Incorporating the Other: Investigating Body Representation and Social Cognition

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This thesis is submitted in fulfilment of the requirements for a degree of Doctor of Philosophy in Psychology at Royal Holloway, University of London.

Declaration of Authorship

I Harry Farmer hereby declare that this thesis and the work presented in it is entirely my own. Where I have consulted the work of others, this is always clearly stated.

Signed:

Date:

Abstract

The aim of the experiments reported in this thesis was to investigate the relationship between the multisensory based processes involved in the generation of a sense of bodily selfhood and the processes involved in social cognition.

The experiments in chapter 2 investigated the effect of skin colour on body ownership and found that participants could indeed experience body ownership over a rubber hand with the skin colour of a racial out-group. The experiments in chapter 3 found evidence that synchronous multisensory stimulation over a hand with the skin colour of a racial out-group led to more positive implicit attitudes towards members of that racial out-group and reduced corticospinal activation when watching either tactile or painful stimuli applied to an out-group hand.

The experiments in chapter 4 investigated whether feeling body ownership over an elderly hand would lead to activation of the elderly stereotype and thus cause participants to imagine their movements as being slower on a motor imagery task. They found that it was possible to induce ownership over the elderly hand and that participants who experienced higher levels of ownership over the old hand imagined their movements as being slower.

Experiments 5.1 and 5.2 investigated whether IMS would lead to increased trust. They found that synchronous IMS led to higher ratings of trust and higher offers in a trust game. Experiment 5.3 found that trustworthiness leads to increased perceived facial similarity. Experiment 6.1 used fMRI to demonstrate that brain areas involved in action observation are modulated by the trustworthiness of an actor.

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Chapter 1. Introduction: The Body, the Self and Social Cognition[1]

"Everywhere in the world, self starts with body"

Roy F. Baumeister (1999, p. 2)

1.1. Theoretical Foundations

1.1.1. Varieties of Embodied Cognition

The past two decades have seen an increasing move towards emphasising the importance of the body for many areas of cognition (Barsalou, 2008; Clark, 1999; Valera, Thompson, & Rosch, 1991; Wilson & Golonka, 2013; Wilson, 2002). In this time the embodied cognition paradigm has grown increasingly more influential and widespread, a search on Google Scholar for academic works using the term "embodied cognition" finds only eighty five results published before 1993 but over eleven thousand and seven hundred published from 1993-2013. The studies reported in this thesis sought to investigate the impact of embodiment on social relationships between one's self and others. Before proceeding to review the literature that motivated these investigations however it is important to first be clear exactly which conception of embodied cognition motivates these investigations.

The embodied position is often contrasted with more traditional cognitivist views of cognition. This traditional view has been characterised by Hurley (2001) as involving three key aspects. The first is the view that action and perception are largely separate from each other and as peripheral processes to cognition. The second is that the mind

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is essentially modular with different cognitive processes operating separately from each other and from perception and action. The final aspect is the view that that at its core cognition involves the manipulation of amodal symbolic representations according to syntactic structures (Fodor & Pylyshyn, 1988). This cognitivist conception of cognition has been described by Hurley as the “classical sandwich” model of the mind as it views action and perception as the peripheral bread that surrounds a cognitive filling. Proponents of the embodied cognition approach generally deny all three aspects of the cognitivist view of cognition claiming instead that action and perception are tightly linked, that they play a vital role in cognitive processes and that cognition is not constituted by the syntactic manipulation of amodal symbolic representations.

Despite the general opposition to the cognitivist model of the mind among proponents of embodied cognition, Alsmith and de Vignemont (2012) note that the research programs covered by the umbrella of embodied cognition include a number of distinct and incompatible different theoretical positions. A number of authors have highlighted the distinct positions that can be held by proponents of embodied cognition. Wilson (M. Wilson, 2002) identified no less than six distinct positions that are commonly held by researchers working in embodied cognition ranging from the importance of viewing cognition as situated within the context of the real-world environment to stressing the role of sensory and motor systems in higher cognitive processes such as mental imagery, memory and reasoning. Shapiro (2010) also distinguishes between different forms of embodied cognition, highlighting three distinct viewpoints that proponents of embodied cognition might hold. The first of these is conceptualization, the view that the concepts an organism can acquire are determined, limited, or constrained by the properties of the organism's body. The second is replacement, the view that the dynamics of an organism's bodily interaction with the environment replaces the need for representational processing and the third is constitution, the view that the constituents of cognition extend beyond the brain and into the body and world.

For the purposes of the present thesis however, the most useful distinction between different forms of embodied cognition has been made by Clark (1997) who distinguished between “radical” and “moderate” version of embodiment. Radical embodied theories, which are most closely linked to Shapiro's (2010) replacement viewpoint, (e.g. Hutto, 1999; O'Regan & Noë, 2001; Thelen & Smith, 1994; Van Gelder, 1998, 2008; Wilson & Golonka, 2013) view embodied cognition as a radically new paradigm in cognitive science and deny that the mind consists of anything like representations. Instead they promote the idea that cognition involves a process of dynamic interaction between brain, body and world and hold that many of the cognitive processes that have classically been thought to require representation can be solved through interaction with the environment, a principle that is often expressed using Rodney Brooks' claim that "the world is its own best model" (Brooks, 1990). In contrast more moderate embodied approaches to embodiment, which are most closely linked to Shapiro's conceptualisation viewpoint, do not seek to deny the existence of representation and are willing to employ both representational and non-representational explanatory schemes depending on the cognitive task under investigation (Clark, 1997; Wilson, 2002). Instead of denying the existence of mental representations entirely, researchers who take the moderate approach to embodied cognition instead tend to challenge the classical notion of amodal representation, emphasising the importance of sensory and motor systems in the creation of offline mental representations of the world (Barsalou, 1999, 2008; Kiefer & Pulvermüller, 2012; Lakoff, 2012; Pezzulo et al., 2012; Prinz, 2009; Svensson & Ziemke, 2005).

1.1.2. Problems with Radical Embodied Cognition

The radical approach to embodied cognition has had a number of successes in demonstrating that tasks normally thought to require complex representation can instead be achieved through the dynamic coupling of brain, body and world. The most notable of these successes have been in the fields of artificial intelligence (for a review see Pfeifer & Bongard, 2006), in explaining how humans and other animals accomplish complex sensorimotor tasks such as catching a ball (Fink, Foo, & Warren, 2009; McBeath, Shaffer, & Kaiser, 1995)and in explaining certain pervasive developmental errors in terms of the immaturity of infants' sensorimotor systems (Thelen, Schöner, Scheier, & Smith, 2001). It is however notable that the radical approach to embodiment has had significantly less success when it comes to explaining more cognitively complex areas such as language, abstract thought and social cognition. The issue of the role of embodiment in social cognition has a direct bearing on the studies reported in this thesis so it is worth pointing out that, while some areas of social cognition relating to direct social interaction may well require less use of mental representations than has commonly been supposed (De Jaegher, Di Paolo, & Gallagher, 2010; De Jaegher & Di Paolo, 2007; Fuchs & de Jaegher, 2009; Gallagher & Hutto, 2008), it seems dubious that all of the complexity of social interactions, such as knowledge of status (Coie, Dodge, & Coppotelli, 1982) dividing people between social in-groups and out-groups (Brewer, 1979; Ruffle & Sosis, 2006) or reasoning about social rewards and punishment (Greene & Haidt, 2002; Trevino & Youngblood, 1990) can be accounted for without at least some form of stored offline mental representations.

A second reason for scepticism that the radically anti-representationalist approach to embodiment is sustainable has been pointed out by Alsmith and De Vignemont (2012). The authors note the widespread use of representational concepts within research involving the body itself, pointing to "forward model" theories of motor control (Davidson & Wolpert, 2005; Jeannerod, 1997; Wolpert & Ghahramani, 2000) as an exemplar of a well-established theory of motor control in which offline representations of the body, decoupled from the actions the body is currently making, play an essential part. Forward model theories of motor control posit that, in order to deal with the slow and noisy nature of peripheral signal about the movement dynamic of the body, motor commands sent to the body are also duplicated within a neural model of the bodies motor systems in order to compute the likely sensory feedback that would be generated by the movements specified (see e.g. Desmurget & Grafton, 2000). These theories therefore directly posit an important role for offline representations of the body in the guidance of action itself and are thus in tension with an anti-representationalist view of embodied cognition. This tension between the radical embodied cognition approach and research into the relationship between the body and the brain has been further increased by the recent popularity of predictive coding approaches to cognition (Apps & Tsakiris, In Press; Brown, Salverda, Dilley, & Tanenhaus, 2011; Friston, 2005, 2010; Kilner, Friston, & Frith, 2007; Lee & Mumford, 2003; Rao & Ballard, 1999; see Clark, 2013 for a recent review and discussion). These accounts extend the key insight of "forward model" theories, the functional importance of comparing incoming sensory input with predictions generated through offline simulation of that sensory input, into perception (Lee & Mumford, 2003; Rao & Ballard, 1999), including perception of the body itself (Apps & Tsakiris, In Press; Kilner et al., 2007b), and higher level cognition (M. Brown et al., 2011; Friston, 2005, 2010)

Due to these two objections to the radical embodied cognition position, the studies undertaken in the current thesis are based on a more moderate version of the embodied cognition thesis which accepts the existence of low level sensorimotor representations and holds that these representations play a vital part in structuring cognition and allowing for the creation of representations referring to more complex and abstract concepts. This conception of embodiment has been most developed by Barsalou and colleagues in their grounded cognition framework (Barsalou, 1999, 2010; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Pezzulo et al., 2012). In brief this framework posits that cognitive agents do not come pre-equipped with arbitrary representations but rather that they acquire “grounded modal symbols” through development and sensorimotor interaction, with genetic constraints presumably also playing a role. Furthermore, the model holds that more abstract concepts develop on top of the architecture for sensorimotor control, and the gradual maturation of the latter constitutes a scaffold for the former and that higher level cognitive processes recruit and reuse lower level sensorimotor competencies in order to process increasingly complex problems. In the current thesis, this grounded cognition framework will be applied to the relationship between two distinction conceptions of selfhood, the bodily self and the social self. This studies presented will show that perceptions of social closeness between one’s self and others can both be affected by and in turn affect perceptions of bodily closeness and similarity.

1.1.3. Two forms of Selfhood

The distinction between two important conceptions of selfhood can be found in thinkers across academic disciplines and traditions. Zahavi (2005) addresses this issue from the perspective of the phenomenological tradition and draws on the analyses made by Husserl (1982), Merleau-Ponty (1962) and Sartre (1956) to argue for the existence of both a phenomenal form of selfhood, which is considered to be an essential component of all subjective experience and a socially situated narrative form of selfhood, which is seen as social constructed and formed in a large part by the way we relate to others. A similar view of the self has also been put forward in analytic philosophy by Bermúdez (1998) and Strawson (1999) who both distinguish between forms of selfhood which require conceptual and linguistic mastery of the first person pronoun and a more basic non-conceptual self-consciousness.

In psychology Neisser (1991) distinguishes between an ecological self which is developmentally primary and more advanced forms of selfhood such as possession of an extended self or a self-concept which require the ability to reflect on one's experiences over long time periods and to be able to identify one's self as part of a larger social group respectively. Finally both Damasio (1999) and Edelman (2004) have used neuroscientific findings to distinguish between a continuously present form of self-awareness, based on (which Damasio terms the "core self" and Edelman terms "primary consciousness") and a higher level, temporally extended sense of self.

While these various accounts of selfhood differ on a number of details it is clear that there is a broad agreement in their division of selfhood between a minimal non-conceptual pre-linguistic self which is a prerequisite for having any form of phenomenal experience and higher level forms of selfhood which depend on the possession of complex cognitive abilities such as episodic memory, language and a conceptual understanding of one's self as being a distinct and separate entity. In the following two sections of this introduction I will first consider the phenomenal self (PS) and make the case that it should correctly be viewed as a bodily form of selfhood and then consider the narrative or social self (SS) and highlight the social nature of this conception of selfhood.

1.2. Phenomenal Selfhood and the Body

1.2.1. The Phenomenal Self as a Bodily Self

The PS has been closely linked to the body by a number of recent thinkers (Bermúdez, 1998; Blanke & Metzinger, 2009; Damasio, 1999; Gallagher, 2003; Hurley, 1998; Legrand, 2006; Zahavi, 2002, 2005). Many draw on the work of phenomenologists such as Merleau-Ponty (1945); others (Bermúdez, 1998, for example) draw on the work of Gibson (1979) to highlight the importance of the body as a source of sensory and motor information (e.g. vision, touch, proprioception) that can be used to differentiate between self and non-self in the absence of a linguistic concept of the self.

Proponents of the link between the body and the PS commonly stress the role of the body as a point of unification between sensory inputs and motor outputs and thus as the source of a unified and spatially localised first person perspective (1PP). Legrand (2006) expresses this role of the body as unifier by saying that:

> *"the self at the bodily level is the body itself. It is [...] the body as it is acting and perceiving, that is, the body as the point of convergence of action and perception." (Legrand, 2006, p.108).*

A similar point is made by Susan Hurley in her seminal work *Consciousness in Action* (1998) when she states that:

> *"having a unified perspective involves keeping track of the relationship of interdependence between what is perceived and what is done, and hence awareness of your own agency. In this sense, perspective already involves self-consciousness. But the sense of self-consciousness that makes good this thought is already tied to ordinary motor agency and spatial perception and need not involve conceptually structured thought or inferences." (Hurley, 1998, p. 141).*

This conception of the bodily self as the nexus of action and perception has also been put forward within the cognitive sciences. Neisser's (1991) account of the ecological self, which draws heavily on Gibson's (1979) theory of the importance of motor affordances in perception, views the ecological self as being specified largely by objective information which allows for the perception of both the location of the body and how it is interacting with the environment. Neisser considers this information to be largely dependent on knowledge of the body's movements and their relationship to vision. As an example of how this relationship can allow for the specification of the ecological self, Neisser highlights the fact that for a perceiving agent the layout of any visual scene is always seen from a particular point of observation and then explains how various transformations in the structure of a visual scene that occur when the point of observation moves (e.g. the kinetic depth effect, looming or optic flow) serve to provide an organism with independently existing forms of visual information which can be used to uniquely specify the location of the ecological self in the environment. This unique specification through the interaction of the mind independent properties of a visual scene and an organism's own movements, thus demonstrates one important way that a bodily form of self can emerge from an interaction of perception and action.

In addition to arguments for a bodily form of selfhood based on the interaction of action and perception more recent theories of the self, such as that put forward by Damasio (1999, 2010), have stressed the importance of other forms of bodily information. In his model of the "core self" Damasio acknowledges the importance of musculo-skeletal information such as emphasised by Neisser (1991) in his account of the ecological self and is involved in sensing the movements of the musculoskeletal system and, through the vestibular system, the position of the body in space. However Damasio also emphasises the importance of the internal milieu and viscera division which includes neural and chemical signals indicating the homeostatic environment of the body's cells, the state of the smooth muscles of the body and sensory signals from receptors for pain, itch, temperature (and also the more recently identified C-afferent fibres which appear to transmit the sensation of pleasant touch (Johansson, Trulsson, Olsson, & Westberg, 1988; Loken, Wessberg, Morrison, McGlone, & Olausson, 2009).

This emphasis on the importance of the perception of internal states of the body, or interoception, in providing a background to conscious experience has also been suggested by Seth, Suzuki, and Critchley (2011) who have developed a model of "presence", defined as the "the sense of being there" (Lombard & Ditton, 1997) or "being now there" (Metzinger, 2003), and roughly equivalent to the PS as discussed by thinkers in the phenomenological tradition such as Gallagher (2003), Legrand, (2006) and Zahavi (2005). On this model the sense of presence is the result of a successful top-down prediction of changes in interoceptive signals evoked by autonomic control systems and by the body's reactions to sensory signals from the external world. In addition to explaining the sense of presence through the brain's successful prediction of internal states Seth et al.'s model also takes account of the importance of the brain's predictions of the consequences of motor actions in producing a sense of agency, as specified by predictive accounts of the sense of agency (Fletcher & Frith, 2009; Haggard & Tsakiris, 2009; Tsakiris & Haggard, 2005a), meaning that it can take account of the contributions of both interoceptive and exteroceptive systems in generating a sense of PS. Thus in the case of both Damasio's (1999, 2010) and Seth et al.'s (2012) models, information about the body's movements and internal states is integrated with afferent sensory information about the external world and it is this process of integration that is thought to underlie constant sense of phenomenal selfhood that we experience.

If this conception of PS as relying on the integration of different modalities of sensorimotor information is correct then greater understanding of the PS might be gained by investigating how bodily representations in these different modalities are integrated into a coherent whole and perceived as belonging to a cognitive agent. Recent work on this issue has distinguished between two distinct ways that one's body can be perceived as being linked to one's self, agency and body ownership (Gallagher, 2000; Graham & Stephens, 1994; Marcel, 2003; Stephens & Graham, 2000; Synofzik, Vosgerau, & Newen, 2008; Tsakiris, Schütz-Bosbach, & Gallagher, 2007; E. van den Bos & Jeannerod, 2002) Briefly, having a sense of agency corresponds to feeling that the actions one's body makes were determined by one's own will, while having a sense of body ownership corresponds to the feeling that I am the one who is experiencing an action, or other bodily sensation. To see how these two concepts can come apart it is only necessary to consider the difference between moving one's own arm voluntarily, a scenario which involves both agency and body ownership and a second case in which one's arm is moved by another person grabbing it, a scenario in which one experiences ownership over one's arm, i.e. it is my arm that is moving, but not agency, i.e. I did not will this movement to happen. When considering the processes that lie at the core of the PS it is of note that while it seems easily possible to have a feeling of body ownership without having a feeling of agency over one's body it is less plausible that one could have a feeling of agency over one's body without also experiencing a feeling of body ownership. These phenomenological reflections suggest therefore that the feeling of ownership over one's body is the more fundamental of these two senses and that body ownership alone, with or without a sense of agency, might be sufficient for the possession of a PS. Given the apparent primacy of body ownership for the possession of a PS I will now proceed to review the empirical research that has been conducted on the nature of the sense of body ownership.

1.2.2. The Phenomenal Self in Infancy

One of the key aspects claimed for the PS is its non-linguistic nature. Therefore one important question when justifying the claim that the PS is primarily based in a bodily form of self-consciousness is whether pre-linguistic infants are capable of integrating the information about the current state of their body being transmitted from different modalities? Here I will briefly note a few findings that demonstrate that, far from the traditional view of the infants world as a "blooming, buzzing, confusion," (James, 1890, p. 462), there is now considerable evidence that infants are able to integrate signals from different perceptual modalities to form a unified representation of their body and its location in the world. First, neonates are able to distinguish between self and other touch. Rochat and Hespos (1997) demonstrated this through manipulating the rooting mechanism in which touch to the infants face leads to purposeful orientation and movement by the infant until a sold object e.g. a nipple or finger comes into contact with the mouth. Rochat and Hespos touched the faces of neonates either with the neonate's own hand or with the finger of another person and found that the infants rooted significantly more to tactile stimulation generated by another person compared to that generated by their own hand.

Second, infants possess the ability to recognise self-generated stimuli even when this stimuli is divorced from current self-generated movements. This was demonstrated by the finding that they are able to distinguish the sound of their own crying from the cries of other infants and respond in a markedly different manner (Martin & Clark, 1982). In addition Rochat and Striano (1999) showed that by the age of 2 months infants can discriminate between auditory tones that were modulated by their own motor actions, via the pressure the infant placed on a pacifier, and auditory tones that were not affected by their sucking and that infants display distinctly more exploratory patterns of sucking when sucking had an effect on the tones compared to when it did not.

Third, infants are able to combine information across both perceptual and motor modalities and to situate themselves in the environment according to this information. For example they are able to adjust their head and body posture to the illusion of movement created by optic flow to their peripheral vision (Jouen, Lepecq, Gapenne, & Bertenthal, 2000) and are capable of adjusting their posture in a moving room long before they are capable of self-locomotion (Bushnell & Boudreau, 1993; D. N. Lee & Aronson, 1974).

Finally there is evidence that even very young infants are able to detect visual and tactile congruencies in the environment and in particular to objects that resemble their own bodies. A recent study by Zmyj, Jank, Schütz-Bosbach and Daum (2011) demonstrated that infants at aged 7 months will look significantly longer at a doll's leg that is stroked in synchrony with their own leg compared to a leg stroked asynchronously or a neutral object (e.g. a piece of wood) stroked in synchrony. A final relevant study, conducted by Cowie, Makin and Bremner (2013) investigated the experience of the rubber hand illusion (RHI, see below) among children between the ages of 4 to 9 years; the authors found that children experienced the illusion of body ownership after synchronous stimulation as strongly as adults did. The children also showed a stronger effect of proprioceptive drift than did adults, although regardless of synchrony of visuo-tactile (VT) stimulation children felt their hand to be closer to the rubber hand than did adults suggesting that children are more susceptible to the "visual capture" of touch (Pavani, Spence, Driver, & Psicologia, 2000) than adults are.

1.2.3. Investigating Body Ownership

For much of the history of cognitive science there was no known methodology that allowed for the manipulation of participant's sense of body ownership. Although it was known that some neurological conditions could lead to somatoparaphrenia, the loss of a feeling of body ownership over one's limbs (see Vallar & Ronchi, 2009, for a review), examining the sense of body ownership in healthy participants seemed impossible due the difficulty in separating participants from what William James memorably described as "the feeling of the same old body always there" (James, 1890, p. 242). In the past decade however a large amount of research into the factors affecting body ownership has been carried out based on a study by Matthew Botvinik and Jonathan Cohen (1998) which showed that it is possible to induce a feeling of body ownership over an artificial hand by combining the visual stimulation of the artificial hand with synchronous tactile stimulation of the participant's own hand, the resultant feeling of ownership over the artificial hand has led to this paradigm being known as the "rubber hand illusion" (RHI). In addition Botvinik and Cohen found that experiencing ownership of the rubber hand led participant's proprioceptively based judgments of the location of their own, unseen, hand to drift towards that of the rubber hand, indicating a reliable behavioural measure of the experience of body ownership. This finding indicates that, as well as involving the integration of visual and tactile signals, the RHI also exerts an influence of proprioceptive representations of the state of the body suggesting that all three sensory modalities are involved in generating the feeling of ownership over one's body.

Following the finding that synchronous VT-stimulation can induce the feeling of ownership over a foreign body part researchers have demonstrated that the integration of other body related senses can also produce a feeling of body ownership. Several studies have now demonstrated that observing the movement of another's hand in synchrony with the movement of one's own hand can also lead to a sense of body ownership (Dummer, Picot-Annand, Neal, & Moore, 2009; Riemer, Kleinböhl, Hölzl, & Trojan, 2013; Sanchez-Vives, Spanlang, Frisoli, Bergamasco, & Slater, 2010; Walsh, Moseley, Taylor, & Gandevia, 2011). A non-visual version of the RHI has also been developed in which participants use one of their hands to apply touch to a rubber hand while receiving synchronous tactile stimulation to their other hand. This tactile-motor version of the illusion leads to the perception that the participant is touching their own other hand (Ehrsson, Holmes, & Passingham, 2005; Lopez, Bieri, Preuss, & Mast, 2012; White, Aimola Davies, & Davies, 2011; White, Aimola Davies, Halleen, & Davies, 2010).

The role of the integration of sensory information from different modalities in creating the feeling of ownership is also revealed by the "rubber voice illusion" (Z. Z. Zheng, Macdonald, Munhall, & Johnsrude, 2011). In this illusion hearing a stranger's voice while saying the same words one's self led participants to experience the other voice as a distorted version of their own voice and also led to a change in participants' vocal output to make their speech more closely match that of the stranger.

Interestingly, given the links that Damasio (1999, 2010), Seth et al. (2012) and others (e.g. Craig, 2003) have made between representations of the internal state of the body and the PS,the sense of body ownership is also modulated by awareness of body from within (Capelari, Uribe, & Brasil-Neto, 2009; Kammers, Rose, & Haggard, 2011; Suzuki, Garfinkel, Critchley, & Seth, 2013; Tajadura-Jiménez & Tsakiris, In Press; Tsakiris, Tajadura-Jiménez, & Costantini, 2011). Capelari et al. (2009) showed that the application of synchronous painful as well as tactile stimulation could induce the feeling of ownership over a rubber hand demonstrating that, despite the greater affective importance of painful compared to tactile stimuli, pain localization is also modified by visual cues.

Other recent studies have shown that synchronous VT-stimulation is more likely to induce the experience of ownership over a rubber hand (Tsakiris et al., 2011) or the face of another (Tajadura-Jiménez & Tsakiris, In Press) in participants with lower interoceptive sensitivity. Interoceptive sensitivity is calculated by comparing participant perception of their own heart beat with their actual heartbeat and the results of these studies suggest that those who are less able to sense their own bodies from the inside are more reliant on integrating exteroceptive sensory signals in order to determine what is and is not part of their body. Interestingly Suzsuki et al. (2013) demonstrated that synchrony between exteroceptive and interoceptive cues can modulate the RHI. In their study synchronous VT-stimulation was applied to a rubber hand which turned red either in or out of synch with the participant's heartbeat. They found that the strength of the RHI was increased when the virtual hand changed colour in synchrony with a participant's heartbeat. Kammers et al. (2011) investigated the role of temperature in modulating the RHI and found that lowering the temperature of participant's own hands prior to VT-stimulation led them to experience a stronger RHI illusion while warming the hand led to a decrease in the strength of the RHI. In line with the findings on interoceptive sensitivity above this finding may reflect the fact that cooling the body decreases the transmission of somatosensory signals (Markand, Warren, Mallik, King, & Mahomed, 1990; Phillips & Matthews, 1993) while warming the body increases them (Russ, Sticher, Scheld, & Hempelmann, 1987).

More evidence of the close relationship between body representation and the PS comes from studies showing that similar synchronous VT-stimulation of a participant and whole body avatars can induce a feeling of ownership over the avatar (Ehrsson, 2007; Lenggenhager, Tadi, Metzinger, & Blanke, 2007) or even over the body of another person (Petkova & Ehrsson, 2008). It has also been shown that experiencing ownership over this full body leads to a whole body variant of proprioceptive drift. When blindfolded participants were moved from the position they experienced the illusion in and then asked to return to it, their final location was significantly closer to the location of the avatar if they had experienced synchronous rather than asynchronous stimulation (Lenggenhager et al., 2007).

Further studies using the full body illusion have shown that it is possible to manipulate perceptions of participant's body size (van der Hoort, Guterstam, & Ehrsson, 2011) or limb length (Schmalzl & Ehrsson, 2011)and that experiencing ownership over the avatar's body leads to the disownership of one's own body (Guterstam & Ehrsson, 2012). The latter finding is particularly important as it implies that the spatial location of the PS is dependent on representations of the location of one's body generated by the constant integration of multiple modes of sensory information. These findings have led Blanke and Metzinger (2009) to make the case that the possession of a minimal form of a PS requires three conditions to be met. On their account in order for a system to possess an MPS the system must first have a weak 1PP defined as an unconscious "purely geometrical feature of a perceptual or imagined model of reality possessing a point of projection functioning as its origin in sensory and mental processing" (Blanke & Metzinger, 2009). In order for phenomenal selfhood to emerge this weak 1PP must also be represented as taking up a certain volume in the world by being mapped onto a global body model. This body model is represented as transparent meaning that the system fully identifies its sense of self with the global model of the body and cannot perceive this global model as a representation from any amount of introspection.

1.2.4. Conditions for Body Ownership

One key question for researchers investigating the experience of body ownership is what conditions under which the feeling of body ownership can be elicited. An early study by Armel and Ramachandran (2003) claimed that synchronous visuo-tactile (VT) stimulation of the participant's own hand and another object alone was sufficient to evoke feelings of ownership over the observed object. Notably however, both subjective ratings of ownership and SCRs to threatening stimuli for a non-hand object, in this case the surface of a table, in the experimental condition were not higher than rating of ownership over a rubber hand in a control condition. This finding indicates the importance of the visual form of the stimulated object determining the intensity of the illusion of ownership. The study also found that increased feelings of body ownership led to higher skin conductance responses (SCRs) in response to threatening stimuli being applied to the observed object, identifying a physiological proxy for the illusion.

The importance of factors other than synchrony of VT-stimulation in determining feelings of body ownership was further underlined by Tsakiris & Haggard (2005b), who systematically examined the influence of the stimulated object's visual form and anatomical location on participant's experience of body ownership. Tsakiris and

Haggard found that the illusion of ownership over the rubber hand only occurred when the object being stimulated was a rubber hand of the same laterality and located in the same anatomical position as the participant's own hand (a finding also noted Ehrsson, Spence, & Passingham, 2004; Farnè, Pavani, Meneghello, & Làdavas, 2000; Pavani et al., 2000), while no feelings of body ownership were induced for non-hand shaped objects, for a rubber hand placed at an angle of 90º from the participant's own hand or for a rubber hand of the opposite laterality from the participant's hand. The importance of anatomical and postural congruency in inducing feelings of body ownership has also been replicated by several further studies. In terms of postural congruency an number of studies (Lloyd, 2007; Makin, Holmes, & Ehrsson, 2008; Preston, 2013) have demonstrated that that the experience of body ownership over a rubber hand only occurs when that rubber hand is presented within peripersonal space of the body. Moreover Cadieux, Whitworth and Shore (2011) found that the RHI is not experienced when the rubber hand is placed on the opposite side of the midline of the body from the participant's own hand. The importance of the orientation of the rubber hand compared to the participant's own has also been investigated. Costantini and Haggard (2007) systematically modulated the posture of the rubber hand, the participant's own hand or the direction of stimulation on either hand. Mismatch between the stimulation delivered to the subject's hand and the rubber hand abolished the illusion. It was found that the RHI survived small changes in the subject's hand posture, provided that the stimulation applied was congruent in hand centred, rather than external space. However no RHI was induced when same posture transformations were applied to the rubber hand. Many other studies (e.g. Ehrsson et al., 2004; Guterstam, Petkova, & Ehrsson, 2011; Holle, Mclatchie, Maurer, & Ward, 2011; Tsakiris & Haggard, 2005; Zopf, Savage, & Williams, 2010) have demonstrated that rotating the rubber hand by 90º or 180º serves to prevent the experience of the RHI.

Further studies have replicated and expanded upon the effects found by Tsakiris and Haggard (2005b). Haans, Ijsselsteijn, & de Kort (2008) found that VT-stimulation over a rubber hand led to greater reports of body ownership than did VT-stimulation over a similarly textured rubber matt, while Tsakiris, Carpenter, James and Fotopoulou (2010) systematically varied the similarity of the stimulated object to a hand and found that only when an actually rubber hand was used did synchronous stimulation evoke the RHI, as measured by subjective reports and proprioceptive drift. Attempting to identify the brain areas responsible for this sensitivity to the visual form of the object Tsakiris, Costantini and Haggard (2008) used repetitive transcranial magnetic stimulation (TMS) to disrupt neural activity in the temporal parietal junction (TJP) lesions to which have been implicated in impairments in body ownership (Berlucchi & Aglioti, 1997; Bottini, Bisiach, Sterzi, & Vallarc, 2002; Fotopoulou et al., 2008; Frassinetti, Maini, Romualdi, Galante, & Avanzi, 2008; Mort et al., 2003). The study revealed that, subsequent to TMS over the TPJ, participants showed reduced proprioceptive drift for a rubber hand after synchronous VT-stimulation but increased proprioceptive drift for a wooden block. This suggests that the TPJ plays an important role in comparing the visual form of a stimulated object with a stored visual representation of the participant’s own hand (Tsakiris, 2010).

Two other recent studies have however shown that some situations do seem to allow for the experience of body ownership over non-hand objects. A recent study by Guterstam, Gentile and Ehrsson (2013) found that when an experimenter stimulated the empty air in front of a participant in a pattern that matched the touch felt on the participant’s own hand, many participants reported the sensation of having ownership over an invisible hand in the location of the stimulation. This finding could be reconciled with the findings of the studies noted above by the fact that the absence of any physical object being stimulated leads to a decreased error signal in the brain areas involved in comparing visual form than does the presence of a physical object that does not match the neural model of the participant’s own hand. A second recent study by Hohwy and Paton (2010) found synchronous visual tactile stimulation could lead to the referral of touch onto a cardboard box. Interpretation of this study is difficult however as the experimenters did not collect subjective reports of the participants experience of ownership over the cardboard box and the illusory referral of touch to the box only occurred after participant’s had experienced a period of synchronous VT-stimulation over a rubber hand.

Based on the findings described above Tsakiris (2010) proposed a neurocognitive model of body ownership in which the strength of experience of body ownership over a foreign object is determined by a series of comparisons between sensory information entering the brain and various different representations of the body (See Figure 1-1). In the first comparison the visual form of the object being viewed is compared with a model of the visual, anatomical and structural properties of the participant's body. Based on the findings of Tsakiris et al. (2008), Tsakiris (2010) suggests that the right TJP is involved in this comparison. The second comparison is between the current postural and anatomical features of one's own body and those of the observed object. Based on findings from PET and EEG studies (Press, Heyes, Haggard, & Eimer, 2008; Tsakiris, Hesse, Boy, Haggard, & Fink, 2007; Tsakiris, Schütz-Bosbach, et al., 2007) the anterior parietal cortex and in particular the primary and secondary somatosensory cortices were implicated in this comparison.

