichle, M. E. (2001). Searching for a baseline: functional imaging and the resting human brain. *Nature Reviews Neuroscience*, 2(10), 685-694.

Haffey, A., Press, C., O'Connell, G., & Chakrabarti, B. (2013). Autistic traits modulate mimicry of social but not nonsocial rewards. *Autism Research*, 6(6), 614-620.

Hallowell, A. I. (1955). Culture and experience: Philadelphia: University of Pennsylvania Press.

Han, S., & Northoff, G. (2008). Culture-sensitive neural substrates of human cognition: A transcultural neuroimaging approach. *Nature Reviews Neuroscience*, 9(8), 646-654.

Hanko, K., Crusius, J., & Mussweiler, T. (2010). When I and me are different: assimilation and contrast in temporal self-comparisons. *European Journal of Social Psychology*, 40(1), 160-168.

Hanley, J. R., Smith, S. T., & Hadfield, J. (1998). I recognise you but I can't place you: An investigation of familiar-only experiences during tests of voice and face recognition. *The Quarterly Journal of Experimental Psychology: Section A*, 51(1), 179-195.

Happé, F., Ronald, A., & Plomin, R. (2006). Time to give up on a single explanation for autism. *Nature Neuroscience*, 9(10), 1218-1220.

Harrop, C., Shire, S., Gulsrud, A., Chang, Y.-C., Ishijima, E., Lawton, K., & Kasari, C. (2015). Does gender influence core deficits in ASD? An investigation into social-communication and play of girls and boys with ASD. *Journal of Autism and Developmental Disorders*, 45(3), 766-777.

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). Emotional contagion: United Kingdom: Cambridge university press. Head, H. (1922). Studies in neurology. The American Journal of the Medical Sciences, 164(4), 601.

Heine, S. J., Lehman, D. R., Peng, K., & Greenholtz, J. (2002). What's wrong with cross-cultural comparisons of subjective Likert scales?: The reference-group effect. *Journal of Personality and Social Psychology*, 82(6), 903.

Heinisch, C., Dinse, H. R., Tegenthoff, M., Juckel, G., & Brüne, M. (2011). An rTMS study into self-face recognition using video-morphing technique. *Social Cognitive and Affective Neuroscience*, 6(4), 442-449.

Heisz, J. J., & Shore, D. I. (2008). More efficient scanning for familiar faces. *Journal of Vision*, 8(1), 9-9.

Henderson, J. M., Williams, C. C., & Falk, R. J. (2005). Eye movements are functional during face learning. Memory & Cognition, 33(1), 98-106.

Hofmann, W., Gawronski, B., Gschwendner, T., Le, H., & Schmitt, M. (2005). A meta-analysis on the correlation between the Implicit Association Test and explicit self-report measures. *Personality and Social Psychology Bulletin*, 31(10), 1369-1385.

Hofstede, G. (1980). Culture's Consequences: International Differences in Work-Related Values: Beverly Hills CA: Sage Publications.

Holzman, P. S., Rousey, C., & Snyder, C. (1966). On listening to one's own voice: Effects on psychophysiological responses and free associations. *Journal of Personality and Social Psychology*, 4(4), 432.

Hughes, S. M., & Nicholson, S. E. (2010). The processing of auditory and visual recognition of self-stimuli. *Consciousness and Cognition*, 19(4), 1124-1134.

Hungr, C. J., & Hunt, A. R. (2012). Physical self-similarity enhances the gaze-cueing effect. *The Quarterly Journal of Experimental Psychology*, 65(7), 1250-1259.

Iacoboni, M. (2006). Failure to deactivate in autism: the co-constitution of self and other. *Trends in Cognitive Sciences*, 10(10), 431-433.

Iacoboni, M., & Dapretto, M. (2006). The mirror neuron system and the consequences of its dysfunction. *Nature Reviews Neuroscience*, 7(12), 942-951.

IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.

Irani, F., Platek, S. M., Panyavin, I. S., Calkins, M. E., Kohler, C., Siegel, S. J., . . . Gur, R. C. (2006). Self-face recognition and theory of mind in patients with schizophrenia and first-degree relatives. *Schizophrenia Research*, 88(1), 151-160.

Itier, R. J., Alain, C., Sedore, K., & McIntosh, A. R. (2007). Early face processing specificity: It's in the eyes! *Journal of Cognitive Neuroscience*, 19(11), 1815-1826.

Jack, R. E., Garrod, O. G., Yu, H., Caldara, R., & Schyns, P. G. (2012). Facial expressions of emotion are not culturally universal. *Proceedings of the National Academy of Sciences*, 109(19), 7241-7244.

James, W. (1890). The principles of psychology (Vol. I). New York: Holt.

James, W. (1913). The principles of psychology, Vol I. New York: Holt.

Janik, S. W., Wellens, A. R., Goldberg, M. L., & Dell'Osso, L. F. (1978). Eyes as the center of focus in the visual examination of human faces. *Perceptual and Motor Skills*, 47(3), 857-858.

Jeannerod, M. (2003). The mechanism of self-recognition in humans. *Behavioural Brain Research*, 142(1), 1-15.

Jeffreys, H. (1998). The theory of probability: OUP Oxford.

Jianli, Q., & Ying, Z. (2002). the self-reference effect of Chinese college students [J]. *Psychological Science*, 3, 004.

Joassin, F., Maurage, P., Bruyer, R., Crommelinck, M., & Campanella, S. (2004). When audition alters vision: an event-related potential study of the cross-modal interactions between faces and voices. *Neuroscience Letters*, 369(2), 132-137.

Jung, J., & Lee, S. H. (2006). Cross-cultural comparisons of appearance self-schema, body image, self-esteem, and dieting behavior between Korean and US women. *Family and Consumer Sciences Research Journal*, 34(4), 350-365.

Kanner, L. (1943). Autistic disturbances of affective contact: publisher not identified.

Kaplan, J. T., Aziz-Zadeh, L., Uddin, L. Q., & Iacoboni, M. (2008). The self across the senses: an fMRI study of self-face and self-voice recognition. *Social Cognitive and Affective Neuroscience*, 3(3), 218-223.

Kärtner, J., Keller, H., Chaudhary, N., & Yovsi, R. D. (2012). The development of mirror self-recognition in different sociocultural contexts. *Monographs of the Society for Research in Child Development*, 77(4), vii-viii, 1-87.

Keenan, J. M., Golding, J. M., & Brown, P. (1992). Factors controlling the advantage of self-reference over other-reference. *Social Cognition*, 10(1), 79.

Keenan, J. P., Gallup, G. C., & Falk, D. (2003). The face in the mirror: The search for the origins of consciousness: HarperCollins Publishers.