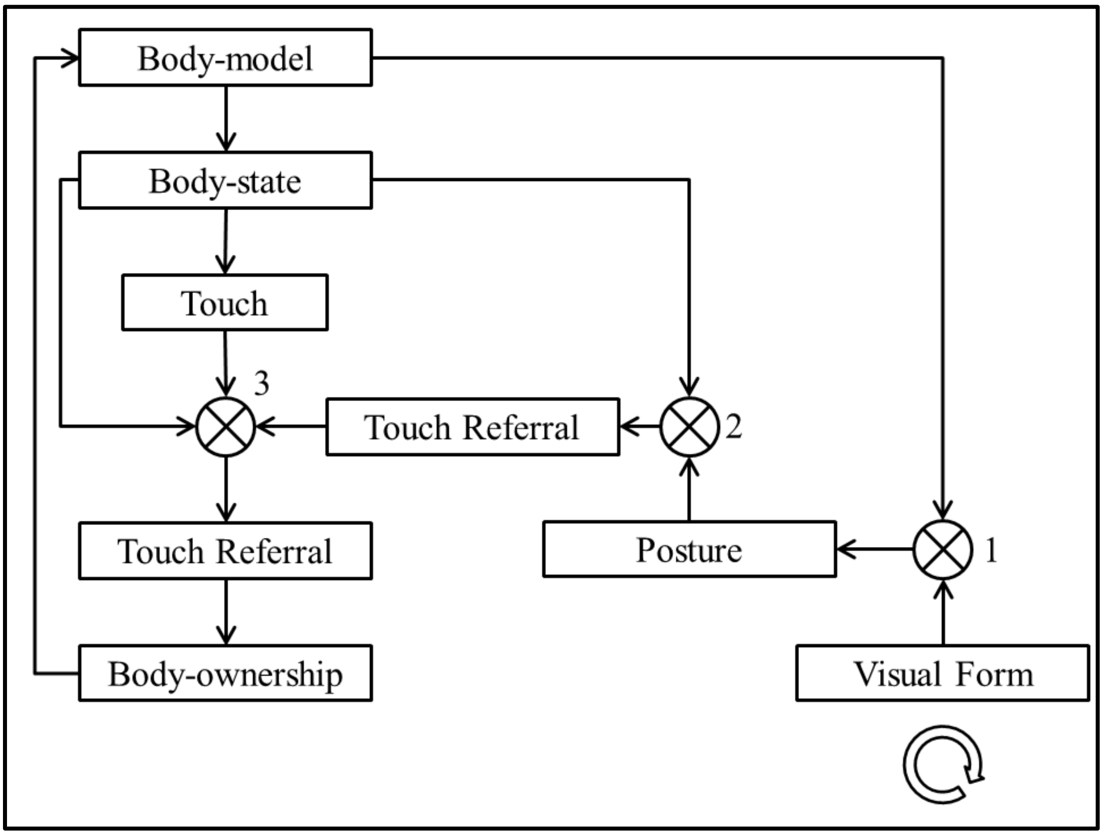

Figure 1-1. Tsakiris' (2010) model of body ownership. Crossed circles indicated different comparators (1 = comparator between visual form of the object and a stored body-model; 2 = comparator between the visually specified posture of the object and the current body state; 3 = comparison between vision of touch, felt touch and the current body state). Recycling sign indicates a loop.

The final comparison is between the vision of touch on the observed object and the felt touch on one's own body and has been argued to have its neural basis in activity in the posterior parietal cortex (PPC; Ehrsson et al., 2004; Makin et al., 2008) which resolves the conflict between visual and tactile information and recalibrates the visual and tactile coordinate systems resulting in the referral of touch which is underpinned by activity in the premotor cortex (Ehrsson et al., 2004). The final connection in Tsakiris' (2010) model is between the change in experience of body ownership, reflected in activity in the right posterior insula (Tsakiris, Hesse, et al., 2007; Tsakiris, Schütz-Bosbach, et al., 2007) and changes to the neural models of the body. Thus on this model body ownership is dependent on the integration of bottom up information coming from sensory signals and top-down information coming from neural representations of the body. In the next section I will elucidate a number of ways that manipulations of body ownership have been shown to affect representations of the body.

1.2.5. The Effects of Multisensory Induced Changes in Body Ownership

Many of the studies reported in this thesis sought to investigate whether multisensory induced changes of participants' representation of their own body could affect representations of the relationship between self and others. In view of this it is instructional to first consider the evidence that such changes can alter how participants perceive both their own body and physical objects in the world.

The first way in which (or by which) changes in body ownership affects body representations is the phenomena of proprioceptive drift described above. However several other modalities of body related information have also been shown to be affected by experiencing ownership over a rubber hand. Longo, Schüür, Kammers, Tsakiris and Haggard (2009) found that, after experiencing synchronous, but not asynchronous, VT-stimulation over a rubber hand, participants rated the rubber hand as being more visually similar to their own than those who did not experience ownership over the hand. This effect occurred despite the fact that objective similarity between the participant's hand and the rubber hand, as measured by skin luminance, hand shape, and third-person similarity ratings, did not appear to influence participants' experience of the RHI, indicating that it was the experience of ownership over the rubber hand that led to the perception of increased similarity, rather than greater similarity between the participant's hand and the rubber hand leading to a greater feeling of ownership. Additionally the study by Hohwy and Paton (2010) referenced above found that after experiencing ownership over a rubber hand participants were more likely to experience ownership over a non-hand object, suggesting that experiencing ownership over one non-self object leads to greater fluidity in the neural model of one's own body.

In addition, experiencing ownership over a non-self hand also leads to effects on the acuity of judgments of tactile stimuli applied to one's own. Longo, Cardozo and Haggard (2008) demonstrated this effect of ownership using the paradigm of visual enhancement of touch (VET) in which observing a hand while making judgments regarding the location or orientation of tactile stimuli on one's own hand leads to increased accuracy in one's judgments (Haggard, 2006; Kennett, Taylor-Clarke, & Haggard, 2001; Press, Taylor-Clarke, Kennett, & Haggard, 2004; Taylor-Clarke, Kennett, & Haggard, 2002; Tipper et al., 1998). Longo et al., (2008) delivered synchronous or asynchronous stimulation to the participant's own hand and a rubber hand and then had participants judge the orientation of different gratings applied to their own hand. It was found that those who were low in accuracy on the task performed significantly better following synchronous stimulation than following asynchronous stimulation. In addition a recent functional magnetic imaging (fMRI) study by Brozzoli, Gentile, and Ehrsson (2012) used a reputation suppression paradigm to show that experiencing body ownership over a rubber hand leads to a recalibration of peripersonal space such that objects approaching the rubber hand lead to the same patterns of neural activation as observed normally when objects approached the participant's own hand.

Changes in body ownership have also been shown to modulate the internal states of the body. Moseley et al. (2008) and Hohwy and Paton (2010) both found that experiencing the RHI lead to a drop in the temperature of the participant's real hand suggesting that that the exclusion or inclusion of a body part in a neural model of the physical self and the physiological regulation of the body are closely linked in a top-down manner. Further Barnsley et al. (2011)found that experiencing ownership over a rubber hand led to increased histamine reaction in the participant's own hand indicating that immunosuppressive as well as homeostatic systems are modulated by the attribution of ownership from one's own hand to a foreign object.

I will now move to examine evidence that multisensory induced changes to body representations can also lead to changes in the perception of objects in the external world. Most of the experiments that have investigated this issue so far have concentrated on the effect of altering perceived body size on the perception of physical objects in the world. Marino, Stucchi, Nava, Haggard, & Maravita (2010) used the RHI to increase or decrease the perceived size of participants' hands and then asked them to grasp a series of different objects that they could see at their real size. They measured the maximum grip aperture (MGA) of participants' grasping movements and found that, after experiencing VT-stimulation over a hand of a larger size than their own participants showed a smaller MGA relative to when they made the grasping movement after experiencing VT-stimulation over a hand of a normal size. This finding suggests that due to the fact that they perceived their hand as larger participants thus perceived the objects they had to grasp as smaller than they actually were. Interestingly the reverse effect was not found after VT-stimulation of a smaller hand, possibly due to the fact that VT-stimulation over small hands seems to lead to a reduced RHI. Bernardi et al. (2013) showed that a similar change in MGA held when hand size was manipulated within a virtual world.

As well as affecting the action, changes in perceived body size can also affect sensory judgments of objects. Haggard and Jundi (2009) demonstrated that participants perceived objects as being heavier after experiencing ownership of a large hand. The authors interpreted this finding in terms of the 'size-weight illusion' in which a smaller object is perceived as heavier than a larger object of the same weight, although again no effect was found when the hand was shrunk. (Linkenauger, Leyrer, Bülthoff, & Mohler, 2013) used a virtual reality setup to increase or decrease the perceived size of participants' hands and found that participant's judged objects as smaller when they had a larger hand and larger when they had a smaller hand. Interestingly in this study, an effect of changes in hand size occurred in both directions although this may be due to the different method by which the feeling of ownership was induced (visuo-motor vs. visuo-tactile)

Experiments with the full-body illusion have shown that multisensory induced changes in the size of the whole body can also lead to changes in the perception of the external world. Van der Hoort et al. (2011) used multisensory stimulation of their participant's body and that of different sized mannequins to alter participants' body representations and then asked them to judge the distance and size of various objects. It was found that participants felt equal feelings of ownership over a larger or smaller body than their own, a fact that may be due to the difference in scope of experiencing a change in ownership over just a hand compared to the feeling of being in a completely different body. Additionally after feeling ownership over the small body they judged objects as being larger and distances as further than they did after experiencing ownership of a normal sized body, and the reverse was true when they experienced ownership over a large body. This finding was recently replicated by Banakou, Groten and Slater (2013) who showed that experiencing ownership of the virtual body of a child led to an increase in the perceived size of objects.

The evidence presented here supports arguments for the bodily basis of the PS and the power of multisensory induced changes in the perception of one's body to affect perceptions of both one's body and the external world. Less well explored so far however, is the question of how much changes in the representation of the bodily self can affect perceptions of the social relationship between self and other. Before moving to review the current literature surrounding this question however, it is first necessary to briefly outline the second key form of selfhood involved in this thesis, the social self.

1.3. The Social Self

1.3.1. Social and Narrative Selfhood

The SS is an explicit conceptual form of selfhood which emerges through our interactions with others, and in particular through linguistic and cultural identifications of selfhood (Gallagher, 2000; Mead, 1913, 1935; Neisser, 1991). The phrase "the social self" was first used by Mead (1913)who argued that the sense of having a self is dependent on the prior presence of social interaction with others. According to Mead:

"The mechanism of introspection is ... given in the social attitude which man necessarily assumes toward himself, and the mechanism of thought, in so far as thought uses symbols which are used in social intercourse, is but an inner conversation." (Mead, 1913, p. 377).

For Mead (1913, 1935) then having a sense of selfhood involves taking a perspective on one's own experience that is first developed when thinking about others. Mead also emphasised that it is only through internalising the way that others think of and define us that we are able to turn the social practices we have learned to apply to others back on to ourselves. Mead distinguished between the "I" and the "Me" as two different forms of self-experience. While the "I" represents the self as a living subject, the "Me" represents the self as the internalised attitudes that others show towards us. In contrast however to the conception of the self as subject being dependent on bodily experience, for Mead the "I" only comes to exist after the "Me" is learned through social interaction with others.

The social self is closely related to the concept of the narrative self (NS). The NS has been elucidated by thinkers from different traditions, with differing conceptions of narrative (e.g. Dennett, 1991; MacIntyre, 1985; Ricoeur, 1985; see Schechtman (2011) for a review). But all emphasise that the experience of a self as unified and continuous across a lifetime relies upon the ability to situate one's memories, personality traits, goals and values within a coherent narrative structure. The aspect of the NS which I wish to emphasise is the role played by social interaction in shaping the stories we tell about ourselves.

For example Dennett (1991) notes the importance of social practices such as storytelling in allowing children to construct their own narratives later in life and MacIntyre (1985) points out that: “We are never more (and sometimes less) than the co-authors of our own narratives. Only in fantasy do we live what story we please” (MacIntyre 1985, p.213). In life, in contrast to fictional stories, we can be affected by the goals and desires of others around us. In the earliest periods of our life we are almost totally dependent on the care of others in order to survive and as we grow older we emerge into a social world in which we must define ourselves according to concepts that have specific cultural and historical traditions. In real life we are rarely living out one simple role but instead have multiple and often conflicting memories and beliefs about who we are (Goffman, 1959). The type of narrative that guides one at work is likely to be very different from the narrative one has when with one’s partner or friends. So, while at one level the role of the NS is to bring a sense of unity to our lives, it is also important to recognise that this greater narrative is made up of a variety of different sub-narratives that are shaped by different social situations.

1.3.2. The Social Self in Psychology

This theme of the self as composed of different social narratives is also reflected in approaches to the self in social psychology. In a recent review McAdams (2013) highlights three distinct aspects commonly reflected in psychological theories of the self, the self as actor, agent and author and notes the important social influences that are necessary for developing a full sense of selfhood. By the self as actor McAdams seeks to capture the sense of the self as slotting into various different social roles in order to gain a sense of identity within a social group and the process of learning, through feedback from one’s social group, exactly which positions in the social hierarchy one should take up. This form of selfhood is closely related to the framework set out by social role theory which argues that our behaviour and attitudes regarding ourselves develop through the social roles we take up. On this conception a social role is a comprehensive pattern of behaviour and attitudes that constitute a strategy for coping with a recurrent set of situations (Turner, 1990). These social roles are hypothesised to emerge from an interaction between the individual in the role, the other people they interact with while in that role and the social norms that govern that role (Charon, 2009). In this way the self is both defined by and plays a part in defining the social roles ascribed to it. In discussing the development of the self as actor McAdams highlights the work of Harter (2006) who has shown that by the time children enter their second decade of life they have moved away from describing themselves based purely on their observable traits e.g. physical appearance or favourite foods and have instead began to attribute themselves traits that capture their broad dispositional tendencies focused on social behaviour.

McAdams (Mcadams, 2013) second conception of selfhood is the self as agent. This aspect of selfhood is intended to capture the self as able to set personal goals for the future and plan towards them. While this agentive self is less obviously social than the actor aspect of the self McAdams highlights the necessity of socialization in allowing children to develop the capacity for planning and reflection necessary for the full development of the agentive self. In doing so he cities the theories of Vygotsky (1978) who emphasised the role of social interaction and support in the development of cognitive capabilities, such as the language, attention and memory all of which are necessary for the greater self-reflection and planning necessary for an agentive self.

The final aspect of selfhood discussed by McAdams is the self as author. By this McAdams refers primarily to the NS concept described above. Here I merely wish to highlight the empirical research that suggests the importance of social interaction in the development of the ability to create a narrative self. This aspect has been addressed by Nelson (2003), among others, who has detailed the way that as children begin to learn language they are taught by care-givers to begin to narrate the events of their lives. Although these narratives begin by being highly localised and simplistic and require a large amount of prompting from the care giver, e.g. “What sort of animals were seen at the circus?” (Fivush & Nelson, 2006). Over time children learn to develop these narratives on their own which adds a new awareness of self in past and future experiences and the contrast of that self to others' narratives of their past and future experiences.

The role of caregivers in scaffolding the child's development of a narrative self is not just necessary for the development of a sense of narrative self in adulthood. In addition the type of scaffolding that the child receives plays a key role in the shaping distinct variations in self-perception across culture and gender. For example girls talk more about feelings and thoughts in personal experiences than boys (Fivush, 2011) and Fivush and Nelson (2004) argue that the cultural differences in conceptions of selfhood between Western and Eastern cultures (for reviews see Cohen, Leung, & Hoshino-Browne, 2007; Markus & Kitayama, 2010) can be traced back to differences in the way that carers in the West and East support their children in developing narratives in autobiographical memory. They note findings that mothers from Western cultures talk about the past in more elaborate and emotional language and tend to focus on the child's own experience of events while mother's from Eastern cultures tend to emphasis the communal setting of events and to highlight the moral emotions and lessons that emerge from experiences (Leichtman, Wang, & Pillmer, 2003). These differences in the style of scaffolding appear to continue across life with both older children and adults from Western cultures tending to have more detailed, elaborate and emotional narratives of their past than their counterparts in Eastern cultures (Pillmer, 1998).

1.3.3. The Gap between Phenomenal and Narrative Selfhood

How does the bodily coupling of sensory and motor information that specifies the PS relate to the development of the more cognitively sophisticated SS, with its sense of being a self with a narrative history intertwined with others around it? This issue has received little attention so far, in part due to the different methodologies and traditions that have been involved in defining these two forms of selfhood and their associated forms of self-consciousness. Scientific investigation of bodily self-consciousness has been primarily driven by an emphasis on a solipsistic approach that examines the role of multisensory input and body representations for the subject, while neglecting the role of interaction with others in the emergence of more complex forms of self-consciousness (Berlucchi & Aglioti, 2010; Lenggenhager et al., 2007).

Conversely social psychological approaches to self-consciousness remain largely focused on the concept of the self as a cognitive, often disembodied, process. The self is treated as an abstract symbolic structure, largely separate from both perception and action, and self-consciousness is largely treated as explicit and reflective. As far as there is interest in the body within social psychology it tends to focus on the role of society in shaping perceptions of body image (O'Dea & Abraham, 2000; Rangkakulnuwat, Pothiban, Metzger, & Tiansawad, 2008; Strauman, Vookles, Berenstein, Chaiken, & Higgins, 1991) or in the alteration of the body as a means for self-expression (Sweetman, 1999). As an example of the lack of development of the links between the bodily and social selves it is worth noting that the quote at the start of this chapter "Everywhere in the world, self starts with the body" comes from Baumeister's (1999) introduction to a collection of essays on The Self in Social Psychology. However, both in the rest of his introduction to the self and in the rest of the book it is clear that for most researchers in the field, the social self is an entity which only happens to be embodied, the body does not even receive an entry in the index.

Thus the more general relation between complex forms of social self-consciousness and bodily experience remains a mystery. However from the embodied cognition perspective outlined in section 1.2 it is a reasonable hypothesis that the bodily representations underlying the PS would play a vital role in scaffolding the development of social conception of the self. Therefore it is possible that body representations of self and other may have an important role in shaping our perceptions of our social similarity to others. The experiments described in this thesis aim to begin to fill this lacuna in the literature by examining the relationship between perceptions of bodily similarity between self and social cognition. Before moving to outline these relationship however I will briefly review a number of forms of research in the current literature that suggest a connection between the bodily self and social cognition.

1.4. The Bodily Self in Social Cognition

1.4.1. Embodied Concepts in Social Cognition

The first source of evidence for a link between the body and social cognition comes from research showing that many social concepts are closely linked to sensorimotor representations of the body. Many of these studies are motivated in part by the embodied metaphor theory put forward by Lakoff and Johnson (1980, 1999) which argues that higher level abstract concepts are grounded in more concrete sensory and motor conceptual schemas whose relations are then mapped on to our thinking of the more abstract concepts. Here I will briefly consider a small number of examples that demonstrate evidence for the mapping of embodied metaphors on to concepts and behaviour involved in social cognition.

The first mapping between body and concepts that I wish to highlight is that of height and social dominance. The relationship between height and dominance has an obvious evolutionary justification, throughout the animal kingdom larger males are more likely to attain social dominance through dominance displays and fights (Goodall, 1986; McElligott et al., 2001; Schuett, 1997). In developmental terms the association between height and power is created early in life as larger parents hold dominance over smaller children (B. Schwartz, Tesser, & Powell, 1982). The link between dominance and height appears to exert an influence in success in later life with taller people earning higher salaries (Frieze, Olson, & Good, 1990; Judge & Cable, 2004), being more likely to be found in higher status occupations (Egolf & Corder, 1991; Melamed & Bozionelos, 1992), to emerge as leaders (Higham & Carment, 1992) and to win presidential elections (Young & French, 1996).

A number of studies have found evidence that this link between height and dominance is present at a very general level (Epperson, 2000; Gagnon, Brunyé, Robin, Mahoney, & Taylor, 2011; Robin, 2001; Schubert, 2005). For example Gagnon and colleagues (2011) showed that people show an implicit link between images of elevated terrain and greater social dominance and also between a more abstract representation of height (the cardinal direction north) and social dominance. Of more interest to the current thesis however are findings that specifically demonstrate a bi-directional link between the perception of power and body size. Duguid and Goncalo (2012) found that being primed with stimuli evoking power or being placed in a powerful role led participants to underestimate an object's height relative to their own height, made participants overestimate their own height and caused participants to choose a taller avatar to represent them in a second-life game. Yap, Mason and Ames (2013)showed that similar manipulations led participants to underestimate the height of other people demonstrating the inherent social effects of this mapping. In addition research by Fessler and colleagues has also demonstrated that increasing the power of another person by giving them a weapon leads that person to be perceived as taller (Fessler, Holbrook, & Snyder, 2012) while the presence of male companions led men to give lower estimates of the height of a potential opponent (Fessler & Holbrook, 2013). Most intriguing, for the hypothesis that altering the bodily self will lead to a change in social behaviour, is a study by Yee and Bailenson (2007) which showed that giving people a taller avatar in a virtual environment led them to subsequently behave more confidently in a negation task. While the manipulation used in this study did not involve the perception of body ownership over the virtual body it does serve to show that even relatively abstract changes to how we imagine our bodies to be can lead to changes in social behaviour.

The second mapping between the body and social cognition I wish to highlight is the relationship between judgements of social closeness or pleasantness and temperature. In this case the relevant mapping is between physical warmth and social closeness and the converse relationship between being physically cold and loneliness. This relationship has been highlighted in the social psychology literature for a long time, for example Asch (1946) proposed psychological warmth as being the central dimension in which people judge one another and later proposed a relationship between physical and psychological warmth (Asch, 1958). As in the case of height there is a clear developmental relationship between feeling warm and being close to another. In infancy the experience of physical warmth is closely associated with being held closely by one's carers and protected from the environment and Bowlby (1969) argued that this association has resulted in an innate drive for the young of many species, including humans, to maintain close distances to their parents and kin.

Indeed Fransson, Karlsson and Nilsson (2005) demonstrated that being held by a carer led to a much lower difference between infants core and skin temperature than did being in a cot.

A number of recent studies have highlighted the bidirectional nature of this association between temperature and social closeness. Williams and Bargh (2009) showed that simply holding a warm beverage led participants to perceive a person as being more socially warm than did holding a cold beverage and, in a second experiment, that experiencing a warm as opposed to cold sensation led participants to be more likely to choose a gift for a friend rather than for themselves as payment for the study. Further work by Bargh and Shalev (2012) showed that people seem to be unconsciously aware of the relationship between temperature and social closeness finding that greater chronic loneliness was associated with taking warm baths, that physical coldness led to increased feelings of loneliness (see also Zhong & Leonardelli, 2008) and that experiencing physical warmth led to a decrease in the need for social affiliation after recalling a past social rejection. A recent study by Ijzerman and colleagues (2012) found evidence for a direct relationship between the actual temperature of the body and social isolation, demonstrating that that being excluded from an online interaction led to a decrease in skin temperature.

The final mapping between the body and social cognition I will highlight is the mapping of a relationship between bodily purity and moral purity, this mapping is of interest due to its greater affective aspect than the previous two examples. A number of researchers in morality have argued that our sense of morality is grounded in emotion and the link between bodily and moral purity is closely linked to the emotion of disgust which can be felt towards both physically and morally repellent stimuli (e.g. Haidt, Rozin, McCauley, & Imada, 1997). Empirical evidence for the association between moral and physical cleanliness has been found in a number of different studies. For example Zhong & Liljenquist (2006) showed that after recalling some previous immoral behaviour participants were more likely to desire to be clean or to choose a cleansing product as a reward for taking part in the study and further that using a cleansing product following such recall lessened the likelihood of taking part in moral compensatory behaviours (i.e., helping others). Interestingly this desire for cleanliness appears to be specific to the effector involved in a morally bad act so that after saying something bad participants are more likely to want mouthwash but after typing something bad they are more likely to want hand sanitizer (Lee & Schwarz, 2010). Further studies have shown that perceived cleanliness can also affect moral judgements, participants judge a transgressor less severely when cleanliness was attributed to the transgressor (Schnall, Benton, & Harvey, 2008), but more severely when cleanliness was attributed to the self (Zhong, Strejcek, & Sivanathan, 2010). The perception of cleanliness also appears to promote prosocial behaviour. Liljenquist, Zhong and Galinsky (2010) found that people in a room which had recently been sprayed with air freshener were more likely both to reciprocate in a trust game and to donate to charity. Evidence has also been found for the reverse association between disgust and moral disapproval (Schnall, Haidt, Clore, & Jordan, 2008; Wheatley & Haidt, 2005). For example, Inbar, Pizarro and Bloom (2012) showed that smelling a disgusting odour can lead to increased disapprobation of gay men, while Eskine, Kacinik and Prinz (2011) showed that tasting a disgusting (bitter) drink led participants to judge various moral transgressions more harshly than did tasting a sweet drink.

The studies covered in this section highlighted three examples of the way that representations based on sensorimotor processes can ground concepts involved in social cognition. However the role of bodily representations of the self in grounding more socially relevant concepts of selfhood is one that has largely been overlooked. Attempting to address this lacuna provides one motivation for the studies reported in this thesis.

1.4.2. Shared Body Representations

Another strand of recent research in cognitive science which makes consideration of the role of the bodily self in social cognition timely is the increasing interest over the past two decades about the role of shared representation of one own body and the bodies of others in social cognition. This interest has been motivated largely by findings from cognitive neuroscience that indicate the existence of a frontal-parietal system of “mirror neurons”, defined as firing during both the observation and execution of particular actions. These neurons were first directly observed in monkeys through the use of single cell recordings (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Gallese, Fogassi, Fadiga, & Rizzolatti, 2002; Rizzolatti et al., 1988) and have recently been identified in humans (Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). There have also been a large number of imaging studies that suggest the existence of a similar shared neural system of shared representations of action execution and observation in humans (for recent reviews see: Bonini, Ferrari, & Fogassi, 2013; Fogassi, 2011; Molenberghs, Cunnington, & Mattingley, 2012; Rizzolatti & Sinigaglia, 2010).

Further research has found evidence that similar pattern of shared activation also occurs in brain areas involved in the perception of touch (Banissy & Ward, 2007; Blakemore, Bristow, Bird, Frith, & Ward, 2005; Ebisch et al., 2008; Keysers et al., 2004), pain (Jackson, Meltzoff, & Decety, 2005; Lamm, Decety, & Singer, 2011; Singer & Frith, 2005) and emotion perception (Bastiaansen, Thioux, & Keysers, 2009; Jabbi, Bastiaansen, & Keysers, 2008; Wicker et al., 2003). The finding of multiple mirror systems in the brain has led several authors to argue that these neural systems offer the possibility of a unified theory of social cognition by giving a neurofunctional account of how the behaviour, sensations and emotions of others, observed from a third person perspective (3PP), can become represented in the same way as one’s own actions, sensations and emotions, which are felt from a first person perspective (1PP) thus explaining such social skills as imitation, empathy and mind reading (Bernhardt & Singer, 2012; Hurley, 2008; Iacoboni, 2009; Keysers & Gazzola, 2009).

The evidence from studies on mirror neurons thus suggests a strong link between representations of one’s own body and the representation of the body of others. However the mechanism behind the formation of mirror neurons is currently disputed. Some authors (Meltzoff & Decety, 2003; Ramachandran, 2000; Rizzolatti & Arbib, 1998; Rizzolatti & Craighero, 2004; Rizzolatti, Fogassi, & Gallese, 2001) have argued mirror neurons are evolved and have used the claims by Meltzoff and Moore to have found evidence of imitative gestures in neonate (Meltzoff & Moore, 1977, 1983, 1989, 1997) to justify this view. However there is increasing evidence to suggest that, rather than being present at birth, mirror neurons in fact develop via a combination of associative learning and experiential canalisation (Del Giudice, Manera, & Keysers, 2009; Heyes, 2010).

First, despite being regularly cited, the evidence for neonatal imitation is less convincing than is often assumed. In particular only a very small number of gestures, such as tongue protrusion have been found to be reliably imitated by neonates and these gestures can also be interpreted as generalized, exploratory responses to arousing stimuli, and response competition rather than true imitation (for more thorough critiques of neonatal imitation see Anisfeld, 2005; Jones, 2009; Ray & Heyes, 2011). Second there is now considerable evidence that mirror neurons can be altered by experience. Haslinger et al. (2005) showed greater mirror activation in pianists than in non-pianists during the observation of piano-playing and Calvo-Merino, Glaser, Grèzes, Passingham and Haggard (2005) found greater mirror activation in classical ballet dancers than in capoeira dancers during observation of ballet movements. Further studies have shown that even a short period of sensorimotor training is capable of enhancing (Press, Gillmeister, & Heyes, 2007), abolishing (Heyes, Bird, Johnson, & Haggard, 2005) and even reversing mirror activation in human subjects (Catmur et al., 2008; Catmur, Walsh, & Heyes, 2007).

If the associative learning account of mirror neurons is correct then shared representations of self and other emerge due to the close match between one's own actions and the actions of others. In the next section of this introduction I will consider one phenomenon that generates such matching situations, non-conscious mimicry, and examine its role in social cognition.

1.4.3. Mimicry and Social Cognition

The importance of synchrony in social interaction can perhaps most clearly be seen in the tendency of people to unconsciously mimic the actions of those they are around (for recent reviews see: (Chartrand & Lakin, 2013; Chartrand & van Baaren, 2009). This tendency exists for both individual actions (Chartrand & Bargh, 1999; Lakin & Chartrand, 2003; Macrae, Duffy, Miles, & Lawrence, 2008) and for temporally extended sequences of action such as postural adjustments, facial expressions and verbal communication (Bernieri, 1988; Cappella, 1997; Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2008; van Baaren, Holland, Steenaert, & Vanknippenberg, 2003).

Mimicry has been shown to exert a number of effects on social interaction. For example being mimicked leads to an increased sense of liking (Chartrand & Bargh, 1999) and affiliation (Lakin & Chartrand, 2003) towards the mimicker. This increased liking translates into behavioural consequences as demonstrated by the fact that people give larger tips to waitresses who repeat their exact words (van Baaren, Holland, et al., 2003). Mimicry also makes people more pro-social, and participants who had been mimicked during an interaction were more likely to help an experimenter pick up a dropped box of pens and to donate money to charity (van Baaren, Holland, Kawakami, & van Knippenberg, 2004; van Baaren, Horgan, Chartrand, & Dijkmans, 2004). As well as these socio-cognitive effects mimicry also seems to influence how well people remember others with people being more likely to remember the details of a social encounter with a person who mimicked them than with one who did not (Macrae et al., 2008).

There is also evidence that people are unconsciously aware of the role of mimicry in building social bonds and that social factors can affect how likely people are to mimic others. Lakin and Chartrand (2003) found that participants who were given the goal, either consciously or unconsciously through priming, to affiliate with others mimicked an experimenter more than those who did not have the goal to affiliate. They also found that when participants failed to affiliate with the other they subsequently increased mimicry. Cheng and Chartrand (2003) followed up these findings by showing that people with high self-monitoring, i.e. a greater awareness of the image they present to others (Snyder, 1974), displayed increased mimicry when interacting with someone of equal or higher status compared to someone of lower status. This effect was not found in people with low self-monitoring suggesting that high self monitors unconsciously recognise the power of mimicry in facilitating social interactions.

Two recent studies have demonstrated that the effect of social attitudes on mimicry was direct and beyond participants' control. Likowski et al. (2008) used written reports to give participants positive, negative or neutral feelings towards three actors and found that participants showed the most facial mimicry of the expressions of the person they had a positive view of and the least for the person they felt negatively towards. Leighton, Bird, Orsini and Heyes (2010) had participants observe hand actions and they were required to perform either the same or a different action with their own hand. Participants were primed with either pro-social or anti-social words and it was found that those primed with pro-social words were faster to perform an action in congruent trials than those primed with anti-social words but slower to perform the action in incongruent trails. This finding shows that the modulation of bodily mimicry is directly modulated by social attitudes as oppose to being mediated by other processes i.e. attention and thus further emphasises the close link between higher level social cognition and sensorimotor processing.

Non-conscious mimicry is also affected by how much one identifies with the person to be mimicked. Yabar, Johnston, Miles and Peace (2006) found greater mimicry of a non-Christian confederate than a Christian confederate among non-Christian participants. They also found that the amount of actions of the Christian that participants mimicked was positively correlated to their implicit attitudes towards Christians. In a similar study Bourgeois and Hess (2008) found greater facial imitation of in-group compared to out-group models. Evidence for the modulation of mimicry by in-group or out-group identification has also been found by several other authors (Liebert et al., 1972; Neely, Heckel, & Leichtman, 1973; van der Schalk et al., 2011; Weisbuch & Ambady, 2008).

Other self-related attitudes can also affect mimicry. In a series of three experiments, (van Baaren, Maddux, Chartrand, de Bouter, & van Knippenberg, 2003) investigated the effect self-construal on mimicry. In the first two studies participants were primed with either an independent or interdependent self-construal and it was found that those primed with an interdependent self-construal showed greater mimicry than those primed with an independent self-construal. In the third study participants from either an independent (American) or interdependent (Japanese) culture were observed while watching a person and the same effect was found. Hogeveen and Obhi (2011) also investigated the relationship between self-construal and non-conscious mimicry. They primed participants with either independent or interdependent self-construal while they perform the same task as used in Leighton et al. (2010). The study found that participants were slower to act on incongruous compared to congruous trial and that this effect was stronger when participants received an interdependent prime compared to an independent prime. Mimicry has also been shown to be affected by competitiveness (Weyers, Mühlberger, Kund, Hess, & Pauli, 2009); feelings of closeness or liking towards the person being imitated (Fischer, Becker, & Veenstra, 2012; Mcintosh, 2006) and whether or not the action to be imitated is carried out by a human or not (Longo & Bertenthal, 2009; Press et al., 2007).

The propensity for unconscious mimicry is so widespread that Lakin et al. (2003) have argued that it must be an evolutionary adaptation which acts to build a sense of affiliation between people like a kind of "social glue." While this theory does offer an explanation for why people so commonly mimic others around them, it fails to address the issue of why mimicry leads to increased feelings of closeness in the first place. The studies on multisensory stimulation's effects on body ownership viewed above suggest one possible answer to this question. When one's own actions are mimicked by a social partner it creates a form of multisensory stimulation in which one's own action intentions are reflected in the actual bodily movements of the mimicker. This synchrony between one's own actions and those of the other could lead to the same blurring of the boundary between self and other and cause me to expand my sense of bodily selfhood to include the other in it, creating the feeling of affiliation and closeness observed in the studies detailed above.

1.4.4. The Power of Synchrony

Further evidence suggesting that the effects of mimicry may be due to the increased overlap it creates between one's own bodily self and the body of others comes from research that has demonstrated the power of synchronous movement to increase cooperative and pro-social behaviours. The study of human movement has demonstrated that people naturally synchronise their body movements to each other across a variety of different activities including: limb movements (Issartel, Marin, & Cadopi, 2007; Schmidt, Carello, & Turvey, 1990), walking (van Ulzen, Lamoth, Daffertshofer, Semin, & Beek, 2008; Zivotofsky & Hausdorff, 2007) and the motion of rocking chairs (Richardson, Marsh, Isenhower, Goodman, & Schmidt, 2007). Such cases of synchronised action are one of the most basic forms of human interaction (Knoblich & Sebanz, 2008). Indeed, there is now evidence that behavioural synchrony occurs not only in humans but also in other social animals such as monkeys (Nagasaka, Chao, Hasegawa, Notoya, & Fujii, 2013) and dolphins (Connor, Smolker, & Bejder, 2006).

Behavioural synchrony has been shown to have an effect on how people perceive observed social interactions. Miles, Nind and Macrae (2009) asked participants to rate the rapport between two walking figures that could be in a variety of different phases of synchrony and found that participants perceived the rapport between two people walking was strongest when their steps where most synchronised with one another and weakest when they were least synchronised. In a similar vein Lakens and Stel (2011) showed that both stick figures and real people were more likely to be perceived as belonging to a cohesive group when they were waving synchronously compared to asynchronously and Bernieri, Davis, Rosenthal and Knee (1994) found that participants judged people moving in synchrony as having a better rapport even when the observed videos had been edited so that only gross bodily actions were visible.

As well as affecting judgements of other people's interactions acting in synchrony has been shown to exert a significant effect on people's feelings towards their own interaction partners. Hove and Risen (2009) demonstrated that synchronous movements between partners also lead to greater feelings of affiliation and Valdesolo and Desteno (2011) showed that participants felt greater compassion towards the victim of a moral transgression when they had previously engaged in synchronous, compared to asynchronous, hand tapping with them. In a related manner Nowak, Watt and Walther (2005) showed that people who interacted remotely using synchronous, as opposed to time delayed communication media, felt increased social attraction to their partners.

There is also evidence to suggest that synchronous movement boosts the cognitive processes involved in social interaction. A recent study by Pellegrini and Ciceri

(2012) found that participants who synchronised their breathing to audio recordings of another person's breathing were more accurate when asked to judge the mental or physical difficulty of the task that person had been performing. Moreover synchronous movement also seems to increase performance in cooperative tasks. Valdesolo, Ouyang and DeSteno (2010) demonstrated that rocking in synchrony enhanced individuals' perceptual sensitivity to the motion of other entities and thereby increased their success in a subsequent joint-action task.

As mentioned above synchronous movements have been shown to have effects on participant's ratings of affiliation and compassion, however such self report measures have a number of limitations including being open to demand characteristics and having questionable validity in predicting behaviour (MacCann, Matthews, Zeidner, & Roberts, 2003; Naef & Schupp, 2009; Spector, 1994). A number of other studies have therefore used techniques from behavioural economics to investigate how far synchrony can affect people's actual behaviour. Wiltermuth and Heath (2009) showed both walking and singing in synchrony with a group of others subsequently led to greater group cooperation in both a public-goods game and a weak link coordination exercise. In subsequent studies one of the authors also highlighted the negative behavioural consequences of increased affiliation due to synchronous movement demonstrating that participants who moved in synch with an experimenter were subsequently more likely to comply with requests to either kill insects (Wiltermuth, 2012b) or administer a noise blast to another group of participants (Wiltermuth, 2012a).

In addition, Launay, Dean and Bailes (2013) recently showed that simply hearing what they believed were sounds made by another person tapping in time with their own actions, although in fact the study used virtual partners, was enough to lead to participants offering greater amounts of money in a trust-game. Fischer, Callander, Reddish and Bulbulia (2013) used an even more ecologically valid approach by having participants take part in real religious rituals that involved varying degrees of synchronised movement and showed that the amount of synchrony involved in a ritual was a key factor in increasing the amount of money offered by participants in a subsequent public goods game. In another study the same group demonstrated that the effect of synchronous action on pro-social behaviour was not confined to interaction partners but also encompassed non-partners, indicating that synchronous action can act as a general prime towards pro-social behaviour Reddish, Bulbulia and Fischer (2013).

Additional support for the idea that synchronous movement plays an important part in creating social links can be seen in considering the role of synchronous bodily movement in many social situations that encourage affiliation within a group. Dancing represents perhaps the most universal example of interpersonal synchronisation. From the campfires of traditional hunter gatherer societies to night clubs in the industrialised world people from all cultures gather to dance and feel a sense of bonding and togetherness while doing so. A number of authors (e.g. Brown, 2000; Levitin, 2008) have argued that the human propensity for dance and music has emerged as the result of an adaptation to facilitate group bonding and the sense of being part of a tight knit community. However there are many other examples; crowds at sporting events, religious gatherings and political rallies will often chant, sing and move in synchrony, Japanese corporations have long used communal exercise such as Tai Chi as a way to encourage a sense of team work among their employees and soldiers are trained to march in step in order to develop the feeling of being part of a well-oiled machine. At the most extreme level such group activities can lead to a loss of one's sense of self as a distinct individual and the feeling of being absorbed into a larger group identity, a phenomenon known as deindividuation (Mann, Newton, & Innes, 1982; Mullen, Migdal, & Rozell, 2003; Zimbardo, 1969).

1.5. Investigating the Relationship between the Bodily Self and the Social Self

The aim of the experiments reported in this thesis was to investigate the relationship between the multisensory based processes involved in the generation of a sense of bodily selfhood and the more abstract socially constructed forms of self that are involved in social cognition. Based on the review of the current literature regarding self, body and social cognition conducted above, such research fills a notable lacuna in the current research on the self. Based on the review of the empirical research above there are two key motivations for filling this lacuna. The first is to examine whether, in line with the predictions of the embodied cognition paradigm, the sensorimotor processes involved in the formation of the bodily self also serve to ground conceptual representations of the self that are involved in social cognition. The possibility of such a relationship is suggested by the previously reviewed work demonstrating that sensorimotor processes play a role in grounding other concepts involved in social cognition. The second motivation comes from the literature showing the power of imitation and synchronous movement to create the perception of social closeness. These findings, together with the large amount of research demonstrating the role of synchronous multisensory and sensorimotor signals in structuring the experience of body ownership, suggest that the feeling of greater bodily similarity may, by leading to an association between self and other, drive feelings of greater social similarity. Given the evidence presented above on the role of multisensory stimulation in changing representations of the bodily self, the investigation of this question is important in ascertaining whether the social effects that have been found for synchrony are mediated by changes in the bodily self.

In the rest of this thesis I will present a series of studies that seek to investigate the relationship between bodily and social conceptions of the self from both directions. These experiments thus sought to discover whether multisensory stimulation, and the resultant feelings of body ownership, can change our social perceptions of others, as well as the reverse question of whether the amount of social closeness we feel towards others affects how closely our representations of their body overlaps with those of our own.

The work presented in this thesis all aims to examine the relationship between bodily and social representations of self and other. Conceptually however, the studies reported can be roughly divided into two distinct, but complementary streams. The first, comprising of the experiments in chapters 2, 3 and 4, investigated how multisensory induced changes in body representation could affect the perception of a different social group. The second, comprising the experiments contained in chapters 5 and 6, investigated the relationship between interpersonal social interaction and representations of one's own and others' bodies.

Chapter 2 investigates the effect of skin colour on inducing sense of body ownership and the effect of feeling ownership over the hand of a racial out-group on attitudes towards that out-group. Experiment 2.1 employs a within subject design to investigate the role of skin colour in the rubber hand illusion using measures of participant self-report (Likert scale responses), proprioceptive drift and physiological response to painful stimuli and also investigated the relationship between body ownership and implicit racial bias as measured by the Implicit Association Task (IAT). Experiment 2.2 built on the results of experiment 2.1 by examining the role of skin colour in the RHI using a more controlled means of measuring physiological response to painful stimuli and by including an additional control of synchronous stroking of a hand from a third person perspective in order to examine whether changes in physiological response to threat were primarily due to synchronous stroking or the experience of body ownership.

Chapter 3 investigates the role of experiencing body ownership over a hand from a different racial group in changing social and bodily signatures of prejudice. Experiment 3.1 follows up the findings from experiment 2.1 by using a between subjects design to investigate whether multisensory stimulation over a hand from a different racial group can alter participants' implicit attitude towards that racial group as measured by the IAT. Experiment 3.2 uses a within subject design to investigate whether multisensory stimulation over a hand from a different racial group can alter sensorimotor racial bias as measured by TMS induced motor evoke potentials (MEPs) in response to painful stimuli.

Chapter 4 moves from examining the effects of body ownership on racial attitudes to examining the power of multisensory induced body ownership to lead to stereotype activation. Experiment 4.1 uses a between subjects design to investigate whether multisensory stimulation over an elderly hand can lead to slower imagined movements in a motor imagery task. Experiment 4.2 attempts to better control for experimenter effects by using a within-subject design to examine the same question.

In chapter 5, I move into the second stream of research and investigate the relationship between social interaction, in this case a trust game, and representations of bodily similarity. Experiment 5.1 investigates, using a between subject design, whether synchronous IMS between the face of the participant and the face of a trustee in a trust game would lead to greater offers of money than asynchronous IMS. Experiment 5.2 investigates the same question but using a within subject design and with a more sensitive measure of the amount of money participants were willing to send. Experiment 5.3 on the other hand investigates the reverse question of whether evidence of trustworthy behaviour leads to a perception of greater facial similarity. Participants took part in two trust games; in one, trust was reciprocated, and in the other, trust was betrayed. Prior and subsequent to these trust games participants performed self-face recognition tasks with the faces of the two trustees.

In the final experiment chapter 6 investigates, using fMRI, whether observing the actions of a trustworthy person while they take part in an economic game with the participant leads to greater activation of neural areas involved in action execution than does observing the same actions made by an untrustworthy person.

Chapter 2. Beyond the Colour of My Skin: How Skin Colour Affects the Sense of Body Ownership[2]

"'First of all,' he said, 'If you can learn a simple trick, Scout, you'll get along a lot better with all kinds of folks. You never really understand a person until you consider things from his point of view-'
'Sir?'
'-until you climb into his skin and walk around in it.'"

Harper Lee, (1960, p. 31)

2.1. Introduction

Recent studies on the role of multisensory integration for body-awareness have aptly demonstrated the malleability of body representations. In particular, bodily illusions such as the RHI, (see Botvinick & Cohen, 1998), the full body illusion (Ehrsson, 2007; Lenggenhager et al., 2007) and the body swap illusion (Petkova & Ehrsson, 2008) suggest that synchronized visuo-tactile (VT) stimulation between one's own body and a foreign body can change the sense of body ownership. The previous chapter Several studies have shown that factors such as the corporeality of the stimulated object (Haans et al., 2008; Tsakiris et al., 2010), the anatomical congruency (Pavani et al., 2000; Tsakiris & Haggard, 2005b), the volumetric congruency (Pavani & Zampini, 2007), the postural congruency (Austen, Soto-Faraco, Enns, & Kingstone, 2004; Costantini & Haggard, 2007) and the spatial relation between viewed and felt body-part (Lloyd, 2007), modulate the induction of the RHI and the experience of body ownership. For example, greater discrepancies

[2] The experiments reported in this chapter are published as:
Farmer, H., Tajadura-Jiménez, A., & Tsakiris M. (2012). Beyond the colour of my skin: How skin colour affects the sense of body ownership. *Consciousness and Cognition*, *21*, 3, pp. 1242-1256.

between the visual form of the viewed object relative to the participant's hand or between the posture of the rubber hand relative to the participant's hand diminish or even abolish the RHI (Tsakiris & Haggard, 2005b).

Less is known however about how more surface level differences between the participant's own hand and the rubber hand affect the RHI. One area of particular interest is whether the skin colour of the rubber hand compared to that of the participant has an effect on the inducement or strength of the RHI. Skin colour is a particularly salient difference between racial groups and, as such, appears to be a default method of separating others into in-group and out-group categories, participating in several social cognition processes (Fiske & Neuberg, 1990; Hewstone, Hantzi, & Johnston, 1991; though see Kurzban, Tooby, & Cosmides, 2001). Therefore the extent to which skin colour affects the RHI provides a viable way of investigating both whether social distinctions influence body ownership, but also how body ownership can influence social distinctions.

The question of whether factors such as skin colour have an effect on body ownership is further motivated by the findings of a number of recent studies. Using behavioural and neuroimaging methods these studies have shown that the activation of shared bodily representations for self and other (Gallese & Sinigaglia, 2010; Keysers & Gazzola, 2009; Rizzolatti & Fabbri-Destro, 2010; Thomas, Press, & Haggard, 2006) can be modulated by whether the other person being observed is considered to be a member of an in-group or an out-group (Désy & Théoret, 2007; Gutsell & Inzlicht, 2010; Molnar-Szakacs, Wu, Robles, & Iacoboni, 2007; Serino, Giovagnoli, & Làdavas, 2009). For example Serino and colleagues (2009) investigated the effect of in-group/out-group distinctions on the visual remapping of touch (VRT), an effect in which the observation of touch on another's body leads to greater sensitivity to tactile stimulation on one's own body. Participants were more accurate in detecting touch when they observed touch delivered on the face of someone from the same ethnic or political group as themselves. The second of these findings is especially interesting as it involves a purely social distinction between self and other with no greater bodily dissimilarity (e.g. same skin colour) between a politician with the opposing views to one's own than to one with the same views.

Given this evidence for a distinction between in-group and out-group in the activation of shared bodily representations the question that the current study seeks to address is whether changes in the sense of body ownership induced by the RHI can also be elicited for a hand of a different skin colour. To date only two studies have commented on this question, but without testing this hypothesis directly. Longo, Schüür, Kammers, Tsakiris and Haggard, (2009) reported that the actual similarity of skin colour between the participants' hands and the rubber hand, as measured by both third person ratings and skin luminosity, seemed to have no effect on the strength of the RHI. Similarly, Holmes, Snijders and Spence, (2006) examined the effect of visual exposure to a white rubber hand on participants' reaching movements and found no difference between white and non-white participants in either the alteration of reaching movements or the sense of perceived body ownership over a white rubber hand, suggesting that skin colour does not affect body ownership. Although Holmes et al.'s study did not induce the RHI using VT stimulation but rather only through visual exposure to a rubber hand perceived as being in the spatial location of the participant's own hand and overall participants did not experience strong feelings of ownership over the rubber hand. However, neither of these studies directly addressed the question of how skin colour impacts on feelings of body ownership. Both Longo et al. and Holmes et al. used a white rubber hand, the skin colour of the culturally dominant group, and only included a small number of non-white participants (around 25% of all participants in both Longo et al. and Holmes et al. (Longo et al., 2009, N. Holmes, personal communication, 7th December, 2011) and neither study directly manipulated the skin colour of either the rubber hand used or the population tested.

The current study is the first to directly investigate in a systematic manner whether the inducement and strength of the RHI is modulated by the skin colour of the rubber hand. Rather than testing different racial groups, we opted for the direct control of the skin colour of the rubber hand. Therefore, across two experiments, the skin colour of the rubber hand (i.e. white vs. black) was manipulated in order to examine the extent to which white participants experienced a sense of body ownership for a body-part from a same or different racial group. The change in body ownership was quantified using introspective (i.e. RHI questionnaire), behavioural (i.e. proprioceptive drift) and physiological (i.e. skin conductance response, SCR) measures. Experiment 2.1 examined the effect of synchronous vs. asynchronous visuo-tactile (VT) stimulation on the experience of body ownership for hands of both skin colours. Experiment 2 built on these findings by including a new condition in which participants observed synchronous stimulation of the hands from a third person perspective (3PP) in addition to the synchronous and asynchronous conditions in which the rubber hand appeared from a 1st person perspective (1PP). A pre-VT stimulation measure of SCR was also introduced in order to examine any differences in baseline SCR to threatening stimuli between the black and white rubber hands.

In order to examine whether the participants' psychosocial attitudes had an effect on the strength of their feelings of body ownership over the black hand, their implicit bias in favour of people of white ethnicity compared to people of black ethnicity was measured. Due to its prevalence and societal importance, people's attitudes towards members of different racial groups have been extensively studied (for a review see Dunham & Degner, 2010). However, research in this area is complicated by the fact that attitudes towards racial out-groups are a socially sensitive area, and therefore few people will admit to being prejudiced against those of a different race if explicitly asked. Therefore in order to gain a measure of attitudes towards other races that goes beyond explicit declarations, researchers have had to develop ways of tapping into people's implicit attitudes which are more difficult to disguise or inhibit due to social pressure. One method for measuring such implicit attitudes is the Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998). The IAT functions by presenting participants with stimuli of two particular types (e.g. pictures of faces and words) and asking them to put these stimuli into one of two categories (e.g. black or white faces and good or bad words). The response buttons for the categories are then paired together (e.g. good words and white faces vs. bad words and black faces) and participants' reaction times are measured, then the categories are switched around (e.g. good words and black faces vs. bad words and white faces) and participants do the task again. Then reaction times for the two conditions are compared and a ratio is derived that reflects how strong the participants associate the two different types of stimuli. In the race IAT participants are typically much faster to respond when pairing good words with white faces and bad words with black faces than vice versa.

Scores on the race IAT have been shown to correlate with behavioural measures of racial bias, including hiring recommendations for black versus white applicants (Ziegert & Hanges, 2005), prosocial behaviour towards black people (Stepanikova, Triplett, & Simpson, 2011), physicians treatment decisions for black and white patients (Green et al., 2007) and other people's judgments of participants' racial bias based on viewing an interaction with a black confederate (McConnell & Leibold, 2001; Richeson & Shelton, 2005). The wide range of correlations suggests that the IAT provides an accurate measure of people's underlying racial attitudes.

Experiment 2.1 also investigated whether there was a converse relationship between body ownership and racial bias by having participants complete the same IAT again after the VT stimulation. In addition participants' trait empathy was also measured using the Interpersonal Reactivity Index (IRI, Davis, 1980, 1983) to examine the relationship between empathy and the RHI and to determine whether those with greater empathic traits were more likely to feel ownership over a hand of a different skin colour.

2.2. Experiment 2.1

2.2.1. Methods

2.2.1.1. Design

The study used a repeated measures design with 3 factors, each with 2 levels. The first factor was the mode of VT stimulation between the participant's hand and the rubber hand (synchronous vs. asynchronous); the second factor was the skin colour of the rubber hand (white hand vs. black hand); and the third factor was the type of stimulus appearing at the end of the VT stimulation (pain vs. touch). Therefore there were a total of 8 conditions (See Table 2-1). Each condition was presented once per participant and conditions were presented in a randomised order.

Table 2-1. Design of Experiment 2.1.

Condition	Synchrony of V-T stimulation	Skin colour of the rubber hand	Type of stimuli applied to the rubber hand
1	Synchronous	White	Pain
2	Synchronous	White	Touch
3	Synchronous	Black	Pain
4	Synchronous	Black	Touch
5	Asynchronous	Black	Pain
6	Asynchronous	Black	Touch
7	Asynchronous	White	Pain
8	Asynchronous	White	Touch

2.2.1.2. Procedure

Participants were asked to attend 2 experimental sessions within 7 days of each other. In the first session participants were asked to complete a demographic questionnaire and the IRI (Davis, 1980, 1983). Following this, participants carried out a computer administered version of the race-IAT. The associations between stimuli and response key and the order of associations (i.e. positive words and white faces or positive words and black faces) were counterbalanced across participants (Greenwald et al., 1998; Greenwald, Nosek, & Banaji, 2003). The data from the IATs were analysed using the improved IAT scoring algorithm recommended by Greenwald et al. (2003; see Table 2-2). The IAT's were performed using Presentation® software (Version 16.03, www.neurobs.com)

At the beginning of the second experimental session two electrodes were attached to the index and middle fingers of the participant's right hand in order to measure skin conductance response (SCR) to the stimulus (pain or touch) presented at the end of VT stimulation. SCR is a sensitive and valid indicator for arousal (Boucsein, 1992).

Physiological signals were sampled at a rate of 250 Hz and amplified (AD Instruments).

Table 2-2. Steps of the improved IAT scoring algorithm (adapted from Greenwald, Nosek and Banaji, 2003).

Step	Procedure
1	Use data from block 3, block 4, block 6 and block 7
2	Eliminate trials with latencies > 10,000 ms, eliminate subjects for whom more than 10% of trials have latency less than 300 ms
3	Use all trials
4	Compute mean of correct latencies for each block
5	Compute one pooled SD for all trials in block 3 & block 6; another for block 4 and block 7
6	Replace each error latency with block mean (computed in Step 5) - 600 ms
7	Average the resulting values for each of the four blocks
8	Compute two differences: Block 6 - block 3 and block 7 - block 4
9	Divide each difference by its associated pooled- trials SD from Step 6
10	Average the two quotients from Step 11

In each of the eight experimental conditions participants received VT stimulation while looking at a rubber hand (see Figure 2-1). The technique used to deliver VT stimulation and collect participants proprioceptive judgements was identical to that used by Tsakiris and Haggard (2005, see experiment 2.1). Participants sat in front of a table with a frame on it covered by a two way mirror. The two way mirror was used to make the rubber hand appear (during stimulation) and disappear (during proprioceptive judgements and questions). For each condition participants saw a ruler reflected on the mirror. The ruler was positioned 18 cm above the mirror, to appear at the same gaze depth as the rubber hand. Participants were asked, "Where is your index finger?" and in response, they verbally reported a number on the ruler. They were instructed to judge the position of their finger by projecting a parasagittal line from the centre of their fingertip to the ruler. During the judgments, there was no tactile stimulation, and the lights under the two-way mirror were switched off to make the rubber hand invisible, leaving only the ruler visible. Following the judgement, the lights under the two-way mirror were switched on so that participants could see the rubber hand, and the experimenter commenced VT stimulation for 120 seconds. During VT stimulation the participant's left hand and the rubber hand were stimulated, on the index, middle and ring fingers alternately, from the knuckle to the tip with two identical paintbrushes with a frequency of approximately 1 Hz. In the synchronous condition the hands were brushed at the same time, while in the asynchronous condition they were brushed 180° out of phase.

After VT stimulation, the experimenter either, produced a hypodermic syringe and thrust it into the rubber hand's index finger (pain stimulus), or produced a cotton-bud, and touched the rubber hand's index finger with it (touch stimulus). To minimize the effect of surprise, participants were shown the syringe and cotton-bud before the experiment began and were assured that these would not touch their own hand. To control for the timing of events across conditions, the experimenter was listening to an audio file that prompted them when to cease VT stimulation and when to apply the pain or touch stimuli to the rubber hand.

4 seconds after the delivery of the pain or touch stimuli, the lights under the two-way mirror were switched off, so that participants could no longer see the rubber hand, and a second judgement of felt location was obtained. Participants were then asked to remove their left hand from the table, and to use a 7-point Likert Scale (ranging from -3, i.e. strongly disagree, to +3, i.e. strongly agree) to indicate their agreement on three statements related to their own subjective experience during each VT condition, which were adapted from Longo, Schüür, Kammers, Tsakiris and Haggard (2008). Longo, Schüür, et al. asked partcicipants to indicate the extent of their agreement or disagreement with 27 statements in each block, using a 7-item Likert scale, they then carried out a principal component analysis on the responses to the questions and identified four factors into which the questions fell, embodiment, loss of own hand, movement and affect. A further analysis revealed that the embodiment facotor could itself be broken down into three subfactors, ownership, location and agency. Of the three questions used in the current study questions 1 and 3 loaded onto the location

factor, question 1 to the location of the touch from the paint brush during VT-stimulation and question 3 to the location of the touch from the cotton bud or syringe following VT stimulation, while question 2 loaded onto the ownership factor. Participants were also asked a fourth question on their perception of pain when the stimuli touched the rubber hand which was rated on a 7 point scale from 0 (no pain) to 6 (intense pain). Once this was completed the next block began. Blocks were presented in a random order across participants. Finally, once all blocks had been completed, participants again carried out the race IAT.

2.2.1.3. Analysis of Behavioural and Physiological Data

Proprioceptive drift was calculated by subtracting participants' pre-stimulation proprioceptive judgements from their post-stimulation proprioceptive judgements for each condition.

SCR values were calculated by taking the mean SCR from the 6 seconds starting 1 second after the appearance of the pain/touch stimuli and subtracting from this the mean SCR between 3 and 1 seconds before the appearance of the stimulus (baseline; Dimberg, 1990). This interval was chosen to be the region of interest, because changes in SCR normally occur between 1 and 2 seconds after stimulus onset, although the response can be delayed up to 5 seconds (Edelberg, 1967). Following standard guidelines for the analysis of electrodermal responses, SCR amplitudes below 0.05 μS were scored as zero responses (Boucsein, 1992; Dawson, Schell, & Filion, 2007). Participants who had zero responses in more than half of the trials in which the pain stimuli appeared were considered 'null-responders' and were excluded from the analysis (Phelps, Connor, Gatenby, Gore, & Davis, 2001). The failure to detect an SCR can be due to a number of factors such as individual differences in SCR (Christie, 1981), rapid habituation to threatening stimuli, or a loss of contact between the electrodes and the participant's skin, since it was not possible to determine which of these factors was the cause of the null responses in any particular case, the removal of null responders from SCR analysis is necessary to prevent their SCR values from distorting results. This left 17 participants in the SCR analysis. All data were individually z-scored to control for individual differences in responsiveness (Boucsein, 1992; Venables & Christie, 1980).

2.2.1.4. Participants

20 participants (mean age ± *SD*: 21 ± 2.49, 6 male) gave their informed consent to participate and were paid for their participation. All participants self-identified as white. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

2.2.2. Results

2.2.2.1. Introspective Measures

In order to examine the effectiveness of the manipulation of body ownership the number of people experiencing ownership over the white and black hand in the synchronous condition was calculated based on participants' responses to the statement "I felt like the rubber hand was my hand". Participants with a mean response greater than 0 were considered to have felt body ownership over the rubber hand, while those with a response less than or equal to 0 were not. The manipulation was largely successful with 75% of participants experiencing body ownership over the white rubber hand and 60% of participants experiencing body ownership over the black rubber hand during synchronous VT stimulation across the pain and touch conditions.

In order to further analyse the relationship between skin colour and introspective judgements of body ownership separate repeated measures ANOVAs were run on each of the four questions. Each ANOVA contained three within-subjects factors: the mode of VT stimulation (asynchronous/synchronous), the skin colour of the rubber hand (white/black), and the type of stimulus appearing at the end of the VT stimulation (pain/touch).

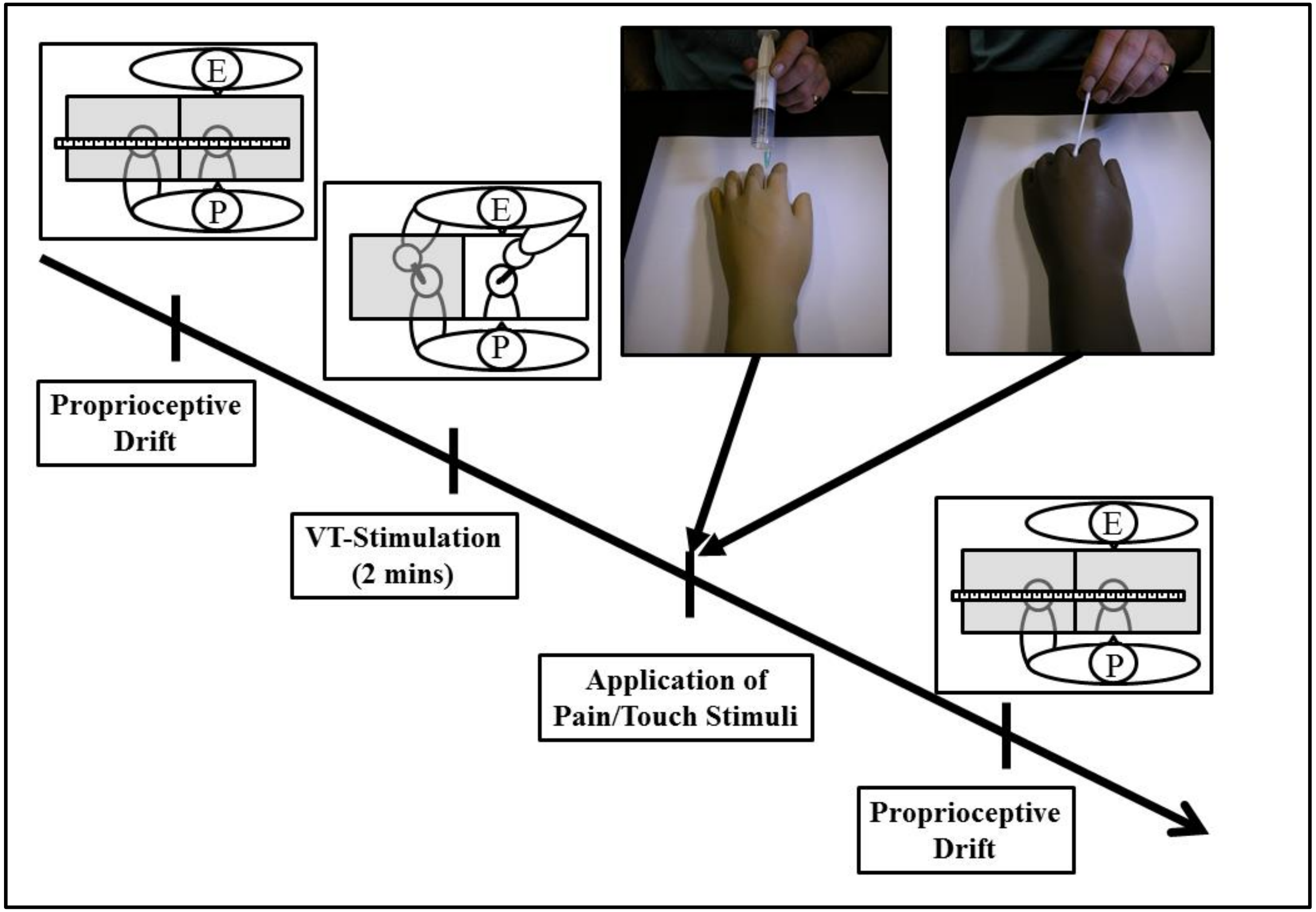

Figure 2-1. Trial structure of experiment 2.1 (E = experimenter, P = participant).

Both the first question "It seemed like the touch I felt was caused by the paintbrush touching the rubber hand." and the second question "I felt like the rubber hand was my hand." showed the same pattern of results (See Figure 2-2). A significant main effect was found for the mode of VT stimulation (Q1: $F(1, 19) = 25.97$, $p < .001$; Q2: $F(1, 19) = 31.32$, $p < .001$), because overall synchronous VT stimulation (Q1: $M = 1.26$, $SD = 1.76$; Q2: $M = 0.68$, $SD = 1.71$) resulted in significantly higher ratings compared to asynchronous stimulation (Q1: $M = -0.8$, $SD = 1.79$; Q2: $M = -1.14$, $SD = 1.61$) across all levels of the other factors. A main effect was also found for the skin colour of the rubber hand (Q1: $F(1, 19) = 7.89$, $p < .01$; Q2: $F(1, 19) = 16.62$, $p < .01$), because overall the white rubber hand (Q1: $M = 0.51$, $SD = 1.63$; Q2: $M = 0.1$, $SD = 1.63$) resulted in higher ratings across all levels of the other factors than the black rubber hand (Q1: $M = -0.5$, $SD = 1.56$; Q2: $M = -0.56$, $SD = 1.45$). For both questions, the main effect of type of stimulus and all interactions were not significant.