Keenan, J. P., Ganis, G., Freund, S., & Pascual-Leone, A. (2000). Self-face identification is increased with left hand responses. Laterality: Asymmetries of Body, *Brain and Cognition*, 5(3), 259-268.

Keenan, J. P., McCutcheon, B., Freund, S., Gallup, G. G., Sanders, G., & Pascual-Leone, A. (1999). Left hand advantage in a self-face recognition task. *Neuropsychologia*, 37(12), 1421-1425.

Keenan, J. P., Wheeler, M., Platek, S. M., Lardi, G., & Lassonde, M. (2003). Self-face processing in a callosotomy patient. *European Journal of Neuroscience*, 18(8), 2391-2395.

Keenan, J. P., Wheeler, M. A., & Ewers, M. (2003). The neural correlates of self-awareness and self-recognition. *The self in Neuroscience and Psychiatry*, 7, 166-179.

Keller, H., Yovsi, R., Borke, J., Kärtner, J., Jensen, H., & Papaligoura, Z. (2004). Developmental Consequences of Early Parenting Experiences: Self-Recognition and Self-Regulation in Three Cultural Communities. *Child Development*, 75(6), 1745-1760.

Kennedy, D. P., & Courchesne, E. (2008). The intrinsic functional organization of the brain is altered in autism. *Neuroimage*, 39(4), 1877-1885.

Keysers, C., & Gazzola, V. (2007). Integrating simulation and theory of mind: from self to social cognition. *Space,* 8, 108-114.

Kircher, T. T., Brammer, M., Bullmore, E., Simmons, A., Bartels, M., & David, A. S. (2002). The neural correlates of intentional and incidental self processing. *Neuropsychologia,* 40(6), 683-692.

Kircher, T. T., Senior, C., Phillips, M. L., Rabe-Hesketh, S., Benson, P. J., Bullmore, E. T., . . . David, A. S. (2001). *Recognizing one's own face. Cognition*, 78(1), B1-B15.

Kita, Y., Gunji, A., Sakihara, K., Inagaki, M., Kaga, M., Nakagawa, E., & Hosokawa, T. (2010). Scanning strategies do not modulate face identification: Eye-tracking and near-infrared spectroscopy study. *PloS one*, 5(6), e11050.

Klatzky, R. L., & Forrest, F. H. (1984). Recognizing familiar and unfamiliar faces*. Memory & Cognition*, 12(1), 60-70.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, 59(9), 809-816.

Knecht, S., Dräger, B., Deppe, M., Bobe, L., Lohmann, H., Flöel, A., . . . Henningsen, H. (2000). Handedness and hemispheric language dominance in healthy humans. *Brain*, 123(12), 2512-2518.

Kühnen, U., Hannover, B., & Schubert, B. (2001). The semantic–procedural interface model of the self: The role of self-knowledge for context-dependent versus context-independent modes of thinking. *Journal of Personality and Social Psychology*, 80(3), 397.

Kühnen, U., & Oyserman, D. (2002). Thinking about the self influences thinking in general: Cognitive consequences of salient self-concept. *Journal of Experimental Social Psychology*, 38(5), 492-499.

Lai, M.-C., Lombardo, M. V., Auyeung, B., Chakrabarti, B., & Baron-Cohen, S. (2015). Sex/gender differences and autism: setting the scene for future research. *Journal of the American Academy of Child & Adolescent Psychiatry*, 54(1), 11-24.

Lai, M.-C., Lombardo, M. V., Ruigrok, A. N., Chakrabarti, B., Wheelwright, S. J., Auyeung, B., . . . Consortium, M. A. (2012). Cognition in males and females with autism: similarities and differences. *PloS one*, 7(10), e47198.

Laird, J. D., Alibozak, T., Davainis, D., Deignan, K., Fontanella, K., Hong, J., . . . Pacheco, C. (1994). Individual differences in the effects of spontaneous mimicry on emotional contagion. *Motivation and Emotion*, 18(3), 231-247.

Lane, R. D., Kivley, L. S., Du Bois, M. A., Shamasundara, P., & Schwartz, G. E. (1995). Levels of emotional awareness and the degree of right hemispheric dominance in the perception of facial emotion. *Neuropsychologia*, 33(5), 525-538.

Laughery, K. R., Alexander, J. F., & Lane, A. B. (1971). Recognition of human faces: Effects of target exposure time, target position, pose position, and type of photograph. *Journal of Applied Psychology*, 55(5), 477.

Leary, M. R., & Tangney, J. P. (2011). Handbook of self and identity: Guilford Press.

Lewis, M. (2012). Social cognition and the acquisition of self: Springer Science & Business Media.

Lewis, M., & Ramsay, D. (2004). Development of Self-Recognition, Personal Pronoun Use, and Pretend Play During the 2nd Year. *Child Development*, 75(6), 1821-1831.

Liew, S.-L., Ma, Y., Han, S., & Aziz-Zadeh, L. (2011). Who's afraid of the boss: cultural differences in social hierarchies modulate self-face recognition in Chinese and Americans. PloS one, 6(2), e16901.

Lin, Z., Lin, Y., & Han, S. (2008). Self-construal priming modulates visual activity underlying global/local perception. *Biological Psychology*, 77(1), 93-97.

Lind, S. (2010). Memory and the self in autism: A review and theoretical framework. Autism, 14(5), 430-456.

Lind, S. E., & Bowler, D. M. (2009). Delayed self-recognition in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 39(4), 643-650.

Lombardo, M. V., Barnes, J. L., Wheelwright, S. J., & Baron-Cohen, S. (2007). Self-referential cognition and empathy in autism. *PLoS One*, 2(9), e883.

Lombardo, M. V., & Baron-Cohen, S. (2010). Unraveling the paradox of the autistic self. Wiley Interdisciplinary Reviews: Cognitive Science, 1(3), 393-403.

Lombardo, M. V., Chakrabarti, B., & Baron-Cohen, S. (2009). What neuroimaging and perceptions of self-other similarity can tell us about the mechanism underlying mentalizing. *Behavioral and Brain Sciences*, 32(02), 152-153.

Lombardo, M. V., Chakrabarti, B., Bullmore, E. T., Sadek, S. A., Pasco, G., Wheelwright, S. J., . . . Consortium, M. A. (2010). Atypical neural self-representation in autism. *Brain*, 133(2), 611-624.

Loring, D. W., Meador, K. J., Lee, G. P., Murro, A. M., Smith, J. R., Flanigin, H. F., . . . King, D. W. (1990). Cerebral language lateralization: evidence from intracarotid amobarbital testing. *Neuropsychologia*, 28(8), 831-838.

Losh, M., & Capps, L. (2003). Narrative ability in high-functioning children with autism or Asperger's syndrome. *Journal of Autism and Developmental Disorders*, 33(3), 239-251.