For both the third question "It seemed as if the needle/cue-tip touched my own hand." and the fourth question "Did you experience any pain when the needle/cue tip touched the rubber hand?" a significant main effect of VT stimulation was found (Q3: $F(1, 19) = 31.32$, $p < .001$; Q4: $F(1, 19) = 4.89$, $p < .05$, see Figure 1). This was because overall synchronous VT-stimulation (Q3: $M = -1.01$, $SD = 1.4$; Q4: $M = 0.35$, $SD = 0.42$) resulted in higher ratings than asynchronous VT-stimulation (Q3: $M = -1.99$, $SD = 0.91$; Q4: $M = 0.16$, $SD = 0.32$) across all levels of the other two factors. No other significant main effects or interactions were found for question 3 or 4.

Overall, the analysis of the psychometric data suggests that an in-group rubber hand is more likely to be experienced as self-relevant independently of the pattern of VT stimulation, but at the same time, the critical manipulation of synchronous vs. asynchronous multisensory stimulation shows synchronous VT stimulation can elicit a sense of body ownership independently of the skin colour of the rubber hand.

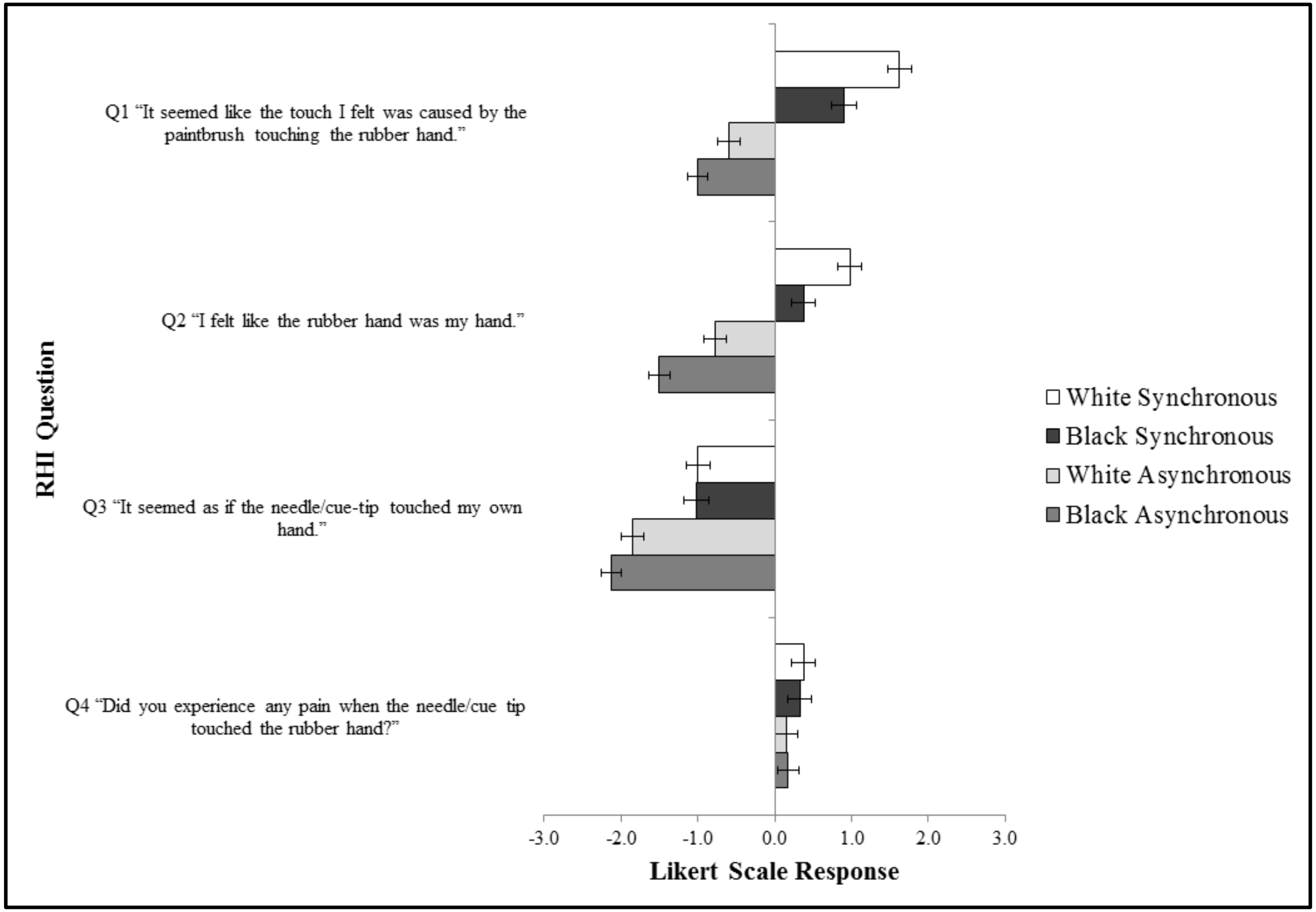

Figure 2-2. Mean responses to the four introspective questions by synchrony and skin colour of the rubber hand. Error bars represent SEM.

The question of whether the magnitude of the change between synchronous and asynchronous conditions in the subjective experience captured by questions 1 and 2 was the same when looking a white rubber hand versus a black rubber hand (averaged across pain and touch conditions) was further examined. The ratings obtained in the asynchronous condition were subtracted from those obtained in the synchronous condition, for each hand, and directly compared the resulting values which reflect the magnitude of change in the subjective experience between synchronous and asynchronous. The differences between black (Q1: M = 1.9, SD = 2.14; Q2: M = 1.87, SD = 1.78) and white rubber hand (M = 2.22, SD = 1.96; Q2: M = 1.75, SD = 1.48) conditions were not significant (Q1: $t(19) = 0.76$, $p > .05$; Q2: $t(19) = 0.58$, $p > .05$), suggesting that the magnitude in the change of the experience between synchronous and asynchronous stimulation was comparable between the two different rubber hands.

2.2.2.2. Proprioceptive Drift

In order to investigate the effect of skin colour on behavioural measures of body ownership a repeated measures ANOVA with mode of VT-stimulation (asynchronous/synchronous) x skin colour of rubber hand (white/black) x type of stimulus (pain/touch) was carried out on the proprioceptive drift values.

A significant main effect was found for the mode of VT stimulation ($F(1,19) = 11.47$, $p < .05$; see Figure 2-3), because overall synchronous VT-stimulation (M = 1.74, SD = 1.44) resulted in greater proprioceptive drift than asynchronous VT-stimulation (M = 0.49, SD = 2.02) across all levels of the other two factors. No main effect of skin colour or type of stimulus was found and there were no significant interactions, suggesting that the increases in proprioceptive drift following synchronous stimulation were not affected by the skin colour of the rubber hand or the stimulus that appeared at the end of stimulation.

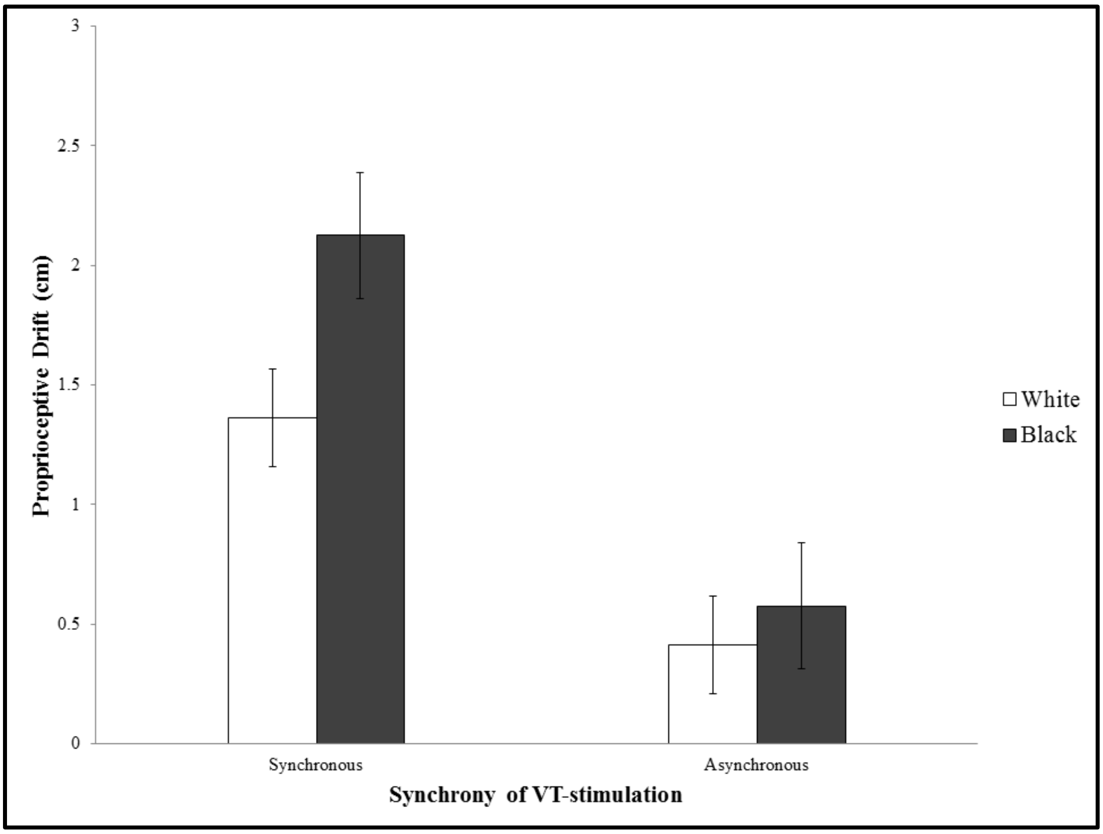

Figure 2-3. Mean proprioceptive drift by synchrony and skin colour of the rubber hand. Error bars represent SEM.

2.2.2.3. Skin Conductance Responses

In order to assess whether physiological response to observing painful stimuli touching the rubber hand was modulated by the skin colour of the rubber hand, a mode of VT stimulation (asynchronous/synchronous) x skin colour of rubber hand (white/black) x type of stimulus (pain/touch) repeated measures ANOVA was run on the z-scored SCR values from each condition (see Figure 2-4). As indicated in the method section, participants who had responses of less than 0.05 μS in more than half of the trials in which the pain stimuli appeared were considered null-responders. Due to the exclusion of null-responders the sample for the SCR analysis was made up of 17 participants.

A main effect was found for type of stimulus ($F(1, 16) = 28.3$, $p < .001$), because the painful stimulus elicited higher SCRs ($M = 0.32$, $SD = 0.26$) than the observation of non-painful stimulus ($M = -0.32$, $SD = 0.26$) touching the rubber hand. A main effect was also found for the mode of VT stimulation ($F(1, 16) = 11.96$, $p < .01$), because overall SCRs were higher following synchronous VT stimulation (*M* = 0.29, *SD* = 0.3) compared to asynchronous stimulation (*M* = -0.29, *SD* = 0.3).

An interaction between type of stimulus and stimulation was also found ($F(1, 16) = 5.38$, $p < .05$). Paired comparisons revealed that this interaction was due to significantly higher SCRs after synchronous stimulation than after asynchronous stimulation for the pain white hand (Synch: *M* = 0.93, *SD* = 1.15; Asynch: *M* = -0.14, *SD* = 0.78), $t(16) = 2.52$, $p < .05$; pain black hand (Synch: *M* = 0.56, *SD* = 1.1; Asynch: *M* = -0.09, *SD* = 0.55), $t(16) = 2.27$, $p < .0$; and touch white hand (Synch: *M* = 0.56, *SD* = 1.1; Asynch: *M* = -0.09, *SD* = 0.55), $t(16) = 3.11$, $p < .01$ conditions, but not for the touch/black hand condition (Synch: *M* = -0.55, *SD* = 0.63; Asynch: *M* = -0.22, *SD* = 0.75), $t(16) = 3.11$, $p < .01$. Finally an interaction between colour and stimulation was found, $F(1,16) = 8.76$, $p < .01$. However, paired comparisons indicated that this interaction was due to significantly higher SCRs for the white hand compared to the black hand in the touch synchronous condition, $t(16) = 2.89$, $p < .05$, and not in the pain synchronous, $t(16) = 0.59$, $p > .05$; pain asynchronous $t(16) = -0.01$, $p > .05$; or the touch asynchronous conditions $t(16) = -1.87$, $p > .05$. The failure to find an effect in the pain synchronous condition rules out the possibility that synchronous stimulation elicited significantly higher SCRs for the painful stimulus when applied to the white hand than to the black hand. Since it is unclear how to interpret SCR data to a non-threatening stimuli and the fact that the touch conditions were primarily included to control for participants becoming habituated to the appearance of painful stimuli this effect will not be addressed further. No main effect of skin colour was found and nor were there any other significant interactions.

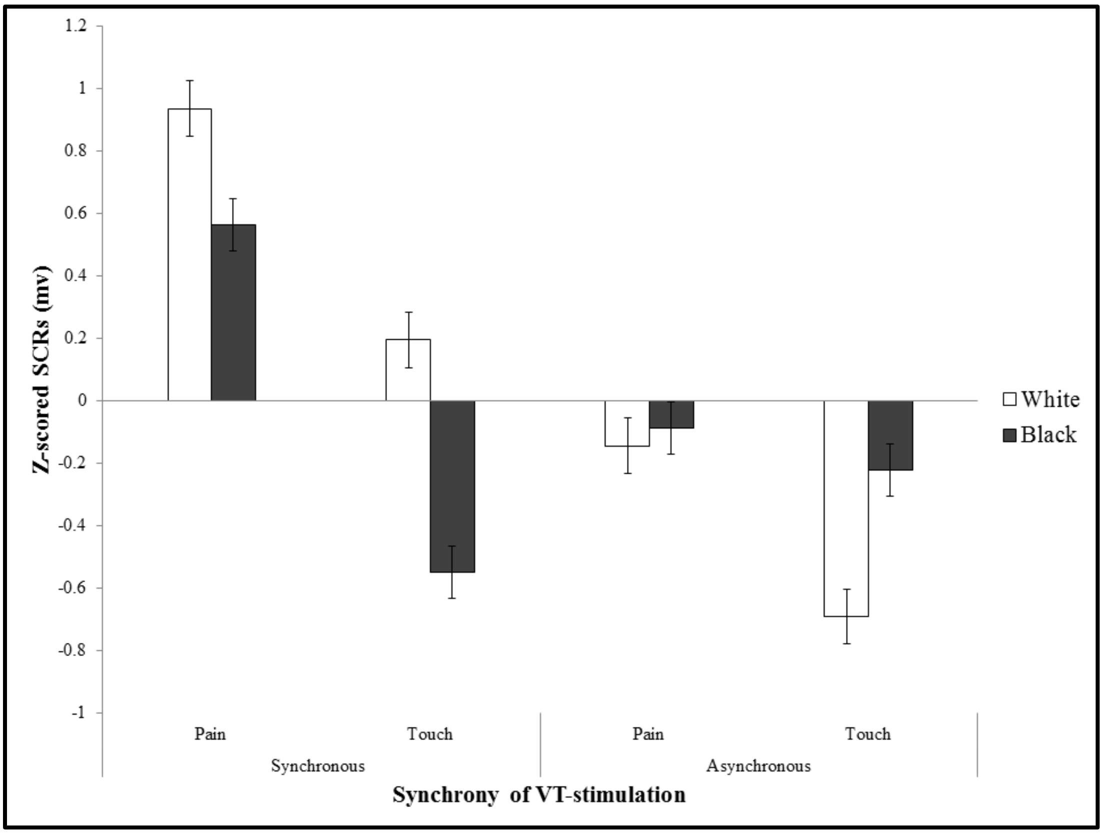

Figure 2-4. Mean standardised SCR to painful stimuli. Error bars represent SEM.

2.2.2.4 Relationship between Empathy and Body Ownership for In-group and Out-group Hands

In order to analyse the factors that predicted the strength of the experience of body ownership for the white and black rubber hands, the mean of each participant's response to question 2 (e.g. "I felt like the rubber hand was my hand") of the questionnaire were averaged across the pain- and touch-synchronous stimulation conditions and the resulting values were used as dependent variables in two multiple regressions (entry method) using participants' scores on the four sub-scales from the IRI as predictors. For the regression carried out on ownership scores for the white rubber hand the overall model fit was significant, $F(4, 15) = 5.88$, $p < .01$ (see Table 2-3). This was due to a significant positive regression weight on the fantasy subscale of the IRI. For the regression carried out on ownership scores for the black rubber hand the overall model fit was also significant, $F(4, 15) = 6.17$, $p < .01$ (see Table 2-4). This was again due to a significant positive regression weight on the fantasy subscale of the IRI. In neither analysis were any of the other IRI subscales significant predictors.

Table 2-3. Summary of linear regression analysis for variables predicting with ownership ratings for the white rubber hand.

Variable	β	*P*
Perspective Taking	0.00	.976
Empathic Concern	0.17	.35
Fantasy	0.24	.001
Personal Distress	-0.09	.172

Note. r^2adjusted = .78.

Table 2-4. Summary of linear regression analysis for variables predicting with ownership ratings for the black rubber hand.

Variable	β	*P*
Perspective Taking	0.9	.346
Empathic Concern	0.05	.656
Fantasy	0.25	.001
Personal Distress	-0.05	.442

Note. r^2adjusted = .79.

2.2.2.5. Relationship between Racial Bias and Body Ownership for In-group and Out-group Hands

In order to investigate whether racial bias, as measured with the IAT, had an effect on the experience of body ownership for the white and black rubber hands, the mean of each participant's responses to question 2 of the questionnaire were averaged across the pain- and touch-synchronous stimulation conditions and the resulting values were used as dependent variables in two linear regressions (entry method) using participants' scores on the pre VT stimulation IAT as the predictor. In this study only question 2 of the questionnaire was used rather than an average of all four questions because the key hypothesis of the study was that ownership of the rubber hand would be the defining factor in determining the effect of VT-stimulation on racial bias. Neither regression however, produced a significant model (for the white rubber hand: $F(1, 18) = 2.08$, $p > .05$, r^2 adjusted = .05; for the black rubber hand:

F(1, 18) = 0.79, $p > .05$, r^2 adjusted = -.11) suggesting that participants' implicit racial bias did not predict whether they would experience the RHI for either the white or black hand.

To investigate whether feeling body ownership over a hand of a different skin colour changed participant's racial bias as measured with IAT, two multiple regressions (entry method) were carried out, the first with participants' ratings for question 2 after synchronous VT stimulation for both the white and black rubber hands (averaged across pain and touch conditions) as predictors and the second with participants' ratings for question 2 after asynchronous VT stimulation for both the white and black rubber hands (averaged across pain and touch conditions) as predictors. In both regressions participants' score on the post VT stimulation IAT was the dependent variable. For the synchronous condition the overall model fit was significant, $F(2, 17) = 3.96$, $p < .05$, indicating that the stronger the sense of body ownership participants experienced over the rubber hands the lower their post testing racial bias, as measured with the IAT (see Table 2-5 and Figure 2-5). Interestingly, the experience of ownership over either the white or the black rubber hand were not individually significant predictors, suggesting that the post-RHI IAT score was predicted by a generalised experience of ownership over any rubber hand rather than exclusively by the experience of ownership of a white or black hand. For the asynchronous condition the overall model fit was not significant, $F(2, 17) = 0.36$, $p > .05$, r^2 adjusted = -.07.

Table 2-5. Summary of linear regression analysis for variables predicting with post VT-stimulation IAT score in the synchronous condition.

Variable	**β**	***P***
Ownership rating for white hand	-0.11	.153
Ownership rating for black hand	-0.01	.928

Note. r^2adjusted = .32.

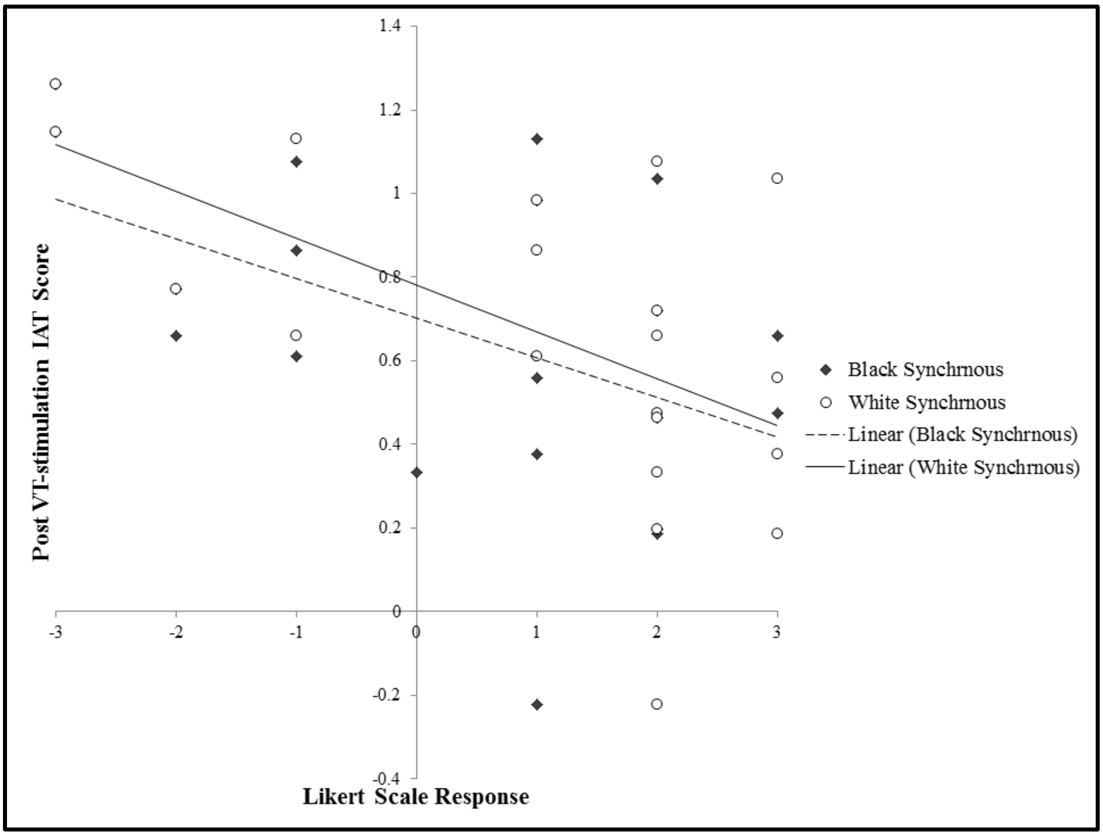

Figure 2-5. Introspective reports of ownership after synchronous VT-stimulation against post VT-stimulation IAT scores.

To investigate whether feeling body ownership over a hand of a different skin colour led to a significant reduction in racial bias a measure of change in racial bias was calculated by subtracting the participants' scores in the pre-stimulation IAT from their scores in the post stimulation IAT. The resulting values were entered as the dependent variable in a multiple regression (entry method) and participants' ratings for question 2 after synchronous VT stimulation (averaged across pain and touch conditions) for both the white and black rubber hands were used as the predictors. The overall model fit was not significant, $F(2, 17) = 0.35$, $p > .05$, r^2 adjusted =-.07.

2.2.3. Discussion

The results from experiment 2.1 suggested that synchronous VT stimulation could lead to the feeling of body ownership over a hand of a different skin colour as measured by introspective reports, behavioural and physiological measures. Analysis of the introspective reports showed that synchronous VT results in body ownership independently of the skin colour. However, subjective reports also indicated that skin colour did have an effect on subjective feelings of body ownership which was independent to that of multisensory stimulation. Unlike subjective reports, the behavioural and physiological data revealed no main effect of skin colour. For the SCR data, significant differences between the synchronous and asynchronous stimulation for the pain stimulus were observed for both the white and the black hand. This finding was consistent with the effect of stimulation observed on proprioceptive drift. In addition multiple regressions indicated a role of empathy in individual differences in the experience of the RHI for both white and black hands. The overall strength of experienced body ownership during the RHI was also found to predict the participants' post-illusion implicit racial bias, with those who experienced a stronger RHI showing a lower bias. Importantly, across all these measures, the effect of synchronous multisensory stimulation, over and above the mere presence of multisensory stimulation (i.e. asynchronous conditions), revealed comparable changes in the experience of body ownership for hands of both skin colours, suggesting that synchronous stimulation can lead to ownership over a hand of a different skin colour.

It is possible however that the observed changes in introspective, behavioural and physiological measures of body ownership were due to factors unrelated to the feeling of body ownership. For example, it might be the case that increased SCRs to threatening stimuli reflect a purely attentional effect that result from the association of synchronous events occurring on one's own body and on an external body-part, rather than a change in the experience of body ownership per se. One way to dissociate the pure effect of synchrony from the effect of synchrony on body ownership is to deliver synchronous VT stimulation under conditions that either induce body ownership or not. To that end, in Experiment 2.2 we included an additional control condition at which participants received tactile stimulation on their own unseen hand, synchronous with that observed on the rubber hand, but the rubber hand was viewed from a third person perspective (3PP). It has been shown that this condition does not induce a sense of body ownership (Ehrsson et al., 2004). Another potential limitation of experiment 2.1, which Experiment 2.2 sought to address, was the absence of a pre-stimulation baseline measure of SCR to observation of threatening objects approaching the hands. Obtaining pre-stimulation SCR measures is important for examining whether there are differences in baseline SCR to threatening stimuli between the black and white rubber hands, and for quantifying the change in SCR as a function of the colour of the rubber hand, the stimulation pattern and the experience of ownership. In order to address these weaknesses a second experiment was conducted.

2.3. Experiment 2.2

2.3.1. Methods

2.3.1.1. Design

The study used a repeated measures design with 2 factors. The first factor was the type of VT stimulation delivered to the participant's hand and the rubber hand. The first two levels of this factor were the same as those in experiment 2.1, that is synchronous and asynchronous stimulation delivered to the participant's hand and a hand seen from a first person perspective (1PP). In addition another level was added in which synchronous VT stimulation was delivered to the participant's hand and another hand which was rotated 180˚ from the position of the participants own hand, so that the hand was viewed from a third person perspective (3PP). Previous studies have demonstrated that the RHI does not occur when the rubber hand is viewed from this perspective (Ehrsson et al., 2004). The second factor was the skin colour of the hand (white hand vs. black hand).Therefore there were a total of six conditions (see Table 2-6). Each condition was presented once per participant and conditions were presented in a randomised order.

2.3.1.2. Materials

Rather than using a physical rubber hand as in experiment 2.1, in this study videos of real hands were used in order to increase the accuracy of the timing of events; however, for the sake of simplicity, the hands displayed in the video will be referred to as "rubber" hands. Twelve videos were used in this study: male participants saw videos of male hands while female participants saw videos of female hands. For both male and female hands there was one video for each of the six conditions (see Figure 2-6). The videos were presented using Presentation® software (Version 16.03, www.neurobs.com).

Table 2-6. Design of Experiment 2.2.

Condition	Condition of V-T stimulation	Skin colour of the rubber hand
1	1PP Synchronous	White
2	1PP Asynchronous	White
3	3PP Synchronous	White
4	1PP Synchronous	Black
5	1PP Asynchronous	Black
6	3PP Synchronous	Black

2.3.1.3. Procedure

At the beginning of the experiment, participants were asked to complete demographic and IRI questionnaires. Following this, participants carried out the same computer administered version of the IAT as used in experiment 2.1. Following the completion of the IAT participants were asked to sit in front of the experimental setup (see Figure 2-6). In this setup the participant's left hand was hidden beneath a sheet of card while a computer screen was visible with its centre at the midline of the participant's body. Two electrodes were attached to the index and middle fingers of the participant's right hand in order to measure SCR. In each of the six experimental conditions participants first viewed the hand in the video being cut by a knife in order to record a baseline measure of arousal to threatening stimuli prior to VT stimulation. Following this, participants received VT stimulation for 120 seconds while looking at the video of the hand. VT stimulation was delivered manually by the experimenter with the use of the same paintbrush as seen in the video.

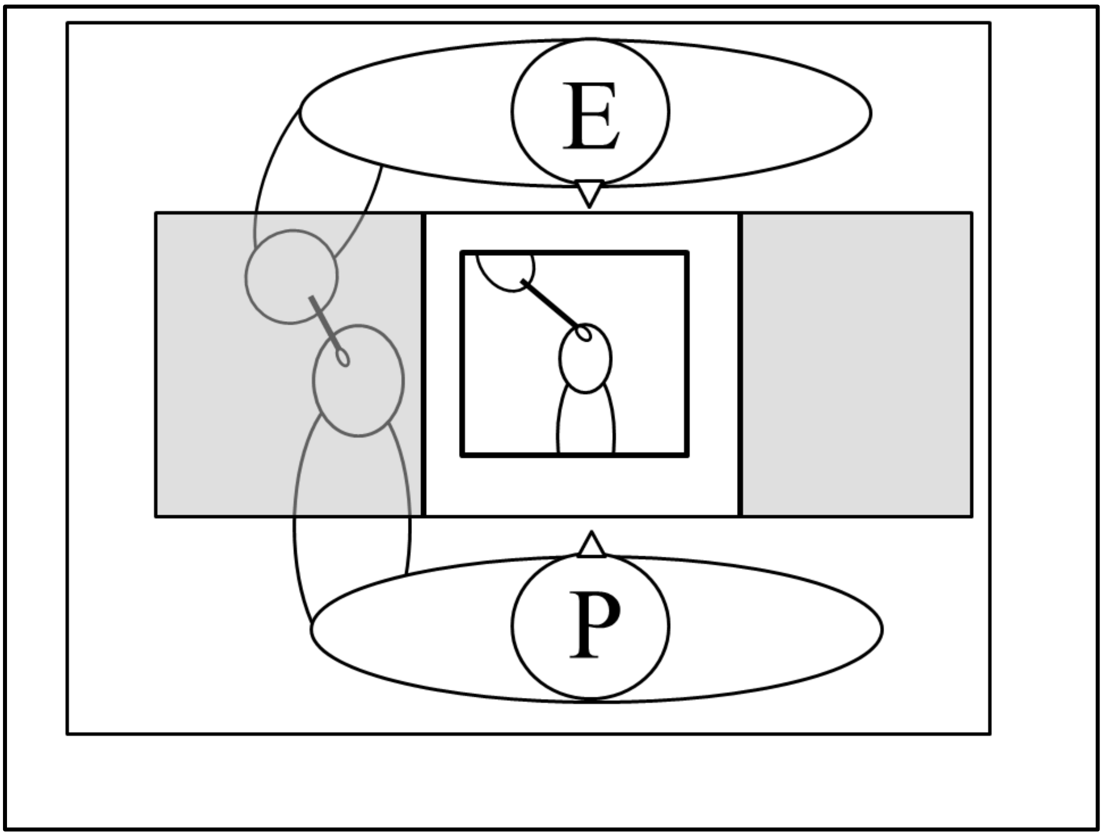

Figure 2-6. Diagram of the experimental setup used in experiment 2.2 (E = experimenter, P = participant).

During VT stimulation the participant's hand and the hand in the video were stimulated on the index finger in the same way, from the knuckle to the fingertip with a frequency of 1 Hz. In the synchronous condition, the participant's hand was brushed at the same time as the hand in the video, while in the asynchronous condition it was brushed 180° out of phase with the video. Following VT stimulation, the video again showed the hand being cut by a knife in order to measure arousal to threatening stimuli subsequent to VT stimulation (See Figure 2-7). After each video, participants were asked to remove their left hand from the table and were asked the same 4 questions used in experiment 2.1. Once this was completed the next block began. Blocks were presented in a random order across participants and each block was presented once per participant.

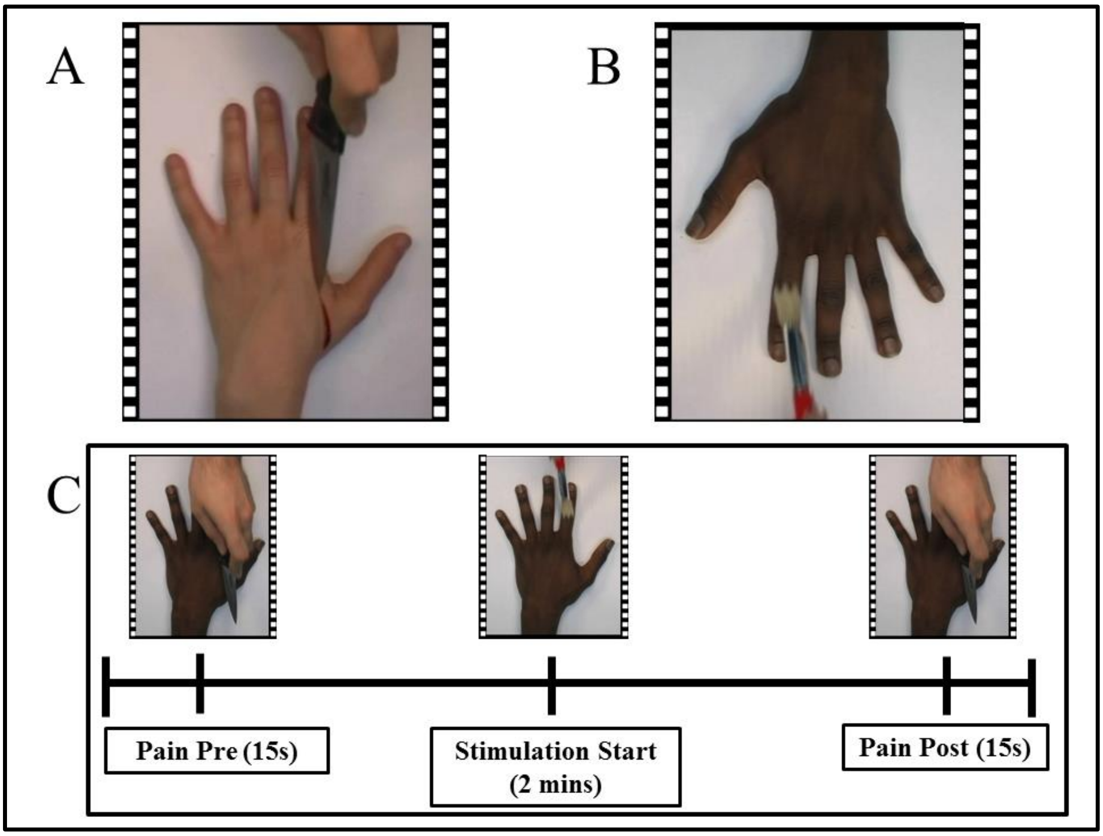

Figure 2-7. A) Example of pain stimuli being applied to a white hand seen from the first person perspective. B) Example of VT-stimulation being delivered to a black hand seen from the third person perspective. C) Time course of experimental videos.

2.3.1.4. Analysis of Physiological Data

Mean SCR change in response to observation of the knife appearing was taken for both the appearance at the beginning (pre-stimulation) and the end (post-stimulation) of VT stimulation. In both cases SCR change was calculated, as in experiment 2.1, by subtracting a baseline measure from the mean SCR over 6 seconds starting 1 second after the appearance of the knife (Edelberg, 1967). The baseline was the mean SCR between 1 and 3 seconds before the appearance of the knife (Dimberg, 1990). SCR amplitudes below 0.05 μS were scored as zero responses (Boucsein, 1992; Dawson et al., 2007). Participants who had zero responses in more than half of the post stimulation trials were considered 'null-responders' and were excluded from the analysis which left 42 participants in the SCR analysis (Phelps et al., 2001). All data were individually z-scored to control for individual differences in responsiveness (Boucsein, 1992; Venables & Christie, 1980).

2.3.1.5. Participants

48 white participants (mean age ± *SD*: 26.5, ± 8.34, 14 male) gave their informed consent to participate and were paid for their participation. All participants self-identified as white. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

2.3.2. Results

2.3.2.1 Introspective Measures

As in experiment 2.1 the number of people experiencing ownership over the white and black hand in the synchronous 1PP condition was calculated based on participants' responses to the statement "I felt like the rubber hand was my hand". Participants with a mean response greater than 0 were considered to have felt body ownership over the rubber hand while those with a response less than or equal to 0 were not. The manipulation for the white hand was largely successful, with 77% of participants experiencing body ownership in the synchronous 1st person perspective (1PP) VT stimulation condition. For the black hand the manipulation was less successful than in experiment 2.1, with only 50% participants experiencing body ownership over the black hand during synchronous 1PP VT stimulation. Possible reasons for this discrepancy between the two experiments are addressed in the discussion.

In order to investigate the role of stimulation, perspective and skin colour on the strength of the RHI a 3x2 repeated measures ANOVA with type of VT stimulation (synchronous 1PP, asynchronous 1PP, synchronous 3PP) and skin colour of the viewed hand (white, black) as the factors was run for each of the four questions (see Figure 2-8).

For the first question, "It seemed like the touch I felt was caused by the paintbrush touching the hand in the video." Mauchly's test indicated that the assumption of sphericity had been violated ($\chi2(2) = 10.06$, $p < .01$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.84$). A significant main effect was found for type of VT stimulation, $F(1.67, 78.57) = 75.68$, $p < .001$, because, overall, synchronous 1PP VT stimulation ($M = 1.49$, $SD = 1.55$) resulted in higher ratings than asynchronous 1PP stimulation ($M = -1.18$, $SD = 1.66$), $t(47) = 10.92$, $p < .001$, or synchronous 3PP stimulation ($M = 0.51$, $SD = 1.69$), $t(47) = 5.98$, $p < .001$, and synchronous 3PP stimulation resulted in higher ratings that asynchronous 1PP stimulation, $t(47) = 7.02$, $p < .001$. A main effect was also found for skin colour, $F(1, 47) = 18.84$, $p < .001$, because, in all condition VT stimulation ratings for the white hand ($M = 0.59$, $SD = 1.39$) were significantly higher than those for the black hand ($M = -0.04$, $SD = 1.54$). There was no significant interaction between stimulation and skin colour, replicating the findings of experiment 2.1.

For the second question, "I felt like the hand in the video was my hand.", a significant main effect was found for type of VT stimulation, $F(2, 94) = 32.3$, $p < .001$, because, overall, synchronous 1PP VT stimulation resulted in higher ratings ($M = 0.65$, $SD = 1.85$) compared to both asynchronous 1PP stimulation ($M = -1.01$, $SD = 1.64$), $t(47) = 7.05$, $p < .001$, and synchronous 3PP stimulation ($M = -0.84$, $SD = 1.41$), $t(47) = 7.07$, $p < .001$. A main effect was also found for skin colour ($F(1, 47) = 35.170$, $p < .001$) because, overall, the white hand ($M = 0.26$, $SD = 1.7$) resulted in higher ratings than the black hand ($M = -1.07$, $SD = 1.39$). There was no significant interaction between stimulation and skin colour.

For both the third question, "It seemed as if the knife touched my own hand." and the fourth question, "Did you experience any pain when the knife touched the hand in the video?", Mauchly's test indicated that the assumption of sphericity had been violated (Q3: $\chi 2(2) = 12$, $p < .01$, Q4: $\chi 2(2) = 16.89$, $p < .001$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (Q3: $\varepsilon = 0.81$, Q4: $\varepsilon = 0.77$). In both questions a significant main effect of type of VT stimulation was found (Q3: $F(1.63, 76.45) = 27.19$, $p < .001$; Q4: $F(1.53, 71.9) = 18.65$, $p < .001$) because, overall, synchronous 1PP stimulation (Q3: $M = -0.13$, $SD = 1.98$; Q4: $M = 1.04$, $SD = 1.32$) led to higher ratings than both asynchronous 1PP stimulation (Q3: $M = -1.61$, $SD = 1.53$, $t(47) = 6.2$, $p < .001$; Q4: $M = 0.43$, $SD = 0.81$, $t(47) = 5.28$, $p < .001$) and synchronous 3PP stimulation (Q3: $M = -1.36$, $SD = 1.59$, $t(47) = 5.13$, $p < .001$; Q4: $M = 0.44$, $SD = 0.84$, $t(47) = 4.33$, $p < .001$). There was no effect of skin colour or any interaction between stimulation and skin colour.

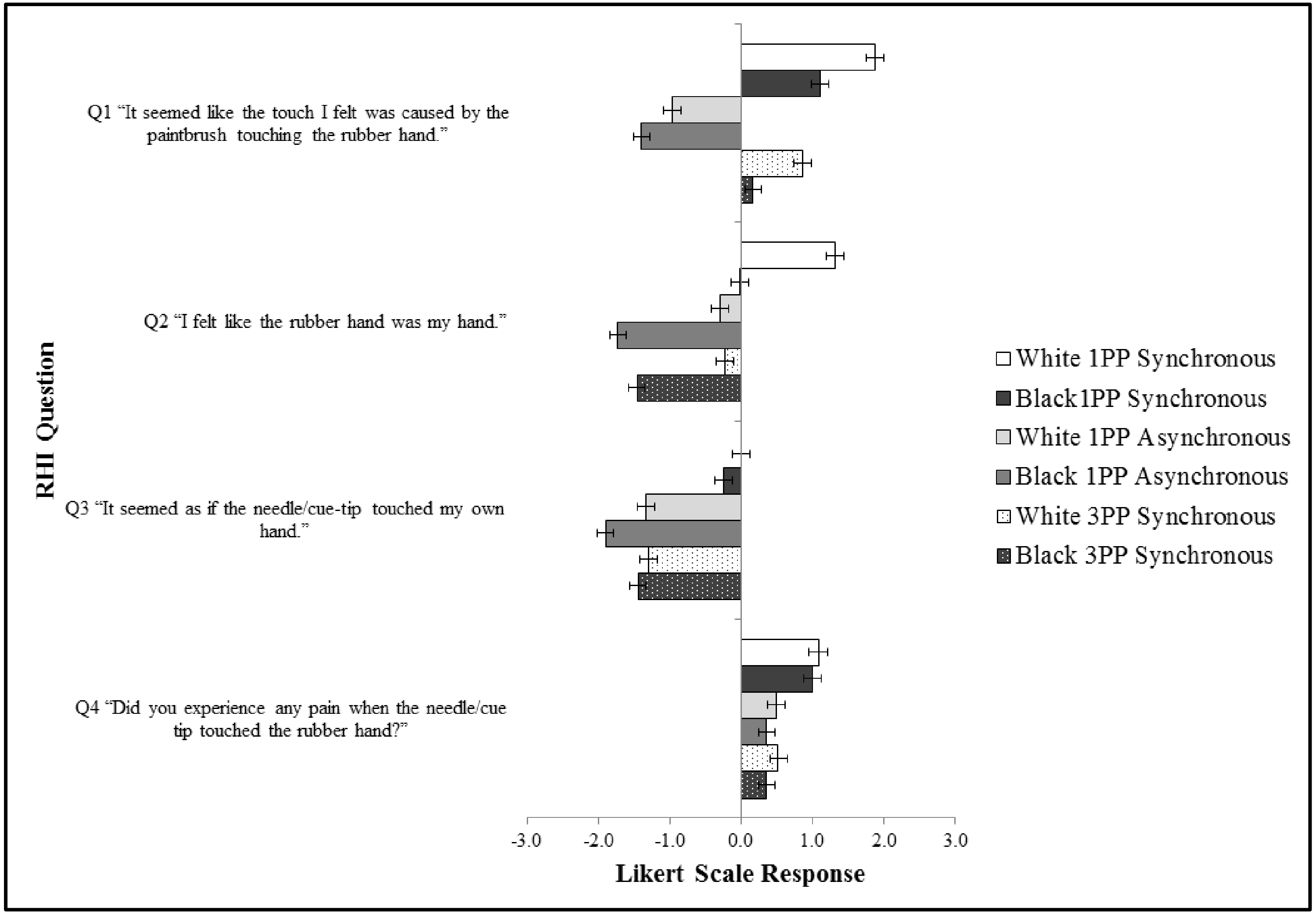

Figure 2-8. Mean responses to the four introspective questions by synchrony and skin colour of the rubber hand. Error bars represent SEM.

As in experiment 2.1 the analysis of the introspective data suggests that an in-group rubber hand is more likely to be experienced as self-relevant independently of the pattern of VT stimulation, but at the same time, the critical manipulation of synchronous vs. asynchronous multisensory stimulation shows synchronous VT stimulation leads to a greater sense of body ownership independently of the skin colour of the rubber hand. As in experiment 2.1 the question of whether the magnitude of the change between synchronous and asynchronous conditions in the subjective experience captured by questions 1 and 2 was the same when looking a white rubber hand (Q1: $M = 2.83$, $SD = 2.06$; Q2: $M = 1.6$, $SD = 1.87$) versus a black rubber hand (Q1: $M = 2.5$, $SD = 2.01$; Q2: $M = 1.71$, $SD = 2.22$) was examined. The differences between black and white rubber hand conditions were not significant (Q1: $t(47) = 1.03$, $p > .05$, Q2: $t(47) = -0.29$, $p > .05$), suggesting that the magnitude in the change of the experience between synchronous and asynchronous stimulation was comparable between the two different rubber hands. We also examined whether the magnitude of the change between synchronous 1PP and synchronous 3PP conditions in the subjective experience captured by questions 1 and 2 was the same when looking at a white rubber hand (Q1: $M = 1.02$, $SD = 1.43$; Q2: $M = 1.54$, $SD = 1.7$) versus a black rubber hand (Q1: $M = 0.94$, $SD = 1.86$; Q2: $M = 1.44$, $SD = 1.8$). The differences between black and white rubber hand conditions were not significant (Q1: $t(47) = 0.24$, $p > .05$, Q2: $t(47) = 0.38$, $p > .05$), suggesting that the magnitude in the change of the subjective experience of ownership between 1st person and 3rd person perspectives was comparable between the two different rubber hands.

2.3.2.2. Skin Conductance Responses

In order to investigate the effect of stimulation, perspective and skin colour on physiological responses to the observation of painful stimuli touching the hand a 3x2x2 repeated measures ANOVA was run on the *z*-scored SCR data. The factors were: the type of VT stimulation (1PP synchronous, 1PP asynchronous, 3PP synchronous), the skin colour of the hand (white, black) and the timing of the appearance of threatening stimuli (pre-VT stimulation, post-VT stimulation).

No significant main effects were found. However, a significant interaction was found between timing and type of VT stimulation ($F(2, 82) = 4.46$, $p < .05$) (see Figure 2-10). Pairwise comparisons revealed that this was driven by significant increases in post- stimulation (*M* = 0.5, *SD* =1.05) compared to pre- stimulation (*M* = -0.19, *SD* = 0.97) SCRs following synchronous 1PP VT-stimulation, $t(41) = -2.7$, $p < .01$. Importantly there was no difference between pre- and post- SCRs following either asynchronous 1PP (Pre: *M* = 0.27, *SD* = 0.97; Post: *M* = -0.13 *SD* = 0.96), $t(41) = 1.89$, $p > .05$, or synchronous 3PP VT-stimulation (Pre: *M* = -0.22, *SD* = 0.89; Post: *M* = -0.29, *SD* = 0.91), $t(41) = 0.39$, $p > .05$. These results support the hypothesis that increased SCRs following synchronous 1PP VT stimulation are due to the experience of ownership rather than to a mere attentional effect due to synchronous VT stimulation.

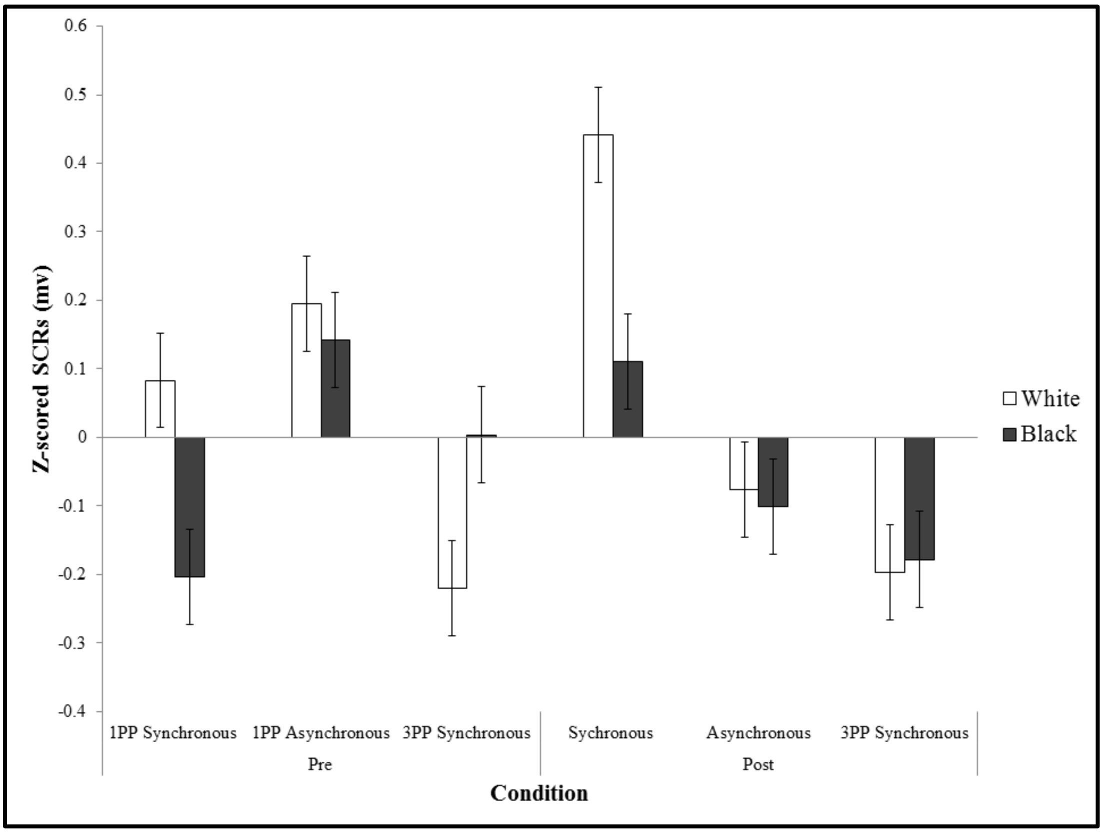

Figure 2-9. Mean standardised SCR to painful stimuli. Error bars represent SEM.

2.3.2.2. Effect of the Experience of Body Ownership for the Black Hand on Skin Conductance Responses

Due to the fact that half of the participants tested in this study did not experience feelings of body ownership over the black hand, the relationship between feeling body ownership and the black hand was further investigated. Participants were divided into two groups based on whether they reported ownership over the black hand or not as measured by their response to question 2 after synchronous 1PP VT stimulation with the black hand (a response greater than 0 was taken as indicating an experience of body ownership). As in experiment 2.1, only question 2 of the questionnaire was used rather than an average of all four questions because the key hypothesis of the study was that ownership of the rubber hand would be the defining factor in determining the effect of VT-stimulation on racial bias. This resulted in two groups; 21 participants who experienced ownership of a black hand, and 21 who did not experience ownership of the black hand.

A 3x2x2x2 mixed factors ANOVA was then run on the *z*-scored SCR data. The three within subject factors were: the type of VT stimulation (1PP synchronous, 1PP asynchronous, 3PP synchronous), the skin colour of the hand (white, black) and the timing of the appearance of threatening stimuli (pre VT, post VT) and the between subjects factor was the experience of ownership over the black hand in the first person synchronous condition.

As in the previous analysis a significant interaction was found between timing and type of VT stimulation ($F(2, 80) = 4.35$, $p < .05$) (see Figure 2-10). A significant interaction was also found between timing, skin colour of the hand and whether or not the participant experienced body ownership over the black hand ($F(1, 40) = 8.18$, $p < .01$). Pairwise comparisons suggested that this effect was driven by the fact that those who experienced ownership of the black hand showed higher SCRs for the black hand in the 1PP synchronous post-stimulation ($M = 0.19$, $SD = 0.94$) compared to 1PP pre–stimulation condition ($M = -0.29$, $SD = 0.87$), $t(20) = -2.33$, $p < .05$. In contrast no significant differences were found between the 1PP synchronous post-stimulation ($M = 0.03$, $SD = 0.85$) compared to 1PP pre–stimulation condition ($M = -0.12$, $SD = 0.97$), $t(20) = -0.68$, $p > .05$, among those who did not experience ownership of the black hand.

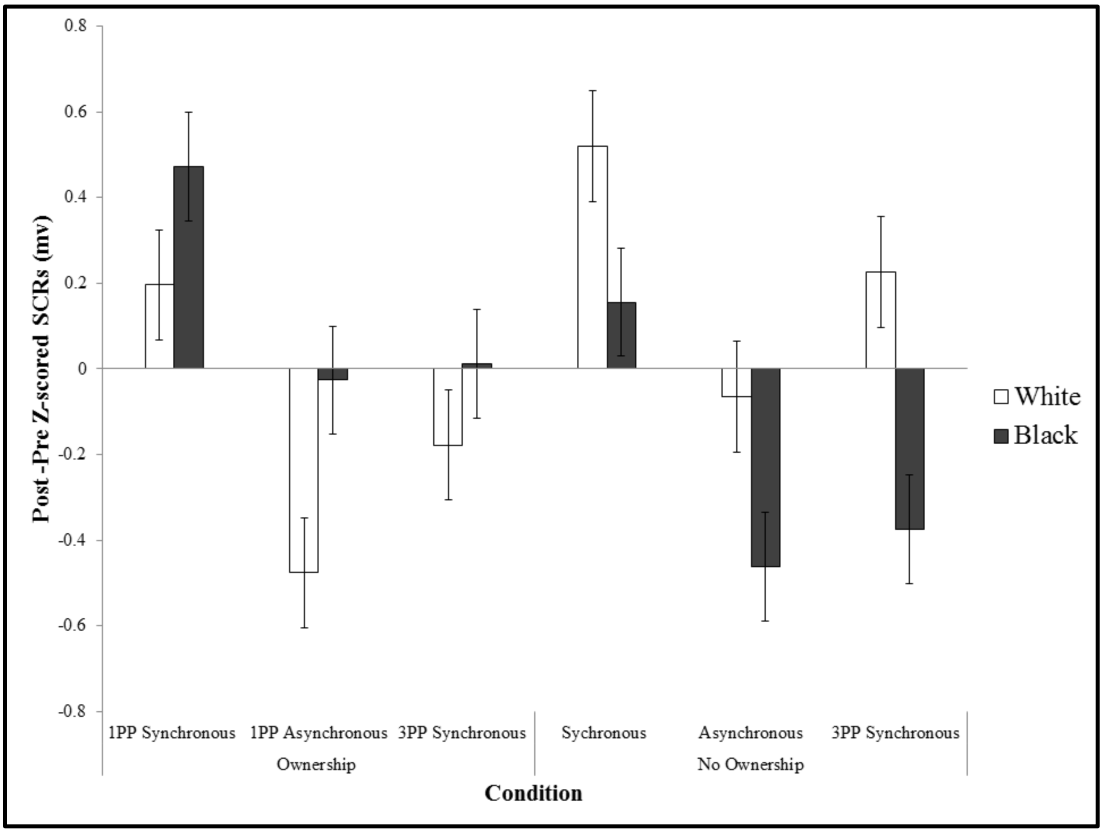

Figure 2-10. Change between pre and post VT-stimulation mean standardised SCR to painful stimuli by experienced ownership. Error bars represent SEM.

2.3.2.3. The Role of Empathy and Racial Bias in Predicting Body Ownership

As in experiment 2.1 in order to investigate whether or not participants' empathy predicted their experienced body ownership for the white or the black rubber hand, participant's ratings for question 2 in both the white and black hand synchronous 1PP condition were entered as the dependent variables in separate multiple regressions (entry method) using participant's scores on the four sub scales from the IRI as predictors. One participant was excluded from these regressions as they failed to correctly complete the IRI. The overall model fit was not significant for the regression carried out on ownership scores for the white rubber hand, $F(4, 42) = 1.07$, $p > .05$, adjusted $r^2 = .01$. A significant model fit was however found for the regression carried out on ownership scores for the black rubber hand $F(4, 42) = 3.18$, $p < .05$ (see Table 2-7). This was due to a significant positive regression weight on both the fantasy and the personal distress subscales of the IRI. None of the other IRI subscales were significant contributors to the model.

Table 2-7. Summary of linear regression analysis for variables predicting with ownership ratings for the white rubber hand.

Variable	**β**	***p***
Perspective Taking	0.14	.087
Empathic Concern	-0.08	.42
Fantasy	0.14	.031
Personal Distress	0.14	.026

Note. r^2adjusted = .16.

In order to investigate whether racial bias as measured with the IAT had an effect on the experience of body ownership for the white and black rubber hands, participant's ratings for question 2 in both the white and black hand synchronous 1PP condition were entered as the dependent variables in separate linear regressions (entry method) using participant's scores on the pre VT stimulation IAT as the predictor. Neither regression however, produced a significant model (for the white hand: $F(1, 46) = .46$, $p > .05$, adjusted $r^2 = .01$; for the black hand*:* $F(1, 46) = .23$, $p > .05$, adjusted $r^2 = -.02$.

2.4. General Discussion

The two experiments reported in this chapter are the first to directly investigate the extent to which the sense of body ownership induced with the RHI depends on the skin colour of the observed hand. The findings of these studies demonstrate that multisensory stimulation can induce a sense of body ownership over a rubber hand with the skin colour of a different racial group than that of the participant. In experiment 2.1 it was found that synchronous, but not asynchronous, VT stimulation led to a feeling of body ownership for both the white and black rubber hands as measured introspectively, behaviourally and physiologically. Almost two thirds of the participants in this experiment reported a sense of body ownership over a black rubber hand, as well as showing the expected proprioceptive drift towards the rubber hand and increase in autonomic responses when viewing a painful stimulus being applied to either the white or the black rubber hand.

Experiment 2.2 expanded on these results by replicating the pattern of findings seen in experiment 2.1 for both the introspective and physiological measures, but with improved control conditions. For example, the inclusion of a form of synchronous VT stimulation that does not induce body ownership (i.e. 3PP, Ehrsson et al., 2004) was used to show that the observed increase in SCR is caused by the experience of body ownership, rather than merely synchronous VT stimulation. This can be seen by the fact that, for hands of both skin colours, synchronous stimulation of a hand seen from a 3PP led to significantly lower introspective reports of body ownership and SCRs to threatening stimuli than did stimulation of a hand seen from a 1PP. The link between experiencing ownership over the observed hand and increased SCR to threatening stimuli can also be seen in the finding that those participants who experienced body ownership for the black hand showed a significantly higher increase in SCRs following 1PP synchronous stimulation of the black hand, while participants who did not experience ownership showed no such increase.

One notable difference in the findings of Experiments 2.1 and 2.2 is that, while in experiment 2.1 almost two thirds of participants reported feelings of ownership for the black hand, in experiment 2.2 only half of all participants reported such feelings. One possible cause of this reduction in the number of participants experiencing body ownership is the different nature of the stimuli used. While the first experiment involved the use of a physically present prosthetic hand, the second used videos instead. A previous study by Ijsselsteijn, de Kort and Haans (2006) investigated differences in the strength of the RHI when induced using a physically present rubber hand or using a ”virtual” projection of a rubber hand and found that the illusion was less vivid when using projection than when using the unmediated hand.

Interestingly, while no effect of skin colour on size of proprioceptive drift (experiment 2.1) or SCR size (experiments 2.1 and 2.2) was found, introspective reports involving the sense of ownership and the location of tactile stimulation were affected by the skin colour of the observed hand, with participants reporting a more vivid experience of the RHI for the white than the black hand. Note, however, that the effect of skin colour was independent of stimulation as higher ratings on these two questionnaire items for the white hand were recorded after both synchronous and asynchronous VT stimulation and in Experiment 2, for hands seen from both the 1PP and the 3PP. This general effect of skin colour implies that a hand of the same skin colour as that of the participant might result in a baseline effect of skin colour which "primes" higher cognitive processes of self-attribution involved in the sense of body ownership, allowing an easier incorporation of the fake hand of same skin colour. Thus, although the skin colour of the rubber hand affected the perceived body ownership, this effect was independent of that of VT stimulation or anatomical congruency. Rather it seems that these findings reflect a greater incorporation of a white hand into the participant's body in *general* rather than a stronger effect of VT stimulation in inducing body ownership of the white hand. In fact the magnitude of the effect of stimulation, that is the difference between synchronous and asynchronous VT, was equal for both white and black hands, suggesting that multisensory stimulation can *change* the sense of body ownership equally for hands of same or different skin colour.

The finding that skin colour does affect the subjective reports of induced body ownership across both stimulation conditions is in line with other studies that have shown that the visual properties of the observed hand can affect the strength of the RHI (Austen et al., 2004; Costantini & Haggard, 2007; Haans et al., 2008; Pavani et al., 2000; Pavani & Zampini, 2007; Tsakiris et al., 2010; Tsakiris & Haggard, 2005b). It is also in line with studies showing that mere visual exposure to an observed hand can influence both proprioception (Holmes et al., 2006) and tactile perception (Durgin, Evans, Dunphy, Klostermann, & Simmons, 2007). Tsakiris (2010) suggested that during the RHI the visual form of the external object is compared against a body model that contains a reference description of the visual, anatomical and structural properties of one's own body. However, the findings from previous studies (Holmes et al., 2006; Longo et al., 2009) suggested that more surface level visual features like skin texture and colour do not enter into this comparison. The current study's results provide partial support for this claim, in that observing VT stimulation of a hand with a different skin colour still led to the experience of ownership in the majority of participants. However, taken together with the results of Haans et al. (2008), which found stronger subjective judgements of ownership after multisensory stimulation of a rubber hand with a skin like texture compared to a rubber hand with a non-skin texture, the current results suggest that surface level features such as skin colour and texture are used as a comparator at a late stage and have a modulating effect on conscious perception of the ownership although not on its behavioural or physiological correlates.

Several recent studies have suggested a link between the experience of body ownership induced by RHI and empathy (Asai, Mao, Sugimori, & Tanno, 2011; Durgin et al., 2007; Schütz-Bosbach & Prinz, 2007). Asai et al. (2011) found a link between the empathic concern subscale and tendency to experience the RHI. The link between empathy and experiencing the RHI was also found in the present study, although in a slightly different way. In experiment 2.1, the experience of the RHI for both the white and black hand was predicted by participants' scores in the fantasy subscale (FS) of the IRI. The finding that participants' FS scores were a significant predictor for experiencing the RHI for the black hand was replicated in experiment 2.2, which in addition indicated that the score on the personal distress subscale was also a significant predictor. Davis (1983) characterises the FS of the IRI as tapping into respondents' tendencies to transpose themselves imaginatively into the feelings and actions of fictitious characters in books, movies, and plays. It is interesting to note that Rochat (2003), in characterising the different levels of self-awareness that occur in adults, relates the ability to step outside one's own embodied self and project one's self into a novel or film to a state of confusion between self and world. The relationship between FS and experience of the RHI found in this study seems to corroborate this view suggesting that those who find it easier to step into the shoes of fictional characters may have a more malleable representation of their own body. Overall, these findings add to the evidence that, along with other factors e.g., schizotypy (Asai et al., 2011), body image dissatisfaction (Mussap & Salton, 2006), and interoceptive sensitivity (Tsakiris et al., 2011), empathy plays a significant role in determining individual differences in the vividness of the RHI. A relative strength of the present study is the that our results do not rely solely on participants' introspective reports of the illusion (which may reflect individual differences in suggestibility or other unknown cognitive factors) but also on participants' autonomic reaction to painful stimuli being administered to the rubber hand (experiments 2.1 and 2.2) and on participants' judgements of the proprioceptive location of their own hand (experiment 2.1). In particular, the pattern of our physiological variable reflects a change in participants' autonomic regulation that at least cannot be changed or controlled at will.

The role of empathy in the RHI ties into the question of whether social factors such as in-group/out-group identification can also play a role in the strength of the rubber hand illusion. The lack of any relationship between participants pre-illusion racial bias and the strength of the RHI suggests that, unlike sensorimotor empathy for pain (Avenanti, Sirigu, & Aglioti, 2010), the processes involved in the generation of a sense of body ownership seem immune to the effects of top-down socio-cognitive factors such as racial bias, at least as measured with the IAT.

More interesting however is the finding of an effect of experiencing the RHI on post-illusion racial bias. A number of recent studies have suggested that sensory processing might alter the perceived physical (Longo et al., 2009) and psychological similarity between self and other, and possibly between in-group and out-group members. For example, seeing a face being touched at the same time as your own face might change self-face recognition (Tsakiris, 2008) but also the felt closeness to the other (Paladino, Mazzurega, Pavani, & Schubert, 2010). Synchronous movement between people has also been shown to increase perceived rapport and affiliation (Hove & Risen, 2009; Lakin & Chartrand, 2003; Miles et al., 2009), to improve performance in joint action tasks (Valdesolo et al., 2010)and to improve co-operation in economic games (Wiltermuth & Heath, 2009).

Experiment 2.1 of the present study adds to this literature on the social effect of synchrony by showing, for the first time, that the experience of body ownership as induced by synchronous VT stimulation can exert a bottom-up effect on participants' perceptions of an out-group. A multiple regression on the change in IAT score between pre- and post-stimulation IATs did not find that experiencing ownership of the rubber hand lead to a significant reduction in racial bias. However, it was found that when the ownership ratings for both the white and black rubber hand were entered as predictors into a multiple regression they significantly predicted participants' post-testing racial bias. Neither predictor was significant independently of the other due to the fact that ownership scores for the white and black rubber hand were themselves highly correlated. There are two possible explanations for this finding. One is that the decrease in racial bias was caused by simply experiencing the RHI for a hand of any skin colour. The other is that the change in IAT scores was driven by ownership of the black rubber hand specifically but that due to the strong correlation between ownership of the black and white rubber hands both ownership scores predicted the decrease. Unfortunately the repeated-measures design used in this study means that it is not possible to determine which of these possibilities is correct. Nonetheless this finding is a promising first step towards demonstrating that synchronous multisensory stimulation can alter higher level socio-cognitive processes. Further investigation of this issue using a between subjects design to separate out the effect of multisensory stimulation of a hand with an in-group as opposed to out-group skin colour on implicit racial bias would help to resolve the ambiguity in the results found in the present study.