Luria, S. M., & Strauss, M. S. (2013). Comparison of eye movements over faces in photographic positives and negatives. *Perception*, 42(11), 1134-1143.

Lutty, G., Thompson, D. C., Gallup, J. Y., Mello, R. J., Patz, A., & Fenselau, A. (1983). Vitreous: an inhibitor of retinal extract-induced neovascularization. *Investigative Ophthalmology & Visual Science*, 24(1), 52-56.

Ma, Y., & Han, S. (2009). Self-face advantage is modulated by social threat–Boss effect on self-face recognition. *Journal of Experimental Social Psychology*, 45(4), 1048-1051.

Ma, Y., & Han, S. (2010). Why we respond faster to the self than to others? An implicit positive association theory of self-advantage during implicit face recognition. *Journal of Experimental Psychology: Human Perception and Performance*, 36(3), 619.

Macrae, C. N., Moran, J. M., Heatherton, T. F., Banfield, J. F., & Kelley, W. M. (2004). Medial prefrontal activity predicts memory for self. *Cerebral Cortex*, 14(6), 647-654.

Maister, L., & Tsakiris, M. (2014). My face, my heart: Cultural differences in integrated bodily self-awareness. *Cognitive Neuroscience*, 5(1), 10-16.

Maki, R. H., & McCaul, K. D. (1985). The effects of self-reference versus other reference on the recall of traits and nouns. *Bulletin of the Psychonomic Society*, 23(3), 169-172.

Mandy, W., Chilvers, R., Chowdhury, U., Salter, G., Seigal, A., & Skuse, D. (2012). Sex differences in autism spectrum disorder: evidence from a large sample of children and adolescents. *Journal of Autism and Developmental Disorders*, 42(7), 1304-1313.

Marian, V., & Kaushanskaya, M. (2004). Self-construal and emotion in bicultural bilinguals. Journal of *Memory and Language*, 51(2), 190-201.

Markus, H., & Nurius, P. (1986). Possible selves. *American Psychologist*, 41(9), 954.

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, 98(2), 224.

Markus, H. R., & Kitayama, S. (2010). Cultures and selves A cycle of mutual constitution. *Perspectives on Psychological Science*, 5(4), 420-430.

Mascolo, M. F., Misra, G., & Rapisardi, C. (2004). Individual and relational conceptions of self in India and the United States. *New directions for Child and Adolescent Development*, 2004(104), 9-26.

Matson, J. L., Hattier, M. A., & Williams, L. W. (2012). How does relaxing the algorithm for autism affect DSM-V prevalence rates*? Journal of Autism and Developmental Disorders*, 42(8), 1549-1556.

Mead, G. H. (1913). The social self. *The Journal of Philosophy, Psychology and Scientific Methods*, 10(14), 374-380.

Meltzoff, A. N., & Brooks, R. (2001). Like me" as a building block for understanding other minds: Bodily acts, attention, and intention. *Intentions and intentionality: Foundations of social cognition*, 171-191.

Mitchell, R. W. (1993). Mental models of mirror-self-recognition: Two theories. *New ideas in Psychology*, 11(3), 295-325.

Molenaar, P. C., & Campbell, C. G. (2009). The new person-specific paradigm in psychology*.* *Current Directions in Psychological Science*, 18(2), 112-117.

Molenberghs, P., Cunnington, R., & Mattingley, J. B. (2012). Brain regions with mirror properties: a meta-analysis of 125 human fMRI studies. *Neuroscience & Biobehavioral Reviews*, 36(1), 341-349.

Moran, J. M., Heatherton, T. F., & Kelley, W. M. (2009). Modulation of cortical midline structures by implicit and explicit self-relevance evaluation. *Social Neuroscience*, 4(3), 197-211.

Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly journal of Experimental Psychology*, 11(1), 56-60.

Muth, J. L., & Cash, T. F. (1997). Body-Image Attitudes: What Difference Does Gender Make? *Journal of Applied Social Psychology*, 27(16), 1438-1452.

Neisser, U. (1988). Five kinds of self-knowledge. *Philosophical Psychology*, 1(1), 35-59.

Neuman, C. J., & Hill, S. D. (1978). Self-recognition and stimulus preference in autistic children. *Developmental Psychobiology*, 11(6), 571-578.

Ng, S. H., Han, S., Mao, L., & Lai, J. C. (2010). Dynamic bicultural brains: fMRI study of their flexible neural representation of self and significant others in response to culture primes. *Asian Journal of Social Psychology*, 13(2), 83-91.

Nielsen, M., & Dissanayake, C. (2004). Pretend play, mirror self-recognition and imitation: A longitudinal investigation through the second year. *Infant Behavior and Development*, 27(3), 342-365.

Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. *Trends in Cognitive Sciences*, 8(3), 102-107.

Northoff, G., Heinzel, A., De Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain—a meta-analysis of imaging studies on the self. *Neuroimage*, 31(1), 440-457.

Orth, U., Robins, R. W., & Meier, L. L. (2009). Disentangling the effects of low self-esteem and stressful events on depression: findings from three longitudinal studies. *Journal of Personality and Social Psychology*, 97(2), 307.

Oyserman, D., & Lee, S. W. (2008). Does culture influence what and how we think? Effects of priming individualism and collectivism. *Psychological Bulletin*, 134(2), 311.

Oyserman, D., & Lee, S. W. (2008). A situated cognition perspective on culture: Effects of priming cultural syndromes on cognition and motivation. *In R. Sorrentino & S. Yamaguchi (Eds.) Handbook of*.

Pannese, A., & Hirsch, J. (2011). Self-face enhances processing of immediately preceding invisible faces. *Neuropsychologia*, 49(3), 564-573.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders*, 32(4), 249-261.

Perner, J. (1999). Theory of mind. *Developmental Psychology: Achievements and Prospects*, 205-230.

Platek, S. M., & Gallup, G. G. (2002). Self-face recognition is affected by schizotypal personality traits. *Schizophrenia Research*, 57(1), 81-85.

Platek, S. M., Keenan, J. P., & Mohamed, F. B. (2005). Sex differences in the neural correlates of child facial resemblance: an event-related fMRI study. *Neuroimage*, 25(4), 1336-1344.

Platek, S. M., & Krill, A. L. (2009). Self-face resemblance attenuates other-race face effect in the amygdala. *Brain research*, 1284, 156-160.

Platek, S. M., Krill, A. L., & Wilson, B. (2009). Implicit trustworthiness ratings of self-resembling faces activate brain centers involved in reward. *Neuropsychologia*, 47(1), 289-293.

Platek, S. M., Thomson, J. W., & Gallup, G. G. (2004). Cross-modal self-recognition: the role of visual, auditory, and olfactory primes. *Consciousness and Cognition*, 13(1), 197-210.