In conclusion, to the extent that race is a strong modulator of social cognition and its underlying neural processes, understanding if and how multisensory processing can alter self-representations across the boundaries of racial groups might be important for probing the sensorimotor basis of social cognition. The present chapter takes a first step towards that direction by showing that changes in body-awareness as a result of multisensory stimulation can go beyond one's own skin colour.

Chapter 3. Change My Body Change My Mind: Multisensory Stimulation, Race and Prejudice[3]

"The completeness of this transformation appalled me. It was unlike anything I had imagined. I became two men, the observing one and the one who panicked, who felt Negroid even to the depths of my entrails. I felt the beginnings of great loneliness, not because I was a Negro but because the man I had been, the self I knew, was hidden in the flesh of another."

John Howard Griffin, (1961, p. 11)

3.1. Introduction

The studies detailed in chapter 2 demonstrated that multisensory stimulation can lead to the experience of body ownership over a hand of a different skin colour. The two studies in this chapter expand on this finding by investigating whether this experience of ownership over a hand of a different skin colour can change participant's responses to a racial out-group at both a cognitive and a bodily level.

In the quote above from his book *Black Like Me* (1961) John Howard Griffin describes his feelings on first looking into the mirror after taking large oral doses of the anti-vitiligo drug Methoxsalen, spending long periods under a UV and staining his skin in order to transform his appearance into that of a black man. Griffin then spent six weeks travelling through the states of the southern USA experiencing the daily inequalities suffered by black people under the "Jim Crow" regime of racial segregation. Griffin's experiences were clearly much more rich and detailed than a

[3] Experiment 3.1 is published as:

Farmer H, Maister L & Tsakiris M (2014). Change my body, change my mind: the effects of illusory ownership of an outgroup hand on implicit attitudes toward that outgroup. *Frontiers in Psychology, 4*:1016.

mere change in skin pigmentation; however the quoted remarks above help to illustrate how much of our identity is defined by our physical appearance. Looking into the mirror at his newly darkened skin Griffin expresses the feeling that "the self [he] knew, was hidden in the flesh of another", but at the same time this experience of being inside another's skin created a feeling of closeness and identity with the black people he encountered during his travels. This allowed him to gain much greater insight into the many injustices they experienced than he could have gained had he made the same journey with his biological skin tone.

While experiencing ownership over a hand of a different racial group is not of course comparable with living as a member of a different race for weeks, it is possible that even the temporary link between one's self and the other racial group may exert an effect of participants' attitudes towards that racial group. Research on stereotype change has shown that people adjust their perception of groups to their personal experiences with individual members of those groups (Johnston & Hewstone, 1992; Kunda & Oleson, 1997; Weber & Crocker, 1983). Thus positive experiences with those of another skin colour can lead to a change, and hopefully a decrease, in racial bias (e.g., Ensari & Miller, 2002; Kunda & Oleson, 1997). A recent longitudinal study showed that liking or disliking of individuals from a particular ethnic group predicted adolescents' general attitudes towards that ethnic group. Such findings, taken together with evidence for a general cognitive bias in favour of automatic positive associations towards the self and self-related stimuli (Greenwald & Banaji, 1995; Mezulis, Abramson, Hyde, & Hankin, 2004) suggest that through linking the skin colour of a racial out-group to the bodily representations of the self it may be possible to alter people's attitudes towards that racial group.

There has been a considerable amount of research investigating what factors can reduce negative implicit attitudes towards racial out-groups. Researchers have identified that a wide range of factors can lead to a decrease in IAT score including; training on how to better individuate the faces of people from a different racial group (Lebrecht, Pierce, Tarr, & Tanaka, 2009); being placed in a situation in which one is subordinate to a member of that racial group (Richeson & Ambady, 2003), having close friends who are members of that racial group (Aberson, Shoemaker, &

Tomolillo, 2004), behaviourally mimicking a member of that racial group (Inzlicht, Gutsell, & Legault, 2012), and viewing positive exemplars from that racial group (Ashby Plant et al., 2009; Dasgupta, Greenwald, McGhee, Mellott, & Nosek, 2001). The sensitivity of the IAT scores to the various methods outlined suggests that it is best thought of as a measure of state rather than trait bias.

In addition to the effects of race on cognitive attitudes and explicit behaviour a series of recent studies have demonstrated that racial bias can also exert an effect on more low level bodily aspects of social cognition. Along with the effect of race on VRT described in the previous chapter (Serino et al., 2009) modulations of shared bodily representations based on race have also been observed in studies investigating sensorimotor empathy for pain (Avenanti et al., 2010; Azevedo et al., 2013; Cheon et al., 2011; Mathur, Harada, Lipke, & Chiao, 2010; Xu, Zuo, Wang, & Han, 2009). For example Xu et al. (2009) found that the observation of members of a racial out-group receiving painful stimuli led to less BOLD activation in brain areas involved in pain processing than did the observation of a racial in-group. Avenanti et al. (2010) used transcranial magnetic stimulation (TMS) to observe corticospinal excitability in black and white participants observing a hand of either their own skin colour or a different skin colour being stabbed with a syringe. They found that, while observation of an in-group hand being stabbed led to motor suppression, observation of an out-group hand being stabbed resulted in motor excitation. Interestingly this effect was greater for the known out-group than for a hand with a violet skin colour and was correlated with the participants' implicit racial bias as measured by the IAT. This suggests that, rather than merely being dependent on the physical difference between the in-group and out-group hands, this effect was related to social attitudes towards the racial out-group. A follow up fMRI study found greater activation to in-group compared to out-group pain in the bilateral anterior insula and found that racial bias as measured by the IAT predicted the difference in the amount of activation in the left anterior insula between the two conditions (Azevedo et al., 2013). Taken together these studies suggest that, as well as affecting cognitive and behavioural level measures, the distinction between racial in-groups and out-groups can also exert an influence on shared body representations.

The two experiments in this chapter aimed at investigating whether using multisensory stimulation to induce the feeling of body ownership over a hand with the skin colour of a racial out-group could lead to a change in cognitive and bodily measures of racial bias. In both studies Caucasian participants experienced either synchronous or asynchronous stimulation over a white or black rubber hand and measures of racial bias taken before and after this experience were compared. Study 3.1. focused on examining the effects of multisensory stimulation on participants' attitudes towards black people as measured using a single category IAT while study 3.2 used TMS to examine the effect of multisensory stimulation on a bodily level measure of racial bias, namely sensorimotor resonance to the observation painful stimuli (Avenanti, Bueti, Galati, & Aglioti, 2005; Avenanti et al., 2010).

3.2. Experiment 3.1

3.2.1. Introduction

The aim of the present experiment was to investigate whether manipulating the feeling of body ownership over a rubber hand of a different racial group could lead to an alteration in participants' implicit cognitive attitude towards that racial group.

A recent study by Inzlicht, Gutsell and Legault (2012) provides indirect support for this possibility. The researchers found that that the behavioural mimicry of an individual from a racial out-group reduced implicit racial prejudice towards that out-group. As discussed in the introduction such behavioural mimicry may lead to a blurring of the boundary between self and other and has been shown to modulate the motor output of brain areas responsible for neural resonance with other's actions (Obhi & Hogeveen, 2010). Inzlicht et al. suggest that mimicry reduced implicit prejudice by increasing self-other overlap, thus enhancing neural resonance with the racial out-group. The current experiment sought to show a similar effect of shared body representation on racial bias but aimed to elicit it using purely perceptual visuo-tactile matching rather than the visuo-motor matching employed by Inzlicht et al.

Another study which sought to test the effects of directly embodying a different racial group on racial attitudes was carried out by Groom, Bailenson and Nass (2009). In this study white participants were placed in a virtual reality environment and either asked to simply imagine that their avatar was white or black, or else shown either a white or black face as the face of their avatar in a virtual mirror. The study found that while merely imagining the avatar as being white or black had no effect on racial bias, those participants who saw their avatar as black subsequently had higher racial bias than those who saw their avatar as white. The authors attributed this increase to increased stereotype activation in those who saw the black face directly. However, this finding is somewhat surprising as given the positive associations people generally have with the self (Greenwald & Banaji, 1995), the link between one's own body and the other race would have been expected to lead to lower rather than greater racial bias. A possible explanation for the failure of the embodiment to reduce racial bias is related to the specific way that participants embodied the avatar. While the head and body of the avatar moved in synchrony with the participant the only cues to the race of the avatar were in the face as the body of the avatar was presented as full clothed with no skin exposed. Given that the facial movement of the participants was not synchronous with those of the avatar, it is possible that this created a feeling of mismatch between the participant and the most relevant part of the avatar in terms of racial identity creating an uncanny feeling in participants that was then reflected in participants' performance on the IAT. Offering support for the view that embodying a black avatar should reduce racial bias a second study that used virtual reality avatars (Peck, Seinfeld, Aglioti, & Slater, 2013) did find a reduction in implicit racial bias for those who embodied a dark skin avatar compared to those who embodied either a white or purple skinned avatar or those who saw the same movements of the dark skinned avatar but without embodiment.

The results of Experiment 2.1 revealed limited evidence in favour of the power of multisensory stimulation to alter attitudes at the cognitive level. While there was no significant change in participants' scores on the race IAT between pre- and post-RHI sessions there was a significant relationship between the levels of ownership the participants reported over both the black and white rubber hands, and post-RHI racial bias. Those who felt ownership over the rubber hands more strongly also showed lower bias in the post-RHI IAT. However, due to the within group design of experiment 2.1 the effect of ownership over the black hand could not be disentangled from the effect of ownership over the white hand. The result of experiment 2.1 is therefore consistent with the possibility that simply experiencing ownership over a rubber hand of any skin colour may lead to a change in racial bias. The study also suffered from a number of other limitations. The within subjects design meant that it was not possible to separate out the effects of synchronous and asynchronous stimulation from those of experienced body ownership because all participants had experienced both synchronous and asynchronous VT-stimulation prior to carrying out the post-stimulation IAT. While these two factors are highly correlated it is possible, given the findings of Inzlicht et al. (2012), that synchronous stimulation alone as opposed to the feeling of body ownership specifically is sufficient to change racial bias. A final limitation of the study relates to the IAT itself. The standard IAT assesses attitudes toward white and black people simultaneously. This makes it difficult to determine whether the effect of implicit race bias effects observed in experiment 2.1 are the result of embodiment leading to a stronger liking for black people, a stronger disliking of white people, or both.

Following on the published findings of experiment 2.1 a recent study by Maister, Sebanz, Knoblich and Tsakiris (2013) investigated whether the effect of changes in body ownership over a hand that has a darker skin colour would lead to a change in implicit biases against people with dark-skin colour. The study used a between subjects design in which participants experienced either synchronous or asynchronous VT stimulation applied to either a light or dark skinned rubber hand (equivalent to the black and white rubber hands employed in the current study). As synchronous, but not asynchronous, VT stimulation has been found to reliably lead to feelings of body ownership over a foreign limb (Botvinick & Cohen, 1998; Tsakiris & Haggard, 2005b) varying the synchrony of VT stimulation allowed for the control of whether or not participants felt ownership over the rubber hand or not, and thus controlled for the effects of visual exposure to a hand of a different skin colour independently of the type of stimulation used. Maister et al. found a significant relationship between experiencing ownership over the dark rubber hand and change in IAT scores with those who experienced greater ownership over the dark rubber hand showing a reduction in skin-tone bias which was not seen with participants who experienced ownership over the light rubber hand. One notable difference between experiment 2.1 of this thesis and Maister et al. was that rather than using actual photographs of black and white faces in the IAT, Maister et al. used a set of images of faces which were identical in the light and dark conditions apart from their skin colour and so did not account for the distinctive differences in facial features between white and black people in real life.

Several studies have investigated contributions of skin colour and facial features to racial categorization and have found evidence that both play an important role (Balas & Nelson, 2010; Balas, Westerlund, Hung, & Nelson, 2011; Eberhardt, Davies, Purdie-Vaughns, & Johnson, 2006; Hagiwara, Kashy, & Cesario, 2012; Livingston & Brewer, 2002; Ma & Correll, 2011; Ratner, Kaul, & Van Bavel, 2013; Ronquillo et al., 2007; Stepanova & Strube, 2009; Strom, Zebrowitz, Zhang, Bronstad, & Lee, 2012). Livingston and Brewer showed that highly prototypic Black targets (e.g., broad nose, large lips, coarse hair texture, dark skin tone) elicited more prejudice than less prototypic targets. Stepanova & Strube demonstrated that both skin colour and facial features affect judgements of racial typicality and racial categorization independently and in an additive manner, while Hagiwara et al. showed a similar independent effect of skin colour and features on white people's affective judgements towards black people. Strom et al. found that white participants were more responsive to facial metrics than to skin tone when making racial prototypicality ratings. Underlining the potentially lethal consequences of these findings is evidence that people with both darker skin and more prototypically black facial features are more likely to receive the death sentence (Eberhardt et al., 2006) and that participants and police officers playing a first person shooter computer game are more likely to shoot black avatars with prototypical as opposed to unprototypical features (Ma & Correll, 2011). In addition to these behavioural studies neuroimaging studies have found that skin colour and facial features selectively modulate neural responses to faces. Balas & Nelson showed participants faces of different races while using EEG to record brain activity and demonstrated that, while the N170 component was modulated only by skin colour, the N250 component was sensitive to both skin colour and facial features. In a follow up study the same authors showed that the neural signature of the 'other-race effect', in which other-race faces tend to look more alike to observers than faces of their own race (Malpass & Kravitz, 1969;

Meissner & Brigham, 2001) only occurs in infants when both skin tone and facial features are combined (Balas et al., 2011). Given the large amount of evidence for the importance of facial features as well as skin colour for perceptions of race, it is important to show that the effects of experiencing ownership over a hand with a dark skin colour found by Maister et al. (2013) generalise to faces with distinctive black facial features as well as merely a dark skin tone.

To expand on the findings of Maister et al. (2013) and address the limitations in study 2.1 the current experiment used a similar between subjects design as that used by Maister et al. However in this study, as in experiment 2.1, the race IAT with photographs of real people was used which allowed for the IAT to directly probe attitudes towards black people as a social group rather than merely about faces with light or dark skin. Finally in order to ascertain whether or not any effects found on implicit attitudes was due to a greater liking of black people, a single category race IAT was used in which participants only had to associate either good or bad words with black faces (Karpinski & Steinman, 2006). This enabled the study to focus on the effect of multisensory stimulation on participants' attitudes towards black people rather than their relative bias between black and white people.

On the basis of the findings from experiment 2.1 it was predicted that participants who experienced synchronous stimulation with the black rubber hand would become more positive in their implicit attitude towards black people compared to those in the other conditions. Based on the finding of experiment 2.1 and of Maister et al. (2013) it was also predicted that those who felt greater embodiment over the black hand would show a greater increase in their implicit attitude.

3.2.2. Methods

3.2.2.1. Design

The study used a between participants design with two factors (see Table 3-1). The first factor was the synchrony of visual-tactile stimulation (synchronous, asynchronous) and the second was the skin colour of the rubber hand (black, white). The dependent variables were participants' scores in the single category IAT for black faces post-VT stimulation and participants' responses to four statements on a 7 point Likert scale taken from Longo, Schüür, et al. (2008). In this study, in contrast to the studies in chapter 2, a larger sample of the questions from Longo, Schüür, et al. were used. Because the relationship between body ownership and racial bias was the key hypothesis in this study questions 1, 3 and 4 all loaded onto the ownership subfactor of the embodiment factor while question 2 loaded onto the location subfactor. In order to have a baseline measure of participants' attitudes towards black people participants also completed a single category black-faces IAT prior to experiencing V-T stimulation.

Table 3-1. Design of Experiment 3.1.

Condition	Synchrony of V-T stimulation	Skin colour of the rubber hand
1	Synchronous	Black
2	Synchronous	White
3	Asynchronous	Black
4	Asynchronous	White

3.2.2.2. Procedure

Participants attended one experimental session. They first completed a demographic questionnaire. Following this, participants carried out a computer administered single-category 'black-faces' IAT (SC-IAT), where they categorized words as 'good' or 'bad' and categorized pictures of black people's faces as 'black' in order to give an initial baseline measure of their implicit attitude towards black people. The associations between stimuli and response key and the order of associations (i.e. positive words and black faces or negative words and black faces) were counterbalanced across participants (Karpinski & Steinman, 2006). The SC-IAT was performed using Presentation® software (Version 16.03, www.neurobs.com). Accuracy and response times were analysed according to the method used in Karpinski and Steinman and the resultant scores were adjusted for counterbalancing so that those with a more positive view of black people had positive scores (i.e. >0) and those with a more negative view of black people had negative scores (<0).

After completing the single category IAT participants received stimulation from a paintbrush on their unseen left hand at a frequency of approximately 1 Hz whilst viewing either a black or white rubber hand being stimulated either synchronously or asynchronously with their felt touch. VT stimulation was delivered manually over two minutes with the use of two identical paintbrushes. Both the participant's left hand and the rubber hand were alternately stimulated on the index, middle and ring fingers from the knuckle to the tip.

Following the two minutes of VT stimulation participants then carried out the first half of the black faces SC-IAT (e.g. the blocks with the associations black faces and negative words), they then received a further two minutes of VT stimulation before completing the remaining block of the SC-IAT (e.g. black faces and positive words; see Figure 3-1). Finally participants completed the four item Ownership questionnaire which indicated the extent to which they experienced illusory ownership over the rubber hand. They completed these questions twice, once for their experience during the first period of VT stimulation, and then again for their experience during the second period of VT stimulation. The questions were presented using Presentation® software (Version 16.03, www.neurobs.com).

3.2.2.3. Participants

148 participants (mean age ± *SD*: 21 ± 6, 43 male) gave their informed consent to participate and were paid for their participation. All participants self-identified as white. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

3.2.3. Results

3.2.3.1. Introspective Rating of the RHI

Participants' ratings on the four RHI questions were averaged together across the two periods of stroking to produce a mean rating for each question. One participant in the white asynchronous group's data was lost due to technical error resulting in a total sample of 147 participants. A multivariate ANOVA was then run using all of the questions as dependent variables and including synchrony and colour as independent variables to establish whether the manipulation of VT stimulation succeeded in generating greater ownership over the rubber hand in the synchronous compared to the asynchronous conditions and to investigate whether the skin colour of the rubber hand had any effect on ratings of ownership (see Figure 3-2).

The MANOVA revealed that there was a significant difference between the synchronous and asynchronous groups on question one, "It seemed like I was looking directly at my own hand, rather than at a rubber hand", $F(1, 143) = 64.32$, $p < .001$, because synchronous stimulation ($M = 1.12$, $SD = 1.7$) led to higher responses than asynchronous stimulation ($M = -0.76$, $SD = 1.67$), question two, "It seemed like the touch I felt was caused by the paintbrush touching the rubber hand", $F(1, 143) = 88.21$, $p < .001$, because synchronous stimulation ($M = 1.46$, $SD = 1.54$) led to higher responses than asynchronous stimulation ($M = -0.73$, $SD = 1.64$), question 3 "It seemed like the rubber hand was my hand", $F(1, 143) = 18.16$, $p < .001$, because synchronous stimulation ($M = 1.34$, $SD = 1.46$) led to higher responses than asynchronous stimulation ($M = -1.08$, $SD = 1.64$),and question four "It seemed like the rubber hand began to resemble my real hand", $F(1, 143) = 47.07$, $p < .001$,because synchronous stimulation ($M = 0.77$, $SD = 1.61$) led to higher responses than asynchronous stimulation ($M = -0.35$, $SD = 1.58$),. There was no significant effect of skin colour of the rubber hand or significant interaction between synchrony or skin colour for any of the four questions. These results demonstrate that the manipulation of synchronous stimulation was successful in eliciting an illusory sense of body ownership over a black rubber hand.

3.2.3.2. Pre-existing Implicit Racial Bias and Experienced Ownership

First, to ensure that there were no significant differences in pre-existing attitudes towards black people between the four groups of participants, a between-subjects ANOVA was carried out on participants' scores with the pre-stimulation SC-IAT as the dependent variable and synchrony of VT-stimulation (synchronous, asynchronous) and skin colour of the rubber hand (black, white) as independent variables.

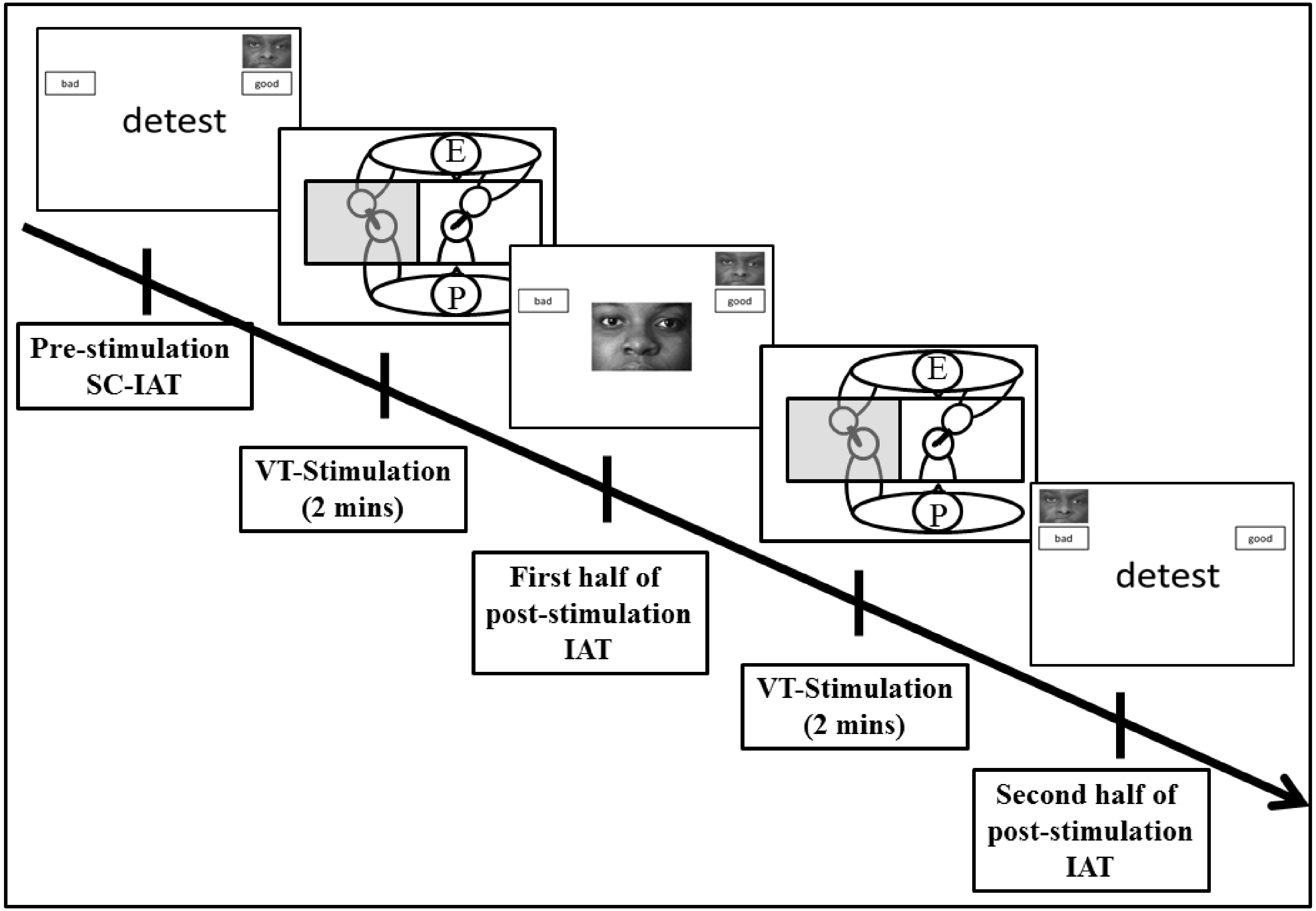

Figure 3-1. Structure of experiment 3.1(E = experimenter, P = participant.)

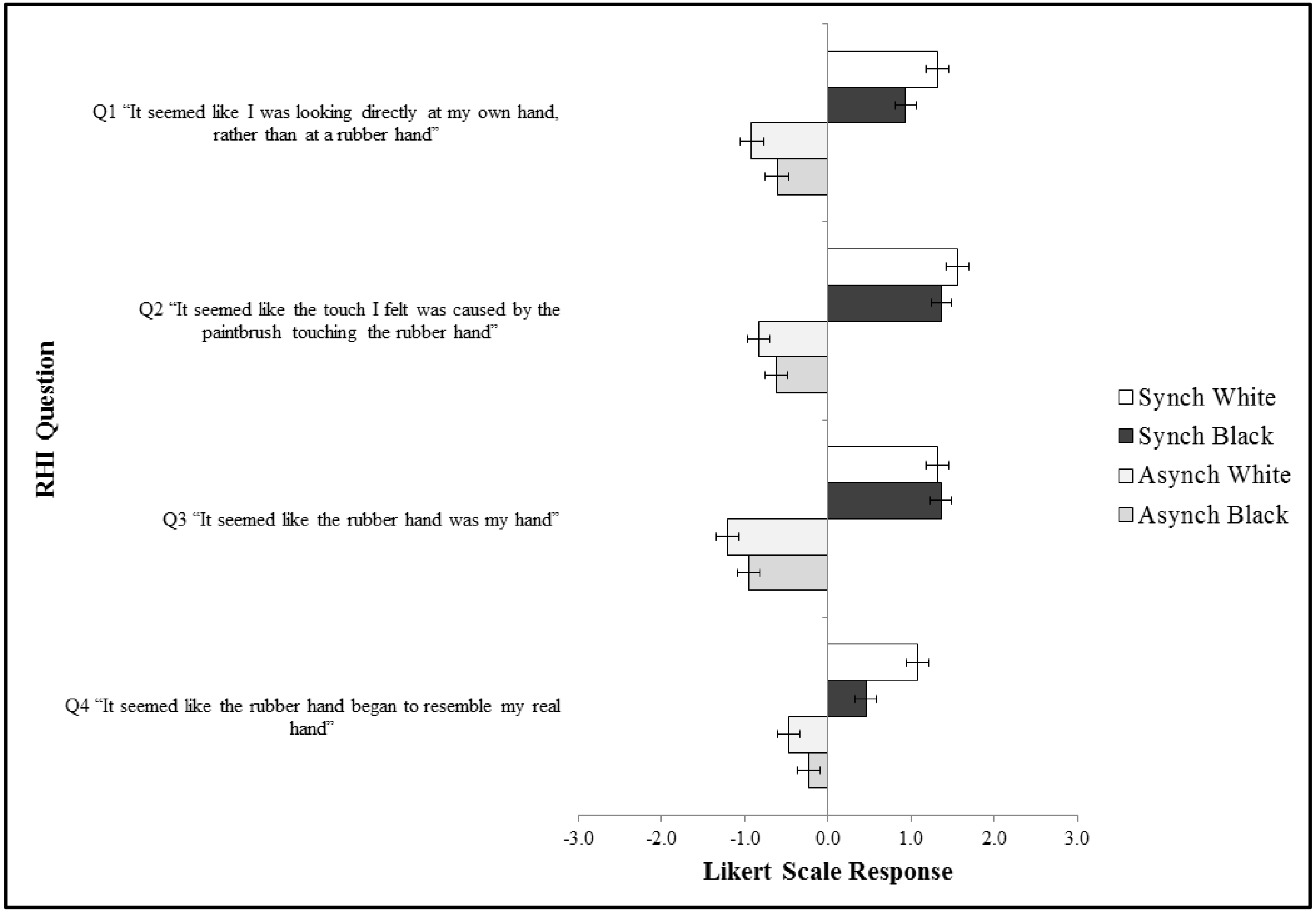

Figure 3-2. Mean Likert scores for each RHI question across each of the four conditions. Error bars represent SEM.

It was found that there were no significant effects of either synchrony of stimulation and nor was there a significant interaction between synchrony and skin colour (Black: Synch: $M = 0.01$, $SD = 0.38$; Asynch: $M = 0.01$, $SD = 0.44$; White: Synch: $M = -0.05$, $SD = 0.35$; Asynch: $M = 0.05$, $SD = 0.35$), indicating that participants across the four groups had comparable scores in the pre-stimulation SC-IAT.

We next investigated whether pre-existing implicit attitudes could predict the extent to which participants experienced ownership for the black rubber hand. To do this, participants' scores in the four introspective questions were averaged together to create an embodiment index. The averaging of all four questions as opposed to just using a single ownership question as in chapter 2 was carried out due to the fact that three of the questions in this study all loaded onto the ownership subfactor meaning that the scale created from averaging all four questions could be reliably interpreted as focused on ownership. Data from participants exposed to the black rubber hand (N = 37 for synchronous stimulation, and N = 37 for asynchronous stimulation) was then entered in a two-step hierarchical linear regression with the embodiment index as the dependant variable. Pre-stimulation SC-IAT score and synchrony of VT-stimulation (synchronous or asynchronous) were entered as potential predictor variables at the first step, and the interaction between them was entered as a potential predictor variable at the second step. The overall model fit was significant at the first step, $F(2, 71) = 15.31$, $p < .001$. Adding the interaction term to the model in Step 2 of the regression did not significantly improve the model fit (see Table 3-2).

<u>3.2.3.3. Effect of Synchronous Multisensory Stimulation on Implicit Attitudes to Black People</u>

In order to assess the effect of synchronous multisensory stimulation on implicit attitudes to black people, an analysis of covariance was carried out with participant's score on the post-stimulation SC-IAT as the dependent variable and two between subjects factors; type of VT-stimulation (synchronous/asynchronous) and skin colour of the rubber hand (black/white). Participants' pre-stimulation SC-IAT scores were included as a covariate in order to control for participants' pre-existing attitudes towards black people (as per Huck & Mclean, 1975; Tabachnick & Fidell, 1996).

Table 3-2. Summary of two-step hierarchical regression analysis for variables ownership of the black hand.

Variable	**β**	***p***
Step 1		
Pre-VT SC-IAT	-0.56	.139
Synchrony	1.64	< .001
Step 2		
Pre-VT SC-IAT	-0.17	.195
Synchrony	0.53	< .001
Pre-VT SC-IAT* Synchrony	0.21	.789

Note. r2adjusted = .28 for Step 1; Δr2=0.001 for Step 2 (p > .05),

The ANCOVA found no significant main effects of either type of VT stimulation or skin colour. Importantly, a significant interaction between them was found, $F(1, 143) = 6.14$, $p < .05$, (see Figure 3-3). However, significant interactions were also found between pre VT-stimulation SC-IAT score and synchrony, $F(1,140) = 7.87$, $p < .01$, and between pre VT-stimulation SC-IAT score, skin colour and synchrony, $F(1,140) = 7.08$, $p < .01$. These interactions between the independent variables and the covariate indicated that the homogeneity of regression slopes assumption for ANCOVA had been violated. Therefore, in order to ensure that the results found in the ANCOVA were reliable, the Johnson-Neyman technique recommended by Tabachnick & Fidell (1996) was used to find the regions of significance for the observed effects. It was found that for those participants with a pre-VT stimulation SC-IAT score of above 0.077 (N = 52), indicating more positive attitudes towards black people, there was no significant effect of VT-stimulation on attitudes towards black people while the observed effects reported above were significant for those with a pre-VT stimulation SC-IAT score below 0.077 (N = 96). This indicated that the manipulation was successful in altering attitudes towards black people only if participants originally held relatively negative attitudes towards black people.

In order to further investigate this interaction four separate ANCOVAs were run. The first ANCOVA investigated the effect of VT stimulation on post-stimulation

IAT, with pre-stimulation IAT score as the covariate, only on participants in the black rubber hand conditions and revealed a significant effect of synchrony, F(1, 71) =5.54, $p < .05$, with those who received synchronous stimulation showing more positive adjusted post stimulation IAT scores (*M* = 0.05, *SD* = 0.3) compared to those who received asynchronous stimulation (*M* = -0.11, *SD* = 0.28). The second ANCOVA included only those participants in the white rubber hand conditions and found no significant effect of synchrony, F(1, 71) =1.74, $p > .05$, indicating no significant difference in SC-IAT score between those who received synchronous stimulation (*M* = -0.01, *SD* = 0.37) compared to those who received asynchronous stimulation (*M* = 0.1, *SD* = 0.37).

The third and fourth ANCOVAs used skin colour as the independent variable, post-stimulation IAT score as the dependent variable and pre-stimulation IAT score as the covariate. The first of these was run for those participants who received synchronous VT stimulation and found no significant difference, $F(1, 71)$ =0.35, $p > .05$, between those who saw the white rubber hand (*M* = -0.01, *SD* = 0.3) compared to those who saw the black rubber hand (*M* = 0.05, *SD* = 0.37). The second was run for those participants who received asynchronous VT and revealed a significant effect of skin colour, $F(1, 71)$ =8.5, $p < .01$, with those who had viewed the white hand showing a more positive adjusted post stimulation IAT score (*M* = 0.1, *SD* = 0.37) than those who had viewed the black hand (*M* = -0.11, *SD* = 0.28).