Platek, S. M., Wathne, K., Tierney, N. G., & Thomson, J. W. (2008). Neural correlates of self-face recognition: an effect-location meta-analysis. *Brain Research*, 1232, 173-184.

Poldrack, R. A. (2006). Can cognitive processes be inferred from neuroimaging data? *Trends in Cognitive Sciences*, 10(2), 59-63.

Preilowski, B. (1979). Consciousness After Complete Surgical Section of the Fore—Brain Commissures in Man - Structure and function of cerebral commissures (pp. 411-420): Springer.

Prinz, W. (2013). Self in the mirror. *Consciousness and Cognition,* 22(3), 1105-1113.

Qin, P., & Northoff, G. (2011). How is our self related to midline regions and the default-mode network? *Neuroimage*, 57(3), 1221-1233.

Raichle, M. E., & Snyder, A. Z. (2007). A default mode of brain function: a brief history of an evolving idea. *Neuroimage*, 37(4), 1083-1090.

Rameson, L. T., Satpute, A. B., & Lieberman, M. D. (2010). The neural correlates of implicit and explicit self-relevant processing. *Neuroimage*, 50(2), 701-708.

Raven, J. C., & Court, J. H. (1998). Raven's progressive matrices and vocabulary scales: Oxford Psychologists Press Oxford, UK.

Riby, D. M., & Hancock, P. J. (2009). Do faces capture the attention of individuals with Williams syndrome or autism? Evidence from tracking eye movements. *Journal of Autism and Developmental Disorders*, 39(3), 421-431.

Rizzolatti, G., Fogassi, L., & Gallese, V. (2001). Neurophysiological mechanisms underlying the understanding and imitation of action. *Nature Reviews Neuroscience*, 2(9), 661-670.

Robins, D. L., Fein, D., Barton, M. L., & Green, J. A. (2001). The Modified Checklist for Autism in Toddlers: an initial study investigating the early detection of autism and pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, 31(2), 131-144.

Robinson, E. B., Munir, K., Munafò, M. R., Hughes, M., McCormick, M. C., & Koenen, K. C. (2011). Stability of autistic traits in the general population: further evidence for a continuum of impairment. *Journal of the American Academy of Child & Adolescent Psychiatry*, 50(4), 376-384.

Rochat, P. (2011). The self as phenotype. *Consciousness and Cognition*, 20(1), 109-119.

Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, 35(9), 677.

Roland, A. (1991). In search of self in India and Japan: Toward a cross-cultural psychology: Princeton University Press, USA.

Ronald, A., Happe, F., Bolton, P., Butcher, L. M., Price, T. S., Wheelwright, S., . . . Plomin, R. (2006). Genetic heterogeneity between the three components of the autism spectrum: a twin study. *Journal of the American Academy of Child & Adolescent Psychiatry*, 45(6), 691-699.

Rosa, C., Lassonde, M., Pinard, C., Keenan, J. P., & Belin, P. (2008). Investigations of hemispheric specialization of self-voice recognition. *Brain and Cognition*, 68(2), 204-214.

Ross, M., & Wilson, A. E. (2003). Autobiographical memory and conceptions of self getting better all the time. *Current Directions in Psychological Science*, 12(2), 66-69.

Rossion, B., Schiltz, C., Robaye, L., Pirenne, D., & Crommelinck, M. (2001). How does the brain discriminate familiar and unfamiliar faces?: a PET study of face categorical perception. *Journal of Cognitive Neuroscience*, 13(7), 1019-1034.

Rotshtein, P., Henson, R. N., Treves, A., Driver, J., & Dolan, R. J. (2005). Morphing Marilyn into Maggie dissociates physical and identity face representations in the brain. *Nature Neuroscience*, 8(1), 107-113.

Russell, J., & Hill, E. L. (2001). Action-monitoring and intention reporting in children with autism. *Journal of Child Psychology and Psychiatry*, 42(03), 317-328.

Sato, W., & Aoki, S. (2006). Right hemispheric dominance in processing of unconscious negative emotion. *Brain and Cognition*, 62(3), 261-266.

Schauder, K. B., Mash, L. E., Bryant, L. K., & Cascio, C. J. (2015). Interoceptive ability and body awareness in autism spectrum disorder. *Journal of Experimental Child Psychology*, 131, 193-200.

Schopler, E., Reichler, R. J., & Renner, B. R. (2002). The childhood autism rating scale (CARS): Western Psychological Services Los Angeles.

Schulte-Rüther, M., Markowitsch, H. J., Shah, N. J., Fink, G. R., & Piefke, M. (2008). Gender differences in brain networks supporting empathy. *Neuroimage*, 42(1), 393-403.

Schyns, P. G., Bonnar, L., & Gosselin, F. (2002). Show me the features! Understanding recognition from the use of visual information. *Psychological Science*, 13(5), 402-409.

Sepeta, L., Tsuchiya, N., Davies, M. S., Sigman, M., Bookheimer, S. Y., & Dapretto, M. (2012). Abnormal social reward processing in autism as indexed by pupillary responses to happy faces. *Journal of Neurodevelopmental Disorders*, 4(1), 1.

Shweder, R. A., & Bourne, E. J. (1982). Does the concept of the person vary cross-culturally? : Springer.

Singelis, T. M. (1994). The measurement of independent and interdependent self-construals. *Personality and Social Psychology Bulletin*, 20(5), 580-591.

Sinha, D., & Tripathi, R. C. (1994).Individualism in a collectivist culture: Theory, method, and applications: Thousand Oaks, CA, US: Sage Publications.

Spalding, L. R., & Hardin, C. D. (1999). Unconscious unease and self-handicapping: Behavioral consequences of individual differences in implicit and explicit self-esteem. *Psychological Science*, 10(6), 535-539.

Spiker, D., & Ricks, M. (1984). Visual self-recognition in autistic children: Developmental relationships. *Child Development*, 214-225.

Sugiura, M., Kawashima, R., Nakamura, K., Okada, K., Kato, T., Nakamura, A., . . . Fukuda, H. (2000). Passive and active recognition of one's own face. *Neuroimage*, 11(1), 36-48.

Sui, J., & Han, S. (2007). Self-construal priming modulates neural substrates of self-awareness. *Psychological Science*, 18(10), 861-866.

Sui, J., & Humphreys, G. W. (2013). The boundaries of self face perception: Response time distributions, perceptual categories, and decision weighting. *Visual Cognition*, 21(4), 415-445.

Sui, J., Liu, C. H., & Han, S. (2009). Cultural difference in neural mechanisms of self-recognition. *Social Neuroscience*, 4(5), 402-411.

Sui, J., Zhu, Y., & Chiu, C.-y. (2007). Bicultural mind, self-construal, and self-and mother-reference effects: Consequences of cultural priming on recognition memory. *Journal of Experimental Social Psychology*, 43(5), 818-824.

Sui, J., Zhu, Y., & Han, S. (2006). Self-face recognition in attended and unattended conditions: An event-related brain potential study. *Neuroreport*, 17(4), 423-427.

Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: a meta-analysis. *Psychological bulletin*, 121(3), 371.

Team, R. C. (2012). R: A language and environment for statistical computing, from http://www.R-project.org/

Thagard, P., & Wood, J. V. (2015). Eighty phenomena about the self: representation, evaluation, regulation, and change. *Frontiers in psychology*, 6, 334.

Tiggemann, M., & Pennington, B. (1990). The development of gender differences in body-size dissatisfaction. *Australian Psychologist*, 25(3), 306-313.

Toichi, M., Kamio, Y., Okada, T., Sakihama, M., Youngstrom, E. A., Findling, R. L., & Yamamoto, K. (2002). A lack of self-consciousness in autism. *American Journal of Psychiatry*.

Tong, F., & Nakayama, K. (1999). Robust representations for faces: evidence from visual search. *Journal of Experimental Psychology: Human Perception and Performance*, 25(4), 1016.

Triandis, H. C. (1989). The self and social behavior in differing cultural contexts. *Psychological Review*, 96(3), 506.

Tsakiris, M. (2008). Looking for myself: current multisensory input alters self-face recognition. *PloS one*, 3(12), e4040.

Turk, D. J., Cunningham, S. J., & Macrae, C. N. (2008). Self-memory biases in explicit and incidental encoding of trait adjectives. *Consciousness and Cognition*, 17(3), 1040-1045.

Uddin, L. Q. (2011). Brain connectivity and the self: the case of cerebral disconnection. *Consciousness and Cognition*, 20(1), 94-98.

Uddin, L. Q. (2011). The self in autism: an emerging view from neuroimaging. *Neurocase*, 17(3), 201-208.

Uddin, L. Q., Davies, M. S., Scott, A. A., Zaidel, E., Bookheimer, S. Y., Iacoboni, M., & Dapretto, M. (2008). Neural basis of self and other representation in autism: an FMRI study of self-face recognition. *PloS one*, 3(10), e3526.

Uddin, L. Q., Kaplan, J. T., Molnar-Szakacs, I., Zaidel, E., & Iacoboni, M. (2005). Self-face recognition activates a frontoparietal "mirror" network in the right hemisphere: an event-related fMRI study. *Neuroimage*, 25(3), 926-935.

Valentine, T., & Bruce, V. (1986). The effects of distinctiveness in recognising and classifying faces. *Perception*, 15(5), 525-535.

Van Belle, G., Ramon, M., Lefèvre, P., & Rossion, B. (2010). Fixation patterns during recognition of personally familiar and unfamiliar faces. *Frontiers in Psychology*, 1(20), 1-8.

van Veluw, S. J., & Chance, S. A. (2014). Differentiating between self and others: an ALE meta-analysis of fMRI studies of self-recognition and theory of mind. *Brain Imaging and Behavior*, 8(1), 24-38.

Verosky, S. C., & Todorov, A. (2010). Differential neural responses to faces physically similar to the self as a function of their valence. *Neuroimage*, 49(2), 1690-1698.

Vigneau, M., Beaucousin, V., Herve, P.-Y., Duffau, H., Crivello, F., Houde, O., . . . Tzourio-Mazoyer, N. (2006). Meta-analyzing left hemisphere language areas: phonology, semantics, and sentence processing. N*euroimage*, 30(4), 1414-1432.

Wagar, B. M., & Cohen, D. (2003). Culture, memory, and the self: An analysis of the personal and collective self in long-term memory. *Journal of Experimental Social Psychology*, 39(5), 468-475.

Wang.(2008). Being American, being Asian: The bicultural self and autobiographical memory in Asian Americans. *Cognition,* 107(2), 743-751.

Wells, G. L., Hoffman, C., & Enzle, M. E. (1984). Self-versus other-referent processing at encoding and retrieval. *Personality and Social Psychology Bulletin*, 10(4), 574-584.

Wheelwright, S., Baron-Cohen, S., Goldenfeld, N., Delaney, J., Fine, D., Smith, R., . . . Wakabayashi, A. (2006). Predicting autism spectrum quotient (AQ) from the systemizing quotient-revised (SQ-R) and empathy quotient (EQ). *Brain Research*, 1079(1), 47-56.

Wickham, H. (2009). ggplot2: elegant graphics for data analysis: Springer Science & Business Media.

Williams, D. (2010). Theory of own mind in autism Evidence of a specific deficit in self-awareness? *Autism*, 14(5), 474-494.

Williams, J. H., Whiten, A., & Singh, T. (2004). A systematic review of action imitation in autistic spectrum disorder. *Journal of Autism and Developmental Disorders*, 34(3), 285-299.

Williamson, D. A. (1996). Body image disturbance in eating disorders: A form of cognitive bias? *Eating Disorders*, 4(1), 47-58.

Wilson, A. E., & Ross, M. (2000). The frequency of temporal-self and social comparisons in people's personal appraisals. *Journal of Personality and Social Psychology*, 78(5), 928.

Yarmey, A. D., & Johnson, J. (1982). Evidence for the self as an imaginal prototype. *Journal of Research in Personality*, 16(2), 238-246.

Ybarra, O., & Trafimow, D. (1998). How priming the private self or collective self affects the relative weights of attitudes and subjective norms.

Zhang, L., Zhou, T., Zhang, J., Liu, Z., Fan, J., & Zhu, Y. (2006). In search of the Chinese self: an fMRI study. *Science in China Series C*, 49(1), 89-96.

Zhu, Y., & Zhang, L. (2002). An experimental study on the self-reference effect. *Science in China Series C: Life Sciences*, 45(2), 120-128.

Zhu, Y., Zhang, L., Fan, J., & Han, S. (2007). Neural basis of cultural influence on self-representation. *Neuroimage*, 34(3), 1310-1316.

Appendix A – The Autism Spectrum Quotient Questionnaire and coding

The below questionnaire was uploaded onto Survey-Monkey (https://www.surveymonkey.com) for participants to complete online:

Below is a list of statements. Please read each statement <u>very carefully</u> and rate how strongly you agree or disagree with it by circling your answer.