3.2.3.3 Effect of Feeling of Body Ownership on Implicit Attitudes to Black People

In order to investigate the effect of experiencing body ownership over the rubber hand on participants' implicit attitudes to black people a three-step hierarchical linear regression was carried out with post-stimulation SC-IAT score as the dependant variable. Synchrony of VT-stimulation, embodiment index, and pre-stimulation SC-IAT score were entered as predictor variables in the first step, all two-way interaction terms entered in the second step and the three-way interaction entered as a third step. Due to the finding in the previous analysis that a significant difference in post-stimulation SC-IAT between synchronous and asynchronous groups existed only for participants in the black rubber hand group only those who saw the black rubber hand were included in the regression The overall model fit was significant at the first step , F(1, 72)=15.31, *p*<0.001. Synchrony of VT-stimulation was the only significant predictor and adding the interaction terms to the model in Steps 2 and 3 of the regression did not significantly improve the model fit (see Table 3-3).

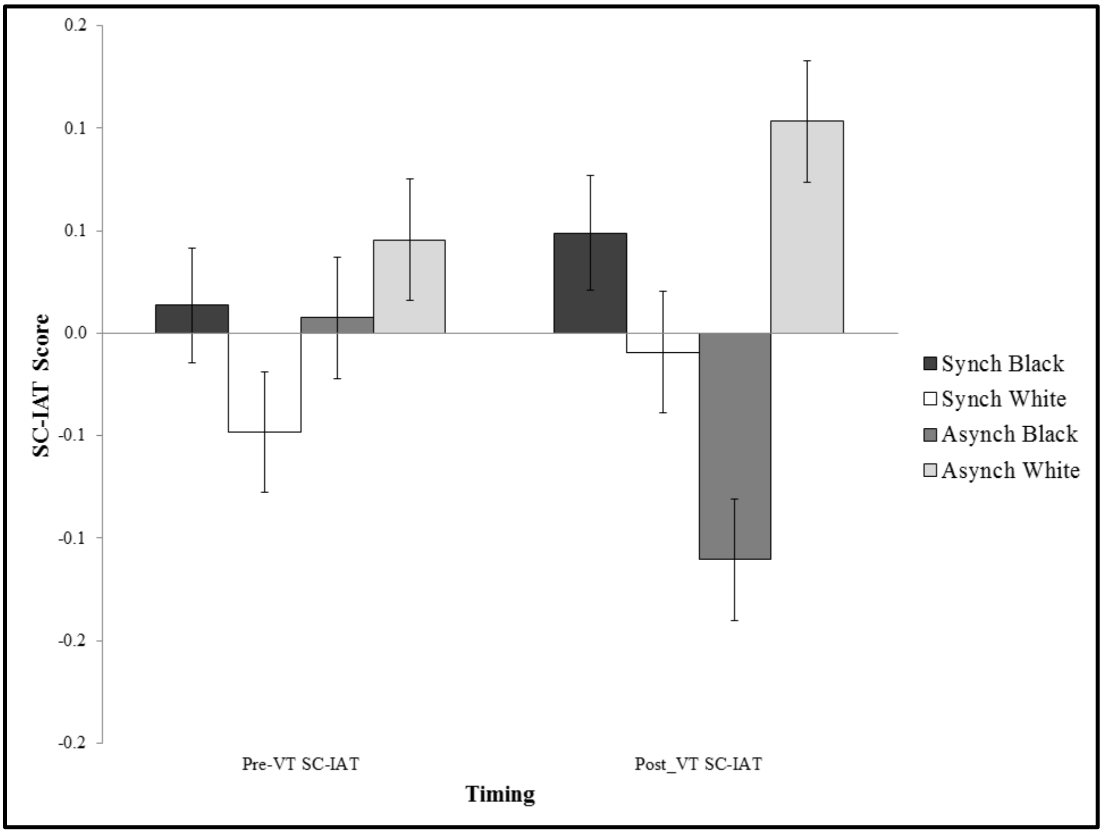

Figure 3-3. Pre- and Post-Stimulation SC-IAT scores grouped by synchrony of VT-stimulation and skin colour of rubber hand. Error bars represent SEM.

3.2.4. Discussion

The present study examined whether using multisensory stimulation to induce feelings of body ownership over the hand of a racial out-group would lead to an increase in positive attitude towards that racial out-group. The study had a number of interesting finding. First, it was found that synchronous multisensory stimulation was successful in eliciting an induced sense of body ownership over a black rubber hand. Second, the strength of the experienced ownership was not predicted by pre-existing levels of implicit attitudes against the out-group, but only by the pattern of stimulation. Third, a significant interaction was found between the synchrony of VT stimulation and the skin colour of the rubber hand. Those participants who received synchronous VT stimulation with the black rubber hand were found to have more positive implicit attitudes towards black people post-stimulation than those who received asynchronous stimulation of the black rubber hand. Fourth, when the effect of pre-VT stimulation attitudes towards black people was taken into account, the effect of VT stimulation was only significant for those participants who had a negative initial attitude towards black people. No significant effects were found for those who had positive initial attitudes towards black people. Finally there was an interesting interaction effect where participants who received asynchronous stimulation over a black hand subsequently showed increased negative attitudes towards black people post-stimulation. I discuss these findings in turn.

The finding that synchronous VT stimulation is capable of inducing ownership over a hand of a different skin colour replicates the previous finding of experiment 2.1 of this thesis and Maister et al. (Maister, Sebanz, et al., 2013). Of note is the fact that the study differed from that of Farmer et al. in finding a main effect of synchrony but not of skin colour on body ownership , whereas experiment 2.1. found a significant difference between ownership scores for the black and white rubber hands. This difference is probably due to the fact that the current study used a between-subject design, while experiment 2.1 employed a within-subject design. Thus, in experiment 2.1 participants were able to directly compare their experience of ownership over the white and black rubber hands, which is likely to have led them to more closely indicate any perceived difference in feeling of ownership between the two conditions. In support of this hypothesis is the fact that Maister et al, who used a similar between-subjects design to that employed in the current study, also failed to find any significant effect of skin colour on introspective judgements of body ownership.

Table 3-3. Summary of three-step hierarchical regression analysis for variables predicting SC-IAT score for participants who experienced ownership of the black hand.

Variable	**β**	***P***
Step 1		
Pre-VT SC-IAT	0	.969

Synchrony	0.41	.003
Embodiment Index	-0.27	.051
Step 2		
Pre-VT SC-IAT	-0.01	.961
Synchrony	0.42	.004
Embodiment Index	-0.24	.187
Pre-VT SC-IAT* Synchrony	0.01	.957
Pre-VT SC-IAT* Embodiment Index	0.01	.937
Embodiment Index * Synchrony	-0.05	.795
Step 3		
Pre-VT SC-IAT	0.08	.681
Synchrony	0.34	.031
Embodiment Index	-0.25	.173
Pre-VT SC-IAT* Synchrony	0.06	.773
Pre-VT SC-IAT* Embodiment Index	0.15	.446
Embodiment Index * Synchrony	0.07	.757
Pre-VT SC-IAT* Embodiment Index * Synchrony	-0.26	.231

Note. $r2_{adjusted}$ = .09 for Step 1; $\Delta r2$ = .001 for Step 2 ($p > .05$), $\Delta r2$ = .019 for Step 3 ($p > .05$). * = $p < .05$.

Second, in common with the previous findings of both Farmer et al. and Maister et al., the study found that pre-stimulation attitudes towards the out-group did not significantly predict feeling of ownership. This result further emphasises that in the case of multisensory-induced changes in body ownership, unlike the cases of empathy for pain (Avenanti et al., 2010)and action observation (Désy & Théoret, 2007; Gutsell & Inzlicht, 2010; Molnar-Szakacs et al., 2007), participant's pre-existing racial bias does not play a significant role in determining the amount of association between self and other. This is an intriguing finding because it suggests that while processes driven by simulation such as empathy and action understanding, are affected by factors such as physical and social similarity between self and other, in the case of shared multisensory stimulation these factors are less relevant, possibly because the direct matching of sensory signals between self and other overrides them.

The third and most important finding of this study was that of a significant interaction effect between the synchrony of VT stimulation and the skin colour of the rubber hand on the post-stimulation implicit racial bias scores. Further analyses demonstrated that this interaction was driven by a significant difference between the synchronous and asynchronous conditions in those who had received VT-stimulation with the black hand but not those who had received it with the white hand. This finding suggests that synchronous VT-stimulation caused an increase in overlap between the black hand and the participant's own hand. This increased overlap was then generalised to the out-group as a whole, leading to a modulation of high-level social attitudes, as evidenced by the change in the post SC-IAT. As such this study presents further evidence in line with that of other recent studies (Banakou et al., 2013; Maister, Sebanz, et al., 2013; Peck et al., 2013) that the plasticity of body-representation constitutes a previously unexplored dimension in social cognition processes.

In contrast to Maister et al.'s (Maister, Sebanz, et al., 2013) study where the change in implicit attitudes was driven by the strength of experienced ownership, the present experiment did not find a significant effect of the experience of body ownership over the rubber hand on attitudes towards black people over and above the effect of synchronous stimulation. It is important to note however that in both Maister et al.'s study and the results reported here there was a strong association between synchronous VT-stimulation and body ownership as measured by participants' responses to RHI questions. This association can be seen by the fact that, defining a mean response to the four RHI questions of greater than zero as constituting an experience of body ownership, in the current study the vast majority of participants (84% in total, 84% for the black hand condition) in the synchronous conditions reported experiencing ownership over the rubber hand. This robust association suggests that, despite the difference in the factor that was found to be most closely linked to changes in attitudes, the results of the current study and that of Maister et al. are largely in agreement as to the power of multisensory stimulation to change participants' attitudes towards an out-group.

Extending the results of Maister et al. (Maister, Sebanz, et al., 2013), we here used the race IAT that presents photographs of black people's faces while in Maister et al.'s study the stimuli used were drawings of faces that had been coloured to give them either light or dark skin. As argued in the introduction, several studies have shown that processing of skin colour and facial features play an important role in judgements of racial typicality and racial categorization independently and in an additive manner. We here show that the induced ownership of a body-part of different skin colour affected the participants' implicit attitudes when processing facial features, in addition to the processing of skin colour as shown in previous studies. Thus, the effects of multisensory-induced changes in body ownership generalise to faces with distinctive black facial features as well as merely a dark skin colour. As highlighted above, a key difference between the current study and that of Maister is the importance of the strength of body ownership as shown in Maister et al. versus the mere fact of a change in body ownership as shown here. It is possible that in the case of the skin colour SC-IAT the strength of the experience of ownership, rather than the fact of whether participants experienced ownership or not, was the key factor in changing implicit attitudes. In the skin-colour variant of the IAT, the stimuli used do not contain prototypical features of black faces. Instead, the focus is on the skin colour, independently of facial characteristics. Skin colour can be thought of as a continuous variable that can also account for physical differences within groups or races (Strom et al., 2012). To the extent that participants experienced the dark-skin rubber hand as their own, and the consequent change that this may have had on their body-image (Longo et al., 2009), it is plausible that the actual strength of the illusion would have a greater impact in processing the skin colour IAT stimuli as more similar to the self. In the current study, by contrast, where photographs of black people's faces were used in the IAT, the more salient nature of the stimuli for race categorization may have meant that the synchrony of stimulation and the consequent change in ownership, but not the strength of this change was the critical factor in determining changes in attitudes.

A novel finding of the present study is that our experimental manipulation seemed to have an effect on those participants whose prior attitude towards black people was negative, while those participants whose attitude towards black people was initially positive were less affected by the manipulation. This finding is important for contextualizing the effects that multisensory-induced changes in self-representations can have on social cognition. While pre-existing levels of implicit biases do not seem to influence whether such multisensory-induced changes can occur for out-groups, we here show that the consequences that such changes have on social cognition are accentuated for people with pre-existing negative biases. Given that IAT seems to be resistant to cognitive strategies or general task demands (Fiedler & Bluemke, 2005; Kim, 2003; Steffens, 2004), the observed changes reinforce the hypothesis that the representation of the self and its relation to others as given to us by multisensory processing is important in maintaining or changing social attitudes.

The final interesting finding of the study was the fact that not only did synchronous VT-stimulation of the black hand lead to increased positive attitudes towards black people, but asynchronous VT-stimulation of the black hand led to increased negative attitudes towards the same out-group, while the reverse pattern was found for the white hand. This finding can be explained by considering recent studies which indicate that asynchronous stimulation is not merely a neutral control condition, but actually seems to lead to an increase in differentiation between one's self and the other. For example, Dolk et al. (Dolk et al., 2011) used the RHI to investigate the role of body ownership in the "Social Simon task" in which participants appear to show an interference effect in their own actions due to co-representing the actions of an interaction partner (Sebanz, Knoblich, & Prinz, 2003). They found that asynchronous VT-stimulation of the hand of an interaction partner led to a stronger interference effect than did synchronous stimulation. It was suggested that the distinct lack of sensory contingency between the participant's hand and the hand of the interaction partner in the asynchronous stimulation emphasized the interaction partner's independent existence, thus making the partner a more salient influence on the representation of the participant's own response. In a similar vein, Rohde, Di Luca and Ernst (2011) found that proprioceptive drift, which is commonly used as a behavioural measure of body ownership, occurred after both synchronous VT-stimulation and pure visual observation of a rubber hand but did not occur after asynchronous VT-stimulation. They therefore concluded that the asynchronous VT-stimulation condition plays a key role in preventing proprioceptive drift by enhancing the feeling of differentiation between the rubber hand and the hand of the participant.

In the present study the power of asynchronous VT-stimulation to increase the amount of differentiation felt between the black rubber hand and the participant's own hand seems likely to be the cause of the higher negative attitude towards black people found in the asynchronous compared to synchronous black hand condition. The present findings suggest that investigating the effects on social attitudes and identifications of one's own sensory and motor experiences being out of synchrony with those of other people could be a fertile area of further research. The fact that asynchronous stimulation of the white hand also led to more positive attitudes towards black people seems at first a more difficult finding to explain. However the fact that participants had completed the SC-IAT shortly before experiencing VT-stimulation may have led to an increased salience for their own racial identity (white). Subsequent vision of the white rubber hand being stroked asynchronously may have led to a feeling of differentiation between the self and the white hand which subsequently manifested itself as a greater positive attitude towards black people when taking the post stimulation SC-IAT.

Recent studies have utilised virtual reality to investigate the effects of embodiment on implicit social attitudes (Banakou et al., 2013; Peck et al., 2013). Peck et al. (2013) demonstrated that experiencing control of a dark skinned avatar led to a decrease in implicit racial bias as measured by the race-IAT. These results are convergent with those reported here, despite several methodological differences. First, Peck et al.'s study involved creating the feeling of body ownership over a whole body rather than just a hand, indicating that the anatomical location of the body part embodied does not make a difference to the influence of embodiment on implicit attitudes. Second, whilst the current study used passive multisensory stimulation to induce the feeling of ownership over a black hand, Peck et al. induced the feeling of ownership over the avatar by creating a sensorimotor experience in which moving one's own body caused the body of the avatar to move in synchrony. The hypothesis that bias towards an out-group can be reduced by synchronisation between one's own movements and those of a member of the out-group has also been supported by the findings of Inzlicht et al. (2012), who have shown that mimicking a member of a racial outgroup can reduce negative attitudes towards that outgroup.

Furthermore, another recent study (Banakou et al., 2013) expanded the investigation of the relationship between embodiment and implicit attitudes by showing that feeling body ownership over an avatar of a child resulted in a change in implicit attitudes towards children as measured by an IAT. Importantly, the IAT used in Banakou et al. (2013) showed an increase in the association between the self-concept and childlike facial features, indicating that the change in implicit associations seen in that study was due to changes in self-representation. This finding suggests the changes in implicit attitudes towards a racial out-group found in the current study may also be mediated by changes in self-representation, whereby the self is seen as more similar to members of a racial out-group.

In conclusion, the present study demonstrates that multisensory stimulation over a hand with the skin colour of a racial out-group can have an effect on high level cognitive attitudes towards that group. Synchronous stimulation of a black rubber hand led to a significantly more positive attitude towards black people compared to asynchronous stimulation. This finding adds to previous research by demonstrating that by manipulating, through multisensory stimulation, the perceived overlap between one's own body and a hand of a different racial group it is possible to change social attitudes towards that racial group. Moreover, the current experiment also expands on previous results showing links between multisensory stimulation and higher level cognition (Banakou et al., 2013; Maister, Sebanz, et al., 2013; Peck et al., 2013) by suggesting that asynchronous stimulation can influence the perceived closeness between self and other by emphasising, contrary to the effects of synchronous stimulation, the dissimilarity between one's own body and that of another.

3.3. Experiment 3.2

3.3.1. Introduction

The second experiment in this chapter sought to explore the effect of multisensory induced changes in body ownership on a more sensorimotor based measure of racial bias, sensorimotor empathy to pain.

This measure of sensorimotor empathy to pain was first identified by Avenanti et al. (2005) who demonstrated, using TMS, that observing a painful stimuli, e.g. a needle, being applied to the hand of a model, consistently led to a reduction in corticospinal (CS) excitability in the hand muscle relative to the response to non-painful stimuli touching the hand. They further demonstrated that this effect was specific to the body part being observed, as they found no reduction in the CS excitability of hand muscles when participants observed either a foot or a non-body object receiving painful stimuli. Further studies by Avenanti and colleagues have expanded on these findings by demonstrating that this sensrorimotor empathy is specific to the lateralization of the observed hand (Avenanti, Minio-Paluello, Sforza, & Aglioti, 2009) and is correlated with participants' perceptions of the intensity of pain (Avenanti, Paluello, Bufalari, & Aglioti, 2006). Sensorimotor empathy for pain appears to be stimuli driven, as it is independent of the instructions given to participants (Avenanti et al., 2006) and may be the result of modulation of motor responses by activity in the somatosensory cortices (Bufalari, Aprile, Avenanti, Di Russo, & Aglioti, 2007).

There is also evidence that this sensorimotor measure of empathy is related to more cognitive measures of empathy. Avenanti and colleagues (Avenanti, Minio-Paluello, Bufalari, & Aglioti, 2009) found that MEP suppression was greater in subjects with high trait-cognitive empathy and lower in subjects with high trait-personal distress and in those with high aversion for the stimuli being observed. They further demonstrated that no decrease in MEP size is found in autistic participants (Minio-Paluello, Baron-Cohen, Avenanti, Walsh, & Aglioti, 2009), further suggesting a link between this low level form of empathy and more congitive forms of social empathy that are known to be impaired in autistic people (Baron-Cohen & Wheelwright, 2004; Schulte-Rüther et al., 2011).

The experiment reported here is motivated by the finding of a relationship between racial bias and sensorimotor empathy for pain by Avenanti et al. (Avenanti et al., 2010). As mentioned in the introduction to this chapter this finding is one of a number of studies demonstrating that shared representations of pain are modulated by whether the person observed is a member of a racial in-group or out-group. Of specific interest for the current experiment was the finding by Avenanti et al. that participants' implicit racial bias was related to their bias in sensorimotor empathy, with those participants with the highest implicit bias showing the greatest difference between in-group and out-group.

Based on the findings reported in Maister et al. (Maister, Sebanz, et al., 2013) and in experiments 2.1 and 3.1 of the current thesis, which demonstrated the power of multisensory stimulation induced feelings of ownership over the hand of a racial out-group to reduced implicit bias towards that out-group the study reported here investigated whether inducing ownership of an out-group hand would lead to a significant change in sensorimotor empathy for the out-group hand. It was predicted that prior to VT-stimulation participants would show sensorimotor bias with a lower CS activation to the observation of pain stimuli compared to touch stimuli for the white hand than for the black hand. It was also predicted that this difference would significantly correlate with participants' implicit racial bias as measured prior to multisensory stimulation. It was then predicted that subsequent to synchronous, but not asynchronous, multisensory stimulation this effect of racial bias would be reduced or absent.

3.3.2. Methods

3.3.2.1. Design

The study used a within participants design with three factors (see Table 3-4). The first factor was the synchrony of visual-tactile stimulation (synchronous, asynchronous); the second was the skin colour of the observed hand (black, white) and the third was the type of stimuli that was applied to the observed hand. The dependent variables were MEP size post-VT stimulation and participants' responses to the same fur statements used in experiment 3.1. In order to have a baseline measure of participants' autonomic reactivity towards painful stimuli being applied to black and white hands, sensorimotor empathy was measured prior to VT-stimulation for both the synchronous and the asynchronous conditions. In order to investigate the role of implicit racial bias on participants' pre and post VT-stimulation sensorimotor empathy participants also completed the race IAT prior to any TMS being applied.

Table 3-4 Design of Experiment 3.2.

Condition	Synchrony of V-T stimulation	Skin colour of the observed hand	Type of stimuli applied to hand
1	Synchronous	Black	Pain
2	Synchronous	Black	Touch
3	Synchronous	White	Pain
4	Synchronous	White	Touch
5	Asynchronous	Black	Pain
6	Asynchronous	Black	Touch
7	Asynchronous	White	Pain
8	Asynchronous	White	Touch

3.3.2.2. Procedure

Participants attended 2 experimental sessions. In the first session they first completed a computer administered version of the race-IAT. The associations between stimuli and response key and the order of associations (i.e. positive words and white faces or positive words and black faces) were counterbalanced across participants (Greenwald et al., 1998, 2003). The IAT was performed using Presentation® software (Version 16.03, www.neurobs.com). The data from the IATs were analysed using the improved IAT scoring algorithm recommended by Greenwald et al. (2003) and the resultant scores were adjusted for counterbalancing so that those with greater racial bias had higher scores and those with less racial bias had lower scores.

After completing the race IAT participants then began the first TMS session. Participants were placed in the experimental setup (see Figure 3-4). Ag/AgCl electrodes were placed over the left FDI (in the region of the index finger) muscles in a belly-tendon montage and the participant's left hand hand was then placed inside a box and hidden from view. EMG signals were sampled at 2kHz and band-pass filtered (10Hz-50Hz, AD instruments). Monophasic single pulses of TMS were generated by a Magstim rapid2 stimulator and delivered through a 70-mm figure-of-eight coil. The position of the coil was adjusted to find the optimal scalp position (OSP) for the left hand FDI muscle. The stimulation intensity was set (separately for each of the four blocks in each session) at 110% of the resting motor threshold, which was defined as defined as the minimal intensity eliciting MEPs with a peak-to-peak amplitude of greater than 1mV in over 50% of 10 test trials. Mean stimulation intensity was 67% (51–87%) of maximum stimulator output. The absence of voluntary contraction before the TMS pulse was continuously verified visually.

Following the identification of the optimal scalp position and the stimulation intensity participants were instructed to watch video-clips of painful (syringe) and non-painful (cotton-bud) stimuli being applied to black and white hands (see figure 3-5). Nine of each of the four types of video were presented to participants as part of a 36-trial block. The videos were presented on a 31cm x 18cm screen at a distance of 80 cm from the participant using Presentation (Version 16.03, www.neurobs.com). The videos were presented in a randomised order and the experimenter applying the TMS was blind to the nature of the video being displayed in each trial. The duration of each video was 1,800 msec and in each trial, a magnetic pulse was randomly delivered between 200 and 600 msec before the end of the video to avoid any priming effects that could affect MEP size. A black screen was shown for 8.2 sec in the intertrial intervals. The choice of a long intertrial interval was based on a study demonstrating that TMS delivered for 1 h at 0.1 Hz frequency did not induce any change in excitability (R. Chen et al., 1997). Following completion of the first pre-stimulation block there was a resting period of two minutes, during which a blank screen was presented to the participant. After this resting period the OSP was again located and participants received a second 36-trials block of TMS.

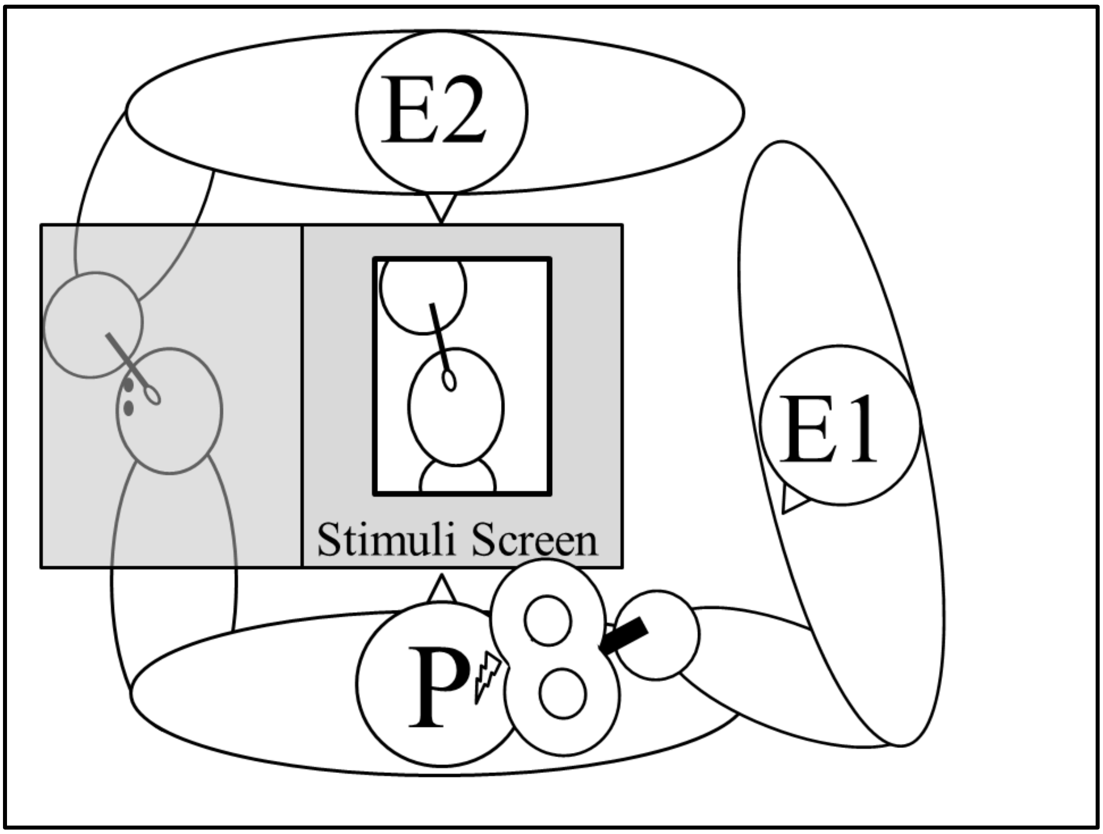

Figure 3-4: Experimental setup for experiment 3.2. Note that, although for the sake of convenience, this image displays both VT-stimulation and TMS being administered. During the experiment participants either received VT-stimulation in time with the hand in the video or received TMS while observing hands receiving painful or tactile stimuli.

At the end of the second block of TMS participants had their left arm covered with a sheet in order to obscure their view of their arm extending into the box. They then received two minutes of tactile stimulation from a paintbrush on the middle finger of their unseen left hand at a frequency of 1 Hz whilst viewing a video of a black hand being stroked with an identical paintbrush either synchronously or asynchronously with their felt touch.

Following the two minutes of VT stimulation the participants hand was uncovered and the OSP was again located. Participants then received a third block of 36-trials of

TMS. They subsequently received another 2 minutes of TMS using the same pattern of synchrony as used in the previous 2 minutes. Following this second period of VT-stimulation, the OSP was located for a final time and participants received a fourth and final block of TMS. Finally participants completed the four item Ownership questionnaire which indicated the extent to which they experienced illusory ownership over the rubber hand (see Figure 3-5). Participants then returned for a second session of TMS stimulation no more than 12 days after their first session. In this second session participants did not complete an IAT but received four blocks of TMS with the same basic structure as in the first session. The only difference between sessions was that participants received the opposite pattern of VT-stimulation from that which had been delivered in the previous session. The order of VT-stimulation across the two sessions was counterbalanced between participants.

3.3.2.3. Analysis of TMS data

Neurophysiological data were processed off-line. Trials with EMG activity prior to TMS pulse or where MEP amplitudes could not be clearly distinguished from background EMG (< 0.05 mV) were discarded from the analysis (2.4% of trials) (see Figure 3-6 for an example). Mean MEP amplitude values for each of the eight blocks were measured peak-to-peak (in mV). The data was then normalised separately for each of the four blocks in both the synchronous and asynchronous conditions (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Papeo, Vallesi, Isaja, & Rumiati, 2009). The z-scored means of the two pre-VT stimulation blocks for each condition were averaged together as were the z-scored means of the two post-VT block for each condition resulting in sixteen values for each participant (time (pre VT, post VT) X skin colour (black, white) X type of stimuli (pain, touch) X synchrony (synchronous, asynchronous)

3.3.2.3. Participants

14 participants (mean age ± *SD*: 22 ± 3.45, 6 male) gave their informed consent to participate and were paid for their participation. All participants self-identified as white. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

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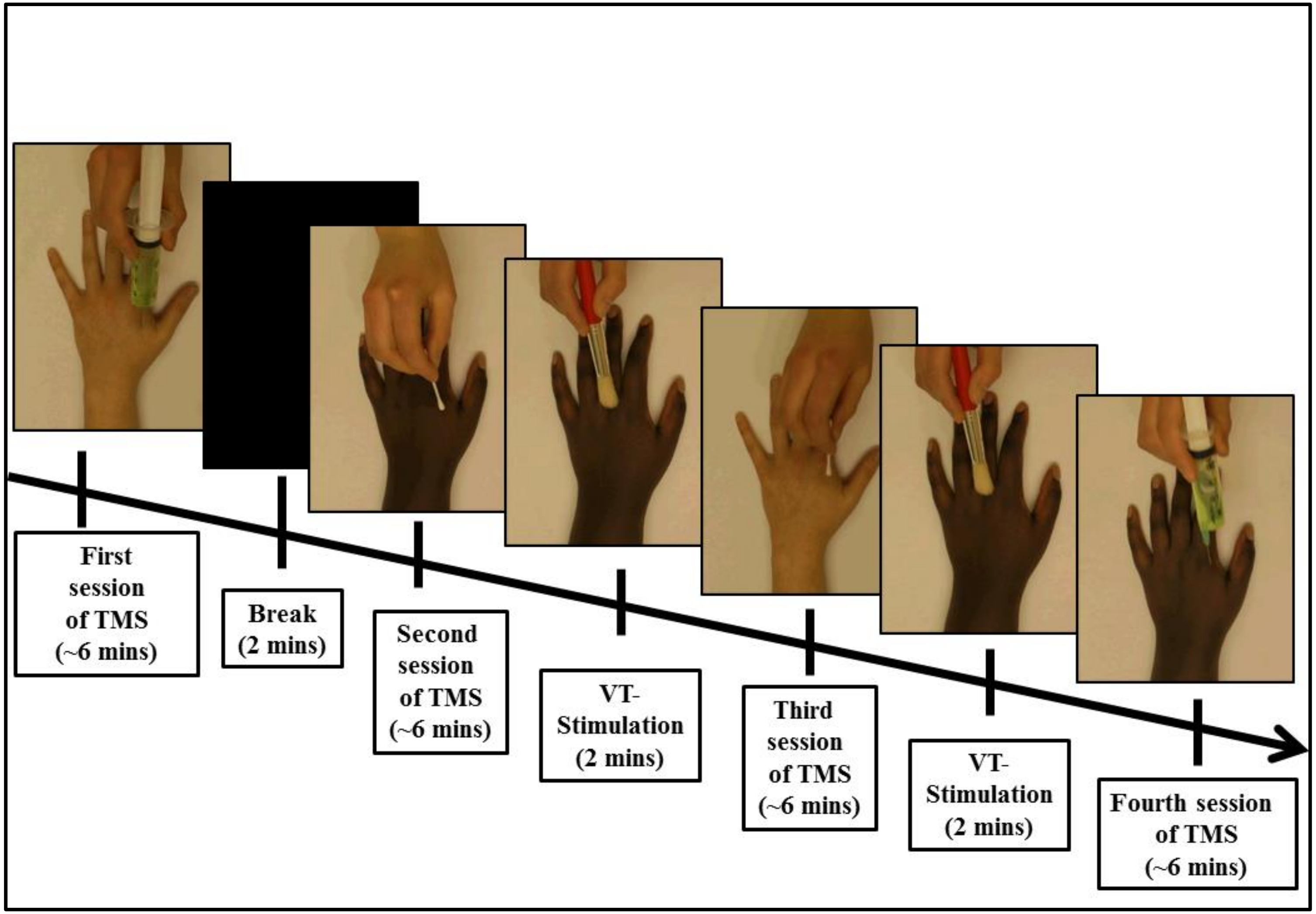

Figure 3-5. Structure of experiment 3.2.