1.	I prefer to do things with others rather than on my own.	definitely agree	slightly agree	slightly disagree	definitely disagree
2.	I prefer to do things the same way over and over again.	definitely agree	slightly agree	slightly disagree	definitely disagree
3.	If I try to imagine something, I find it very easy to create a picture in my mind.	definitely agree	slightly agree	slightly disagree	definitely disagree
4.	I frequently get so strongly absorbed in one thing that I lose sight of other things.	definitely agree	slightly agree	slightly disagree	definitely disagree
5.	I often notice small sounds when others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
6.	I usually notice car number plates or similar strings of information.	definitely agree	slightly agree	slightly disagree	definitely disagree
7.	Other people frequently tell me that what I've said is impolite, even though I think it is polite.	definitely agree	slightly agree	slightly disagree	definitely disagree
8.	When I'm reading a story, I can easily imagine what the characters might look like.	definitely agree	slightly agree	slightly disagree	definitely disagree
9.	I am fascinated by dates.	definitely	slightly	slightly	definitely

		agree	agree	disagree	disagree
10.	In a social group, I can easily keep track of several different people's conversations.	definitely agree	slightly agree	slightly disagree	definitely disagree
11.	I find social situations easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
12.	I tend to notice details that others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
13.	I would rather go to a library than a party.	definitely agree	slightly agree	slightly disagree	definitely disagree
14.	I find making up stories easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
15.	I find myself drawn more strongly to people than to things.	definitely agree	slightly agree	slightly disagree	definitely disagree
16.	I tend to have very strong interests which I get upset about if I can't pursue.	definitely agree	slightly agree	slightly disagree	definitely disagree
17.	I enjoy social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
18.	When I talk, it isn't always easy for others to get a word in edgeways.	definitely agree	slightly agree	slightly disagree	definitely disagree
19.	I am fascinated by numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
20.	When I'm reading a story, I find it difficult to work out the characters' intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
21.	I don't particularly enjoy reading fiction.	definitely agree	slightly agree	slightly disagree	definitely disagree
22.	I find it hard to make new friends.	definitely	slightly	slightly	definitely

		agree	agree	disagree	disagree
23.	I notice patterns in things all the time.	definitely agree	slightly agree	slightly disagree	definitely disagree
24.	I would rather go to the theatre than a museum.	definitely agree	slightly agree	slightly disagree	definitely disagree
25.	It does not upset me if my daily routine is disturbed.	definitely agree	slightly agree	slightly disagree	definitely disagree
26.	I frequently find that I don't know how to keep a conversation going.	definitely agree	slightly agree	slightly disagree	definitely disagree
27.	I find it easy to "read between the lines" when someone is talking to me.	definitely agree	slightly agree	slightly disagree	definitely disagree
28.	I usually concentrate more on the whole picture, rather than the small details.	definitely agree	slightly agree	slightly disagree	definitely disagree
29.	I am not very good at remembering phone numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
30.	I don't usually notice small changes in a situation or a person's appearance.	definitely agree	slightly agree	slightly disagree	definitely disagree
31.	I know how to tell if someone listening to me is getting bored.	definitely agree	slightly agree	slightly disagree	definitely disagree
32.	I find it easy to do more than one thing at once.	definitely agree	slightly agree	slightly disagree	definitely disagree
33.	When I talk on the phone, I'm not sure when it's my turn to speak.	definitely agree	slightly agree	slightly disagree	definitely disagree
34.	I enjoy doing things spontaneously.	definitely agree	slightly agree	slightly disagree	definitely disagree
35.	I am often the last to understand the point of a joke.	definitely	slightly	slightly	definitely

		agree	agree	disagree	disagree
36.	I find it easy to work out what someone is thinking or feeling just by looking at their face.	definitely agree	slightly agree	slightly disagree	definitely disagree
37.	If there is an interruption, I can switch back to what I was doing very quickly.	definitely agree	slightly agree	slightly disagree	definitely disagree
38.	I am good at social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
39.	People often tell me that I keep going on and on about the same thing.	definitely agree	slightly agree	slightly disagree	definitely disagree
40.	When I was young, I used to enjoy playing games involving pretending with other children.	definitely agree	slightly agree	slightly disagree	definitely disagree
41.	I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	definitely agree	slightly agree	slightly disagree	definitely disagree
42.	I find it difficult to imagine what it would be like to be someone else.	definitely agree	slightly agree	slightly disagree	definitely disagree
43.	I like to plan any activities I participate in carefully.	definitely agree	slightly agree	slightly disagree	definitely disagree
44.	I enjoy social occasions.	definitely agree	slightly agree	slightly disagree	definitely disagree
45.	I find it difficult to work out people’s intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
46.	New situations make me anxious.	definitely agree	slightly agree	slightly disagree	definitely disagree
47.	I enjoy meeting new people.	definitely agree	slightly agree	slightly disagree	definitely disagree

48.	I am a good diplomat.	definitely agree	slightly agree	slightly disagree	definitely disagree
49.	I am not very good at remembering people's date of birth.	definitely agree	slightly agree	slightly disagree	definitely disagree
50.	I find it very easy to play games with children that involve pretending.	definitely agree	slightly agree	slightly disagree	definitely disagree

Coding of the questionnaire

Definitely agree" or "Slightly agree" responses to questions 2, 4, 5, 6, 7, 9, 12, 13, 16, 18, 19, 20, 21, 22, 23, 26, 33, 35, 39, 41, 42, 43, 45, 46 score 1 point. "Definitely disagree" or "Slightly disagree" responses to questions 1, 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 40, 44, 47, 48, 49, 50 score 1 point.

Appendix B – The Self-Construal Scale questionnaire and coding

The below questionnaire was uploaded onto Survey-Monkey (https://www.surveymonkey.com) for participants to complete online:

This is a questionnaire that measures a variety of feelings and behaviors in various situations. Listed below are a number of statements. Read each one as if it referred to you. Beside each statement write the number that best matches your agreement or disagreement. Please respond to every statement. Thank you.

1=STRONGLY DISAGREE

2=DISAGREE

3=SOMEWHAT DISAGREE

4=DON'T AGREE OR DISAGREE

5=AGREE SOMEWHAT

6=AGREE

7=STRONGLY AGREE

1.	I enjoy being unique and different from others in many respects.
2.	I can talk openly with a person who I meet for the first time, even when this person is much older than I am.
3.	Even when I strongly disagree with group members, I avoid an argument.
4.	I have respect for the authority figures with whom I interact.
5.	I do my own thing, regardless of what others think.
6.	I respect people who are modest about themselves.
7.	I feel it is important for me to act as an independent person.
8.	I will sacrifice my self-interest for the benefit of the group I am in.
9.	I'd rather say "No" directly, than risk being misunderstood
10.	Having a lively imagination is important to me.
11.	I should take into consideration my parents' advice when making education/career plans.

12.	I feel my fate is intertwined with the fate of those around me.
13.	I prefer to be direct and forthright when dealing with people I've just met.
14.	I feel good when I cooperate with others.
15.	I am comfortable with being singled out for praise or rewards.
16.	If my brother or sister fails, I feel responsible.
17.	I often have the feeling that my relationships with others are more important than my own accomplishments.
18.	Speaking up during a class (or a meeting) is not a problem for me.
19.	I would offer my seat in a bus to my professor (or my boss).
20.	I act the same way no matter who I am with.
21.	My happiness depends on the happiness of those around me.
22.	I value being in good health above everything.
23.	I will stay in a group if they need me, even when I am not happy with the group.
24.	I try to do what is best for me, regardless of how that might affect others.
25.	Being able to take care of myself is a primary concern for me.
26.	It is important to me to respect decisions made by the group.
27.	My personal identity, independent of others, is very important to me.
28.	It is important for me to maintain harmony within my group.
29.	I act the same way at home that I do at school (or work).
30.	I usually go along with what others want to do, even when I would rather do something different.

Coding of the questionnaire

There are 15 questions coding for independent self (items - **1, 2, 5,7, 9, 10, 13, 15, 18, 20, 22,24, 25, 27, and 29)** and 15 items coding for interdependent self (items - **3, 4, 6, 8, 11, 12, 14, 16, 17, 19, 21, 23, 26, 18 and 30).** To score the scale, each subject's scores (1 to 7) for the independent and interdependent items are added and then divided by 15 to give the mean score of the items. ***Each subject receives two scores***: one for the strength of the independent self and one for the interdependent self.

Appendix C – Trait adjectives used for the SRE paradigm

The following trait adjectives were used for the SRE paradigm.

Column 1 - pseudorandom order in which the traits were presented for each participant.

Column 2 – the trait words

Column 3 – the corresponding phase for which the words were used. Phase 1 was the trait judgment phase. Phase 2 was the recall phase. Words from Phase 1 were also used as the target word for phase 2.

Column 4 – different conditions for which the trait words were used. 'Distractor's were used as the 'new' words presented in phase 2. The other conditions were words on which 'self', 'other' trait judgments were made or words for which 'syllables' were counted.

Column 5 - indicates words that were used as distractors and words that were used for targets in phase 2. In total, there were 90 distractor/new words and 90 target/old words previously presented in phase 1 (30 each for 'self', 'other' and 'syllable' condition).

Column 6 – likeableness ratings of the words.

Column 7 – number of syllables present in each word.

Column 8 – number of characters present in each word.

The word list was originally taken from the work by Anderson & Norman (Anderson, 1968)and adapted by Lombardo et al (Lombardo et al., 2007).

rand	**word**	**corr**	**cond;**		**likeableness**	**syllables**	**Characters**
1	"sharp-witted"	2	"distractor";	distractor	486	3	12
1	"inconsistent"	2	"distractor";	distractor	193	4	12
4	"enthusiastic"	2	"distractor";	distractor	489	5	12
5	"intellectual"	2	"distractor";	distractor	476	5	12
6	"clownish"	2	"distractor";	distractor	247	2	8
6	"painstaking"	2	"distractor";	distractor	345	3	11
9	"resourceful"	2	"distractor";	distractor	481	3	11
10	"frustrated"	2	"distractor";	distractor	188	3	10
11	"rebellious"	2	"distractor";	distractor	258	3	10

13	"cheerful"	2	"distractor";	distractor	504	2	8
14	"indecisive"	2	"distractor";	distractor	219	4	10
15	"heartless"	2	"distractor";	distractor	78	2	9
15	"crude"	2	"distractor";	distractor	102	1	5
24	"resentful"	2	"distractor";	distractor	150	3	9
25	"distrustful"	2	"distractor";	distractor	99	3	11
25	"good"	2	"distractor";	distractor	480	1	4
27	"nosey"	2	"distractor";	distractor	102	2	5
30	"unappreciative"	2	"distractor";	distractor	126	5	14
30	"unintellectual"	2	"distractor";	distractor	180	6	14
35	"unconventional"	2	"distractor";	distractor	346	5	14
36	"talented"	2	"distractor";	distractor	478	3	8
38	"uncultured"	2	"distractor";	distractor	201	3	10
38	"cowardly"	2	"distractor";	distractor	110	3	8
40	"congenial"	2	"distractor";	distractor	462	3	9
42	"lonely"	2	"distractor";	distractor	256	2	6
44	"unappealing"	2	"distractor";	distractor	119	4	11
44	"bossy"	2	"distractor";	distractor	112	2	5
46	"aimless"	2	"distractor";	distractor	122	2	7
51	"boisterous"	2	"distractor";	distractor	163	3	10
57	"consistent"	2	"distractor";	distractor	411	3	10
63	"unruly"	2	"distractor";	distractor	150	3	6
65	"weak"	2	"distractor";	distractor	155	1	4
65	"clear-headed"	2	"distractor";	distractor	479	3	12
66	"inexperienced"	2	"distractor";	distractor	262	5	13
67	"grateful"	2	"distractor";	distractor	482	2	8
69	"noninquisitive"	2	"distractor";	distractor	184	6	14
73	"humorless"	2	"distractor";	distractor	101	3	9

74	"hypochondriac"	2	"distractor";	distractor	118	5	13
80	"unaccomodating"	2	"distractor";	distractor	174	6	14
80	"sportsmanlike"	2	"distractor";	distractor	477	3	13
81	"phony"	2	"distractor";	distractor	27	2	5
81	"untruthful"	2	"distractor";	distractor	43	3	10
82	"petty"	2	"distractor";	distractor	118	2	5
83	"inefficient"	2	"distractor";	distractor	178	4	11
83	"envious"	2	"distractor";	distractor	157	3	7
83	"philosophical"	2	"distractor";	distractor	386	5	13
86	"forceful"	2	"distractor";	distractor	263	2	8
89	"self-disciplined"	2	"distractor";	distractor	491	4	16
95	"sad"	2	"distractor";	distractor	209	1	3
95	"cooperative"	2	"distractor";	distractor	476	5	11
96	"antisocial"	2	"distractor";	distractor	144	4	10
96	"conformist"	2	"distractor";	distractor	241	3	10
96	"inquisitive"	2	"distractor";	distractor	413	4	11
97	"childish"	2	"distractor";	distractor	109	2	8
99	"inoffensive"	2	"distractor";	distractor	332	4	11
99	"selfish"	2	"distractor";	distractor	82	2	7
104	"warm-hearted"	2	"distractor";	distractor	504	3	12
105	"unlucky"	2	"distractor";	distractor	280	3	7
105	"decisive"	2	"distractor";	distractor	427	3	8
111	"poised"	2	"distractor";	distractor	448	1	6
115	"rational"	2	"distractor";	distractor	438	3	8
118	"definite"	2	"distractor";	distractor	375	3	8
119	"gracious"	2	"distractor";	distractor	437	2	8
123	"uncongenial"	2	"distractor";	distractor	175	4	11
125	"lonesome"	2	"distractor";	distractor	274	2	8