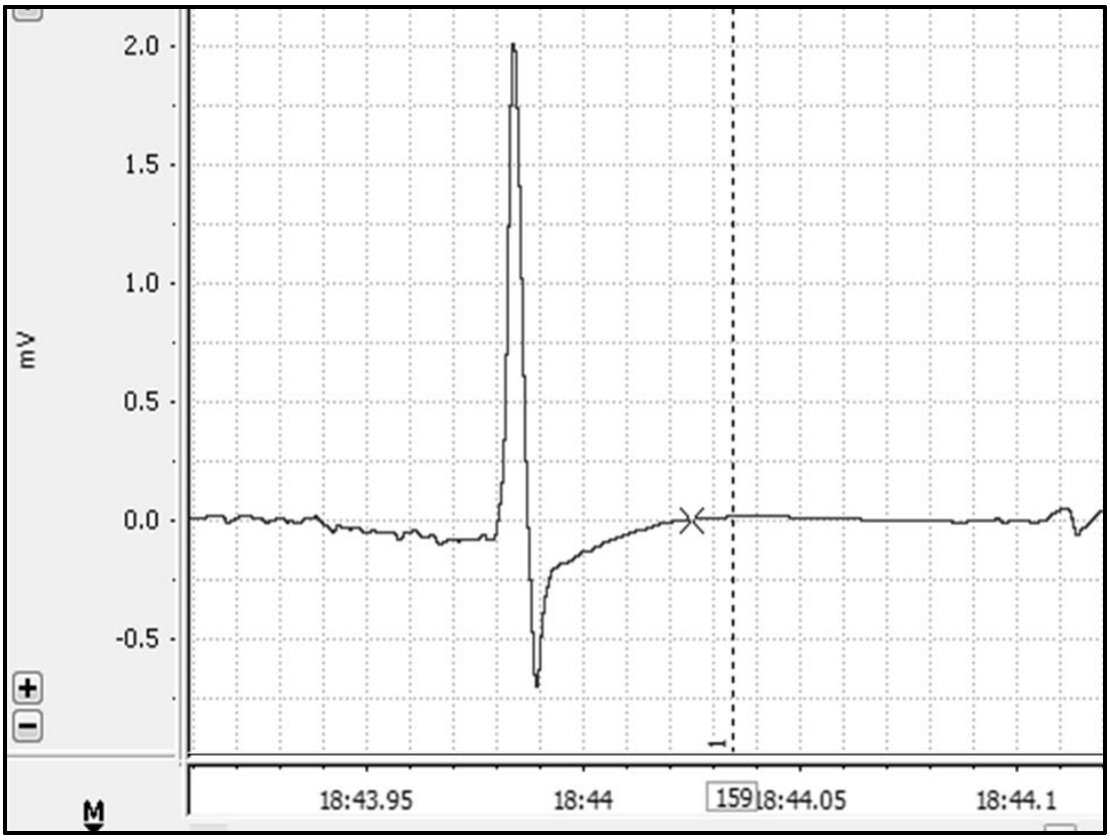

Figure 3-6. Example of MEP.

3.3.2. Results

3.3.3.1. Pre VT-stimulation Corticospinal Activation to Observation of Ingroup and Outgroup Pain

In order to investigate whether the current study replicated Avenanti et al.'s (2010) finding of an effect of racial group on sensorimotor empathy for pain a 2x2x2 ANCOVA was carried out, with pre VT-stimulation z-scored MEP size as the dependent variable and synchrony (synchronous, asynchronous), type of stimuli (pain, touch) and skin colour (white, black) as the independent variables (see figure 3-6). A finding of an interaction between colour and stimuli type would have indicated a replication of Avenanti et al. (2010). A significant main effect of type of stimuli was found $F(1, 36.5) = 9.99$, $p < .05$, because overall touch stimuli (M = -0.17, SD = 0.63) elicited smaller MEPs than did pain stimuli (M = 0.17 SD = 0.63). No other significant main effects were found and there were no significant interactions.

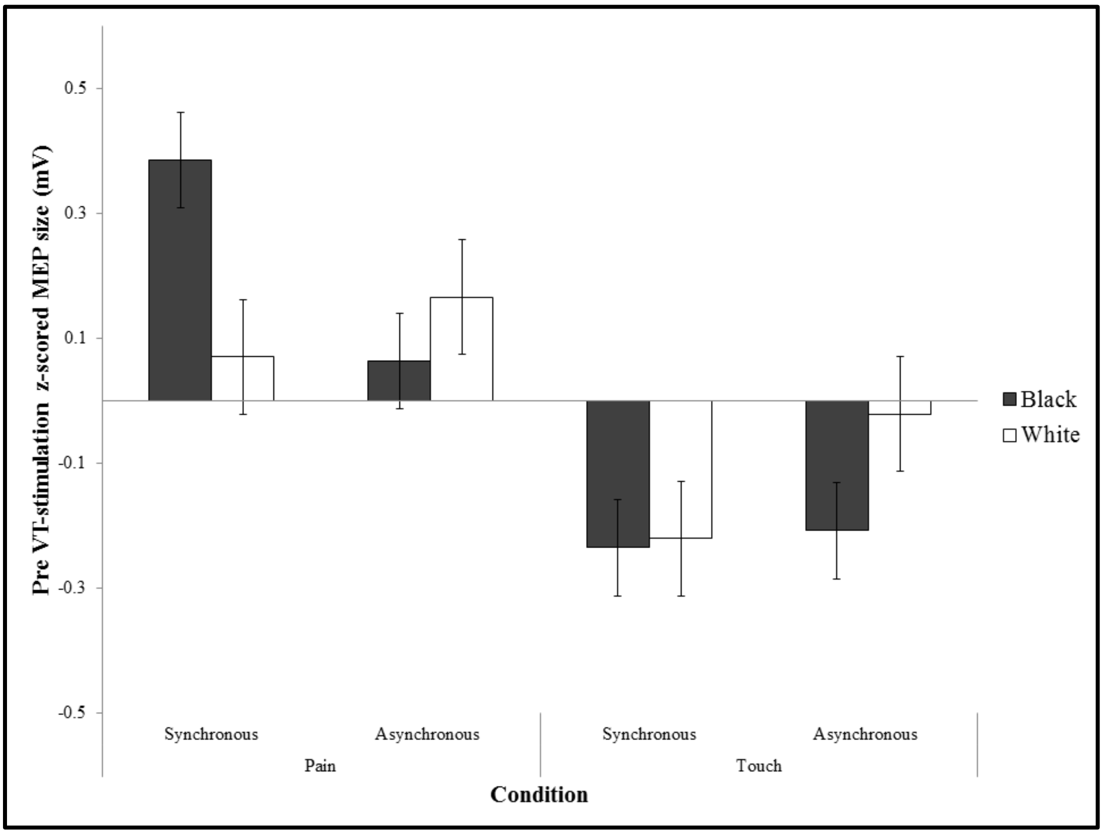

Figure 3-7: Pre VT-stimulation z-scored MEP size in response to the different experimental videos. Error bars represent SEM.

3.3.3.2. Introspective Rating of the RHI

In order to investigate whether synchronous VT-stimulation had indeed led to a greater experience of body ownership paired sample t-tests were carried out between participants' ratings for each the 4 RHI questions in the synchronous and asynchronous conditions (see Figure 3-7).

The t-tests revealed a significant difference between the synchronous and asynchronous conditions at the two tailed level for question two, "It seemed like the touch I felt was caused by the paintbrush touching the rubber hand", $t(13) = 5.08$, $p < .001$, because synchronous stimulation ($M = 1.57$, $SD = 1.28$) led to higher responses than asynchronous stimulation ($M = -1.07$, $SD = 1.86$). There was also a significant effect of synchrony at the one tailed level for question one, "It seemed like I was looking directly at my own hand, rather than at a rubber hand", $t(13) = 1.79$, $p < .05$, because synchronous stimulation ($M = -0.36$, $SD = 2.02$) led to higher responses than asynchronous stimulation (*M* = -1.29, *SD* = 1.73) and question four, "It seemed like the rubber hand began to resemble my real hand", *t(13)* = 1.81, *p* < .05, because synchronous stimulation (*M* = -0.5, *SD* = 2.28) led to higher responses than asynchronous stimulation (*M* = -1.29, *SD* = 1.77). No significant difference was found for between the synchronous (*M* = -0.5, *SD* = 2.24) and asynchronous conditions (*M* = -1.5, *SD* = 1.83) for question three, "It seemed like the rubber hand was my hand", *t(13)* = 1.81, *p* < .05. Given these generally low scores for synchrony, the responses for the four questions in were averaged together to form an embodiment index and a further t-test was run comparing overall embodiment for the synchronous (*M* = 0.54, *SD* = 0.46) compared to asynchronous (*M* = 0.54, *SD* = 0.46) conditions. A significant difference was found at the two tailed level, *t(13)* = 2.92, *p* < .05, indicating that the manipulation of synchrony was successful in eliciting a greater sense of embodiment over the black hand in the synchronous compared to asynchronous condition.

3.3.3.3. Relationship Between Pre VT-Stimulation Sensorimotor Racial Bias and Implicit Racial Bias

In order to investigate whether the current study successfully replicated Avenanti's finding of a significant relationship between participants' IAT scores and their sensorimotor empathy for pain, the z-scored pre VT-stimulation MEPs from the observation of touch stimuli were subtracted from those for pain stimuli for the black and white hand conditions respectively and the resultant value for the black hand was subtracted from that for the white hand in order to give a measure of sensorimotor bias. This was done separately for the synchronous and asynchronous conditions. In order to ensure there was no significant difference between the synchronous and asynchronous conditions, a paired sample t-test was carried out with sensorimotor bias as the dependent variable and synchrony as the independent variable. No significant difference was found between the synchronous (*M* = 0.29, *SD* = 0.99) and asynchronous (*M* = 0.19, *SD* = 1.27) conditions, *t(13)* = 0.39, *p* > .05 and so the mean of these two values was calculated and used as a dependent variable in a linear regression with IAT score as the predictor variable (see Table 3-5). The overall model fit was not significant, F(1, 12)=2.14, *p* > .05, r2adjusted = .08, indicating that sensorimotor bias was not predicted by implicit racial bias.

3.3.3.4. Effect of VT-stimulation on Corticospinal Activation to Observation of In-group and Out-group Pain

In order to investigate how synchronous and asynchronous VT-stimulation affected corticospinal activation during the observation of pain and touch stimuli to hands from a racial ingroup and a racial outgroup a 2x2x2 ANCOVA was carried out with participant's post VT-stimulation z-scored MEP size as the dependent variable, pre VT-stimulation z-scored MEP size as the covariate, synchrony (synchronous, asynchronous), type of stimuli (pain, touch) and skin colour (white, black) as the independent variables (see Figure 3-9).

No significant main effects were found, but there was a significant interaction between colour and synchrony, $F(1, 90.32) = 3.93$, $p = .05$, because, accounting for pre-VT stimulation z-scored MEPs size synchronous stimulation led to lower z-scored MEPs to pain and touch stimuli applied to the black hand (Estimated marginal mean (*EMM*) = -0.08, standard error (*SE*) = 0.11) compared to the white hand (*EMM* = -0.02, *SE* = 0.11) while asynchronous stimulation led to higher z-scored MEPs to pain and touch stimuli applied to the black hand (*EMM* = 0.21, *SE* = 0.12) compared to the white hand (*EMM* = -0.19, *SE* = 0.13). There was also a significant interaction between type of stimulation and synchrony, $F(1, 90.32) = 4.66$, $p > .05$, because synchronous stimulation led to higher z-scored MEPs for the observation of painful stimuli (*EMM* = 1.18, *SE* = 0.1) compared to touch stimuli (*EMM* = -0.28, *SE* = 0.12) while asynchronous stimulation led to lower z-scored MEPs for the observation of painful stimuli (*EMM* = -0.02, *SE* = 0.12) compared to touch stimuli (*EMM* = 0.35, *SE* = 0.14). No other interactions were found to be significant. These findings suggest that synchronous VT-stimulation over the hand of a racial outgroup led to increased inhibition in CS excitability when watching painful and tactile stimuli touching a hand from that racial group and also that synchronous VT-stimulation leads to increased CS excitability when watching painful stimuli compared to tactile stimuli.

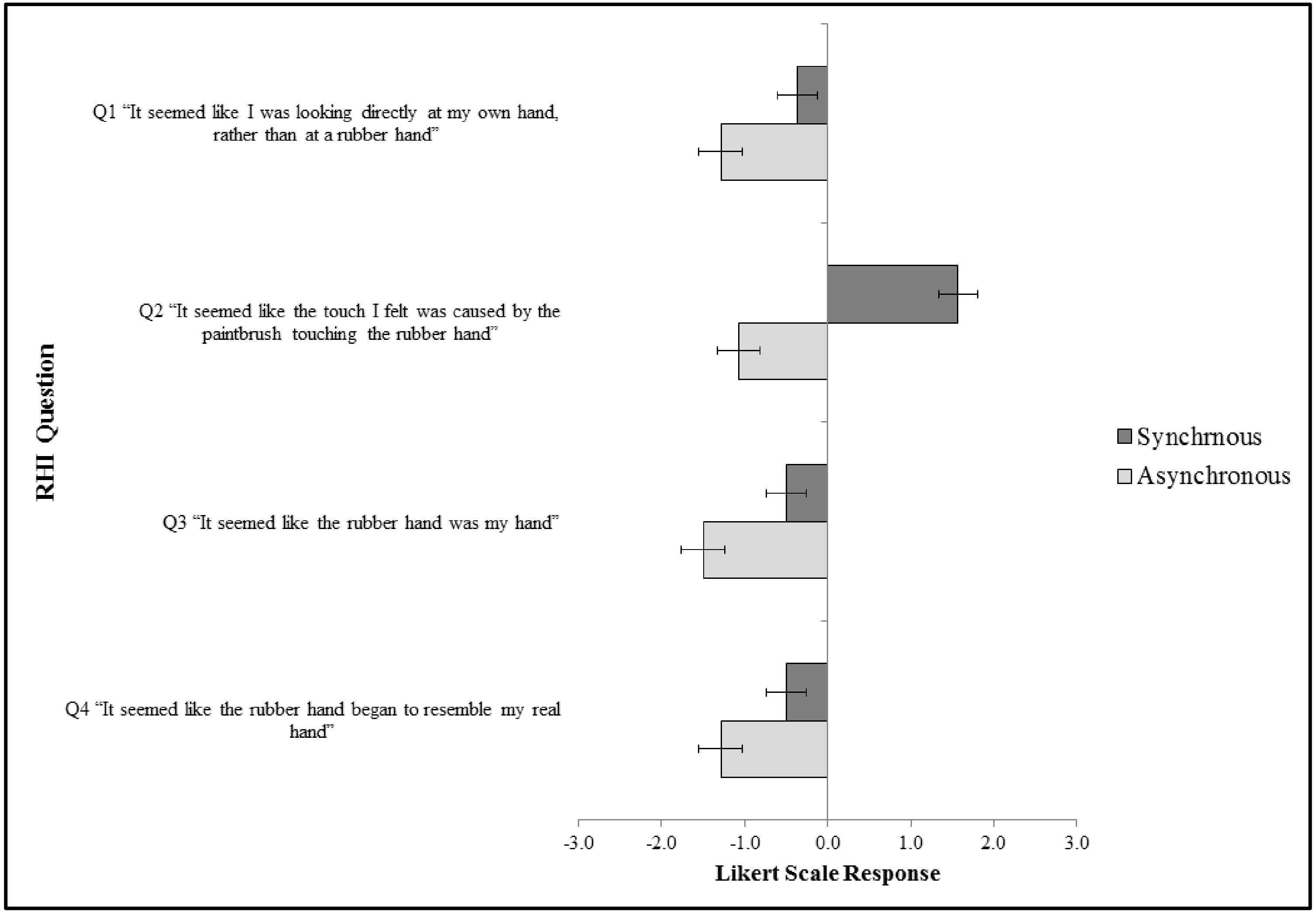

Figure 3-8: Responses to introspective questions following synchronous and asynchronous VT-stimulation. Error bars represent SEM

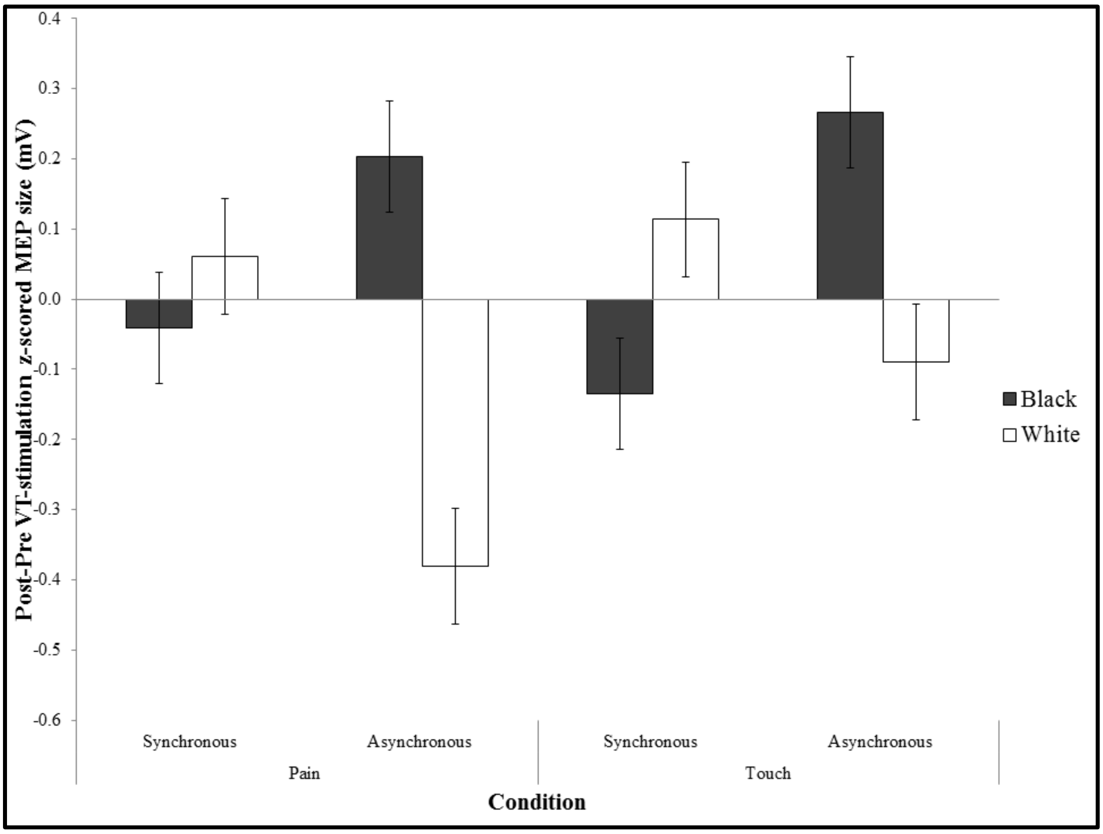

Figure 3-9: Change between Pre and Post VT-stimulation z-scored MEP size in response to the different experimental videos. Error bars represent SEM

3.3.4. Discussion

The current experiment sought to examine whether multisensory induced body ownership over the hand of a racial out-group would lead to a reduction in sensorimotor bias for empathy towards that out-group. However, since the results of the study failed to find an effect of sensorimotor bias prior to the administration of VT-stimulation it is not possible to draw any conclusion about the effects of VT-stimulation on sensorimotor bias. The study did, however find evidence that synchronous multisensory stimulation could have an effect on MEP response to the observation of somatic stimuli being delivered to the hand of a racial out-group regardless of whether such stimuli was nociceptive or tactile and also that synchronous VT-stimulation led to an increase in MEP response to painful stimuli compared to tactile stimuli. I will now briefly discuss possible reasons for the failure to replicate the findings of Avenanti and colleagues (Avenanti et al., 2010) before moving to discuss possible interpretations of the studies positive findings.

There are a number of possible reasons why the current study failed to replicate the findings of Avenanti et al. (2010). First it is notable that the IAT scores for the participants in the current study were generally low. In fact the mean score was negative (*M* = -0.22, *SD* = 1.03) showing that overall participants showed a slight bias in favour of black faces as opposed to white faces and only half of the participants showing a bias in favour of white faces. In contrast the IAT scores in Avenanti et al.'s study showed that both white and black participants had an implicit bias towards their own racial group. Given the relationship between racial bias and sensorimotor empathy found by Avenanti and colleagues the lack of a strong implicit bias in the participants in the current study might explain the failure to find an effect of skin colour on sensorimotor empathy.

However, the current study not only failed to find a significant suppression effect for pain stimuli on pre VT-stimulation z-scored MEP size, which would have indicated an effect of sensorimotor empathy for pain in general, but in fact found the opposite effect, greater suppression for touch stimuli than pain stimuli. Therefore it seems that the low implicit racial bias of the participants is unlikely to be the sole cause of the failure to replicate the findings of Avenanti and colleagues previous studies(Avenanti et al., 2005, 2006, 2010; Avenanti, Minio-Paluello, Bufalari, et al., 2009; Avenanti, Minio-Paluello, Sforza, et al., 2009; Minio-Paluello et al., 2009). One possible explanation for this reversal in effects is a difference in the way that the stimuli were presented. While in Avenanti et al.'s studies the different conditions were presented in separate blocks, in the current study the order of presentation for the different stimuli was randomised so that in each of the four blocks participants saw nine videos from each condition. This randomising of conditions enabled a better control of expectancy effects and also made it possible to ensure that the experimenter administering the TMS was blind to the condition being presented. Ensuring that the experimenter is blind to the condition being presented is an important factor in TMS studies as the susceptibility of MEP size to even very slight movements of the coil position makes TMS studies particularly at risk of unconscious modulation by the experimenter. It is possible therefore that the failure to replicate the findings of Avenanti et al. (2010) were due to these greater controls on the experiment.

Regardless however of the failure to replicate the findings of Avenanti et al. (2010) the study did produce some positive findings relating to the effect of multisensory induced changes in body ownership. Of particular interest is the interaction between skin colour of the observed hand and synchrony of VT-stimulation. Relative to asynchronous VT-stimulation, synchronous VT-stimulation over the black hand led to both higher ratings of embodiment and decreased CS activation in response to the observation of objects touching the black hand, regardless of whether those objects produced nociceptive or tactile sensations. There has been little research investigating the effect of the observation of touch on MEP size which makes it difficult to draw any solid conclusions from this finding. It is however important to note that although in Avenanti et al. motor empathy was calculated by subtracting MEP size in response to touch from that of pain, previous studies investigating the effects of observing pain on MEP size have used the observation fixation crosses (Avenanti, Minio-Paluello, Bufalari, et al., 2009) or painful stimuli applied to other body parts as a baseline measure (Avenanti et al., 2005, 2006). In the current study it was possible to adjust MEPs in the post VT-stimulation sessions taking into account participants' MEPs in the pre stimulation sessions. It is arguable therefore that the current experiments finding of lower MEPs during the observation of painful stimuli being applied to the black hand after synchronous, but not asynchronous VT-stimulation can still be considered evidence for an increase in sensorimotor empathy. despite the fact that a similar decrease was present during the observation of touch being delivered to the black hand.

Another possible interpretation is suggested by a study by Schütz-Bosbach, Mancini, Aglioti and Haggard (2006) who demonstrated that experiencing synchronous VT-stimulation over a hand and then observing that hand performing actions led to lower MEPs than did receiving asynchronous stimulation. This finding was seen as a sign that reduced MEPs at least to motor stimuli are a marker of self attribution. It is possible therefore that the findings in the current study may be explained by the existence of a general reduction in MEP size following the experience of body ownership over an observed hand.

The study also found that overall synchronous VT-stimulation led to increased CS excitability in response to painful as opposed to tactile stimuli. Such a finding would seem to suggest that VT-stimulation led to lower feelings of sensorimotor empathy than did asynchronous stimulation. However examination of the difference between pre and post VT-stimulation MEPs suggests that this interaction is largely due to reduced CS response to pain in the white hand and increased response in the black hand following asynchronous stimulation. This finding further supports the hypothesis put forward in the discussion of experiment 3.1, that asynchronous stimulation may act as a cue to the distinction between self and other. In this case experiencing a cue for dis-ownership over the black hand may have led to increased identification with the white hand as a member of the racial ingroup thus increasing CS inhibition when observing that hand in pain while increasing motor excitation during the observation of painful stimuli being applied to the black hand.

One key limitation of the current experiment is the generally low ownership scores after synchronous VT-stimulation. This finding may be due to the fact that throughout the study participants would have been aware of the tactile stimulation coming from the electrodes attached to their own hand. Since the hand that they received VT-stimulation with visibly did not have any electrodes attached this may have led to a conflict between the tactile stimulation received during VT-stimulation and the tactile stimulation participants were experiencing on their own hand. A second possible cause of the low ownership scores in the current study may be that as in experiment 2.2 the hand that received VT-stimulation was presented on a video screen rather than being physically present. It is notable that only half of the participants in this study experienced embodiment over the hand which matches the findings for the black hand in experiment 2.2, and offers support for the possibility expressed in the discussion of chapter 2 that the combination of a hand of a different skin colour and the presentation of that hand on a video increases the feeling that the hand is less “real” and thus leads to lower introspective ratings of embodiment.

A second key limitation of the current study is that participants only experienced VT-stimulation over a black but not over a white hand. This makes it impossible to disentangle whether the effects of skin colour seen here are due to participants experiencing ownership specifically over a hand from a different racial group, or whether they are primarily caused by the increased association between self and other that experiencing ownership over a hand of any skin colour causes. In order to address this issue a further study is needed which compares the effect of experiencing ownership over a white hand on CS activation during the observation of painful and tactile stimuli.

In conclusion the current study while failing to replicate the findings of Avenanti et al. (2010) did find some evidence that experiencing ownership over the hand of a racial out-group can lead to alterations in how sensorimotor systems process the application of painful and tactile stimuli to that hand. In so far as these responses can be considered a form of empathic response the current study demonstrates that the experience of body ownership over the hand of a racial out-group can lead to a modulation in sensorimotor empathy towards that racial group.

3.4. General Discussion

Given the disparate findings of the two studies in this chapter I will not spend a large amount of time discussing them together. However I will recap here two key similarities between the experiments reported in this chapter, namely the power of synchronous VT-stimulation to alter cognitive and sensorimotor representations of the relationship between self and other and the effect of asynchronous VT-stimulation in increasing the perceived distance between self and other.

In both the experiments reported here synchronous VT-stimulation led to greater feelings of body ownership over the hand of a different skin colour to that of the participant and also resulted in changes in participants' responses to stimuli from a racial group with that skin colour (in this case black people). This finding suggests that experiencing ownership over a hand that is clearly from a different social group increases one's self identification with that social group which therefore leads to changes in how participants conceptualise that group in line with the strong links between bodily and social representations of the self predicted by the embodied cognition paradigm. The exact nature of this relationship is currently unclear but will be further considered in the general discussion of this thesis in chapter 7.

The second interesting finding shared by both studies is that, as well as synchronous VT-stimulation leading to an increase in association between self and other, asynchronous VT-stimulation also appears to have an effect on how people perceive the relationship between self and other. In experiment 3.1 asynchronous stimulation of a black rubber hand led to decreased implicit attitudes towards black people while asynchronous stimulation of a white rubber hand led to increased implicit attitudes towards black people. In experiment 3.2 synchronous stimulation of the black rubber hand led to an increase in CS activity when observing painful stimuli being applied to the black hand but a decrease in CS activation when observing painful stimuli being applied to the white. If reduced CS activation to painful stimuli is indeed a sign of increased sensorimotor empathy then the finding of increased CS activity to the black hand after asynchronous stimulation implies that asynchronous stimulation of the black hand reduced sensorimotor empathy for the observation of pain in the out-group hand, while correspondingly increasing it for the in-group hand.

These findings suggest that asynchronous VT-stimulation may play an important role in establishing the separation of self and other, a view also put forwards by Dolk et al. (2011) and Rohde et al. (2011). It is interesting to note, given the link discussed in the introduction between synchronous movement and social cognition, that cases of natural asynchronous movement also occur most notably in social control situations that involve dominance and submission (R. Cook, Dickinson, & Heyes, 2012). In such cases expansive gestures by one interaction partner are contrasted with contraction movements by the other, and vice versa (Tiedens & Fragale, 2003). If asynchronous stimulation does indeed increase the distinction between self and other then it is possible that part of the power of these displays of dominance/submission is that they reduce any sensorimotor overlap between self and other, establishing instead a sense of the other as occupying a distinctly different role in the social hierarchy.

In conclusion, the experiments reported in this chapter demonstrate the power of multisensory stimulation over a hand with the skin colour of a racial outgroup to alter attitudes towards that group, whether measured by implicit attitudes or by sensorimotor empathy for pain. Interestingly while synchronous VT-stimulation led to increased positive responses towards the outgroup, presumably due to closer association between self and other, asynchronous stimulation led to increased negative reactions suggesting that asynchronous multisensory stimulation may act to increase the difference between self and other.

Chapter 4. A Brush with The Imagination: Age, Body Ownership and Motor Imagery.

"As in this body, there are for the embodied one childhood, youth, old age, even so is there the taking on of another body."

Bagavard Gītā, (Telang, 1882)

4.1. Introduction

The studies detailed in the previous two chapters have focused on the power of multisensory stimulation to induce feelings of body ownership over a hand belonging to a different racial group and the effects of such multisensory stimulation in altering both cognitive and sensorimotor measures of racial out-group. The two studies described in the current chapter aimed to investigate whether multisensory stimulation using stimuli that are related to other social categories can have effects on self-representations. To investigate this question the studies moved from using multisensory stimulation to induce the RHI over a hand with a different skin colour to that of the participant to inducing the RHI over a hand of a different age from that of the participant, in this case an elderly hand.

Researchers in the field of impression formation have identified age, along with race, gender and social class, as one of the key primary or primitive categories which is initially activated on the first encounter with an individual. These categories are processed with speed and ease, and are difficult to suppress attention towards even in situations where the information is irrelevant (Brewer, Dull, & Lui, 1981; Bruner, 1957; Cosmides, Tooby, & Kurzban, 2003; Kinzler, Shutts, & Correll, 2010; Messick & Mackie, 1989; S. E. Taylor, 1981).

In general research into the attributes associated with age suggests that old age is largely associated with stereotypes which lead to negative treatment of the elderly including discrimination (Kite, Stockdale, Whitley, & Johnson, 2005; Kornadt & Rothermund, 2011; Rosen & Jerdee, 1976). Cuddy, Norton, and Fiske (2005) characterised the stereotype of the elderly as being evaluatively mixed with old people being seen as both warm (positive attribute) and incompetent (negative attribute). They also gathered information from seven different nations demonstrating that this stereotype is pan-cultural, appearing in both individualist and collectivist cultures. One particular negative attribute that is strongly associated with old age and linked to the perception of the elderly as incompetent is that the elderly are slower than younger people.

The link between old age and slowness has been held up as an example of the way that social stereotypes can exert an effect on behaviour. The first, and most well-known, study to find evidence for this relationship was conducted by Bargh, Chen, and Burrows (1996). They conducted two studies in which participants were given a scrambled sentence task in which the experimental group were primed with words that were related to the elderly stereotype, e.g. old, lonely, grey, selfishly, careful, while the control group were primed with neutral words. The researchers then recorded the amount of time that participants took to walk down a corridor and found that those who had been primed with the elderly stereotype took longer to walk down the corridor than those who had seen the neutral words. This effect was found in both the original study and in a second study that aimed to replicate the effect.

Since this study a number of other researchers have also investigated the link between age and movement speed, and reported findings that support the original results (Aarts & Dijksterhuis, 2002; Branaghan & Grey, 2010; Cesario, Plaks, & Higgins, 2006; Chambon, Droit-Volet, & Niedenthal, 2008; Ginsberg, Rohmer, & Louvet, 2012; Kawakami, Young, & Dovidio, 2002; Wyer, Neilens, Perfect, & Mazzoni, 2011; although see Doyen, Klein, Pichon, & Cleeremans, 2012 for a failed replication).

These further studies have served to further explore various aspects of the relationship between stereotype activation and behaviour. It has now been shown that priming with an elderly stereotype can lead to a change not only in walking speed but also in reaction times during a lexical decision task (Kawakami et al., 2002), in driving speed in a driving simulator (Branaghan & Grey, 2010), in performance on a motor coordination task (Ginsberg et al., 2012), on ratings of the perceived speed of a stick figure (Aarts & Dijksterhuis, 2002) and perception of time (Chambon et al., 2008). It has also been demonstrated that only elderly stereotypes, as opposed to stereotypes related to women or disability, selectively affect movement speed (Ginsberg et al., 2012; Kawakami et al., 2002). Another study by Mussweiler (2006) demonstrated that the relationship between the elderly stereotype and slower movement is bidirectional. In that study participants who were unobtrusively induced to move in the slow manner that is stereotypic of elderly people subsequently ascribed more elderly-stereotypic characteristics to a target than did control participants.

The effect of stereotype activation on behaviour also seems to be mediated by social attitudes towards the stereotyped group. Cesario et al. (2006) showed that only those participants' who had a positive implicit attitude to the elderly slowing down after seeing being primed with the elderly while those who had a negative implicit attitude actually walked more quickly. Finally and of particular interest to the current work is a study by Wyer et al. (2011) which examined the effect of stereotype activation on the self-concept. Participants were primed with photographs of elderly people and then had their walking speed and memory for words measured. In