126	"impulsive"	2	"distractor";	distractor	307	3	9
127	"careless"	2	"distractor";	distractor	140	2	8
128	"spendthrift"	2	"distractor";	distractor	221	2	11
128	"modest"	2	"distractor";	distractor	428	2	6
132	"untidy"	2	"distractor";	distractor	175	3	6
136	"disciplined"	2	"distractor";	distractor	379	3	11
140	"refined"	2	"distractor";	distractor	422	2	7
140	"fearless"	2	"distractor";	distractor	366	2	8
145	"romantic"	2	"distractor";	distractor	439	3	8
146	"hesitant"	2	"distractor";	distractor	290	3	8
147	"careful"	2	"distractor";	distractor	390	2	7
149	"disrespectful"	2	"distractor";	distractor	83	4	13
153	"headstrong"	2	"distractor";	distractor	196	2	10
154	"objective"	2	"distractor";	distractor	370	3	9
162	"irreligious"	2	"distractor";	distractor	234	4	11
169	"sensitive"	2	"distractor";	distractor	358	3	9
171	"trustworthy"	2	"distractor";	distractor	539	3	11
171	"composed"	2	"distractor";	distractor	439	2	8
173	"good-natured"	2	"distractor";	distractor	527	3	12
174	"literary"	2	"distractor";	distractor	425	4	8
174	"moody"	2	"distractor";	distractor	182	2	5
174	"subtle"	2	"distractor";	distractor	365	2	6
177	"nonchalant"	2	"distractor";	distractor	324	3	10
180	"temperamental"	2	"distractor";	distractor	221	5	13
180	"suave"	2	"distractor";	distractor	335	1	5
6	"downhearted"	1	"other";	target	194	3	12
38	"honest"	1	"other";	target	555	2	6
49	"sincere"	1	"other";	target	573	2	7

51	"religious"	1	"other";	target	387	3	9
54	"dominating"	1	"other";	target	153	4	10
61	"untrustworthy"	1	"other";	target	65	4	13
73	"discontented"	1	"other";	target	237	4	12
79	"deceptive"	1	"other";	target	117	3	9
82	"educated"	1	"other";	target	500	4	8
86	"good-tempered"	1	"other";	target	482	3	13
95	"generous"	1	"other";	target	459	3	8
101	"skilled"	1	"other";	target	433	1	7
101	"curious"	1	"other";	target	432	3	7
124	"choosy"	1	"other";	target	272	2	6
124	"non-confident"	1	"other";	target	196	4	12
125	"inventive"	1	"other";	target	463	3	9
133	"silent"	1	"other";	target	228	2	6
136	"enterprising"	1	"other";	target	437	4	12
147	"likable"	1	"other";	target	497	3	7
149	"accurate"	1	"other";	target	464	3	8
149	"dishonest"	1	"other";	target	41	3	9
153	"worrier"	1	"other";	target	205	3	7
156	"sarcastic"	1	"other";	target	210	3	9
162	"ethical"	1	"other";	target	476	3	7
164	"proud"	1	"other";	target	358	1	5
167	"annoying"	1	"other";	target	84	3	8
170	"dislikable"	1	"other";	target	90	4	10
171	"self-confident"	1	"other";	target	421	4	14
172	"self-controlled"	1	"other";	target	456	3	15
176	"obnoxious"	1	"other";	target	48	3	9
7	"insulting"	1	"self";	target	69	3	9

10	"wordy"	1	"self";	target	261	2	5
16	"uncivil"	1	"self";	target	116	3	7
16	"tidy"	1	"self";	target	427	2	4
21	"undecided"	1	"self";	target	249	4	9
33	"soft-spoken"	1	"self";	target	380	3	11
35	"nonconforming"	1	"self";	target	369	4	13
36	"persistent"	1	"self";	target	347	3	10
41	"earnest"	1	"self";	target	521	2	7
46	"malicious"	1	"self";	target	52	3	9
48	"grouchy"	1	"self";	target	117	2	7
59	"self-conscious"	1	"self";	target	249	3	14
64	"misfit"	1	"self";	target	147	2	6
66	"argumentative"	1	"self";	target	227	5	13
74	"meditative"	1	"self";	target	366	4	10
77	"neglectful"	1	"self";	target	159	3	10
88	"unromantic"	1	"self";	target	214	4	10
96	"entertaining"	1	"self";	target	442	4	12
101	"withdrawn"	1	"self";	target	213	2	9
116	"humorous"	1	"self";	target	505	3	8
116	"suspicious"	1	"self";	target	163	3	10
122	"nervous"	1	"self";	target	196	2	7
129	"neat"	1	"self";	target	466	1	4
142	"serious"	1	"self";	target	379	3	7
143	"punctual"	1	"self";	target	466	3	8
152	"cold"	1	"self";	target	113	1	4
156	"compulsive"	1	"self";	target	205	3	10
162	"shrewd"	1	"self";	target	328	1	6
164	"boring"	1	"self";	target	97	2	6

169	"hostile"	1	"self";	target	91	2	7
12	"superstitious"	1	"syllable";	target	189	4	13
14	"respectable"	1	"syllable";	target	455	4	11
32	"lively"	1	"syllable";	target	466	2	6
36	"cruel"	1	"syllable";	target	40	2	5
36	"light-hearted"	1	"syllable";	target	424	3	13
47	"withdrawing"	1	"syllable";	target	227	3	11
50	"hard-hearted"	1	"syllable";	target	107	3	12
72	"lucky"	1	"syllable";	target	358	2	5
77	"ordinary"	1	"syllable";	target	266	4	8
82	"spirited"	1	"syllable";	target	477	3	8
98	"ingenious"	1	"syllable";	target	466	4	9
105	"moderate"	1	"syllable";	target	351	3	8
105	"scolding"	1	"syllable";	target	166	2	8
110	"timid"	1	"syllable";	target	222	2	5
114	"scornful"	1	"syllable";	target	145	2	8
115	"deliberate"	1	"syllable";	target	345	4	10
123	"short-tempered"	1	"syllable";	target	159	3	14
123	"well-bred"	1	"syllable";	target	423	2	9
123	"agreeable"	1	"syllable";	target	434	4	9
126	"versatile"	1	"syllable";	target	474	3	9
131	"loyal"	1	"syllable";	target	547	2	5
134	"mediocre"	1	"syllable";	target	197	4	8
136	"social"	1	"syllable";	target	398	2	6
142	"satirical"	1	"syllable";	target	351	4	9
144	"emotional"	1	"syllable";	target	283	4	9
171	"rash"	1	"syllable";	target	186	1	4
172	"pompous"	1	"syllable";	target	177	2	7

174	"ill-mannered"	1	"syllable";	target	95	3	12
176	"cynical"	1	"syllable";	target	171	3	7
179	"unpredictable"	1	"syllable";	target	290	5	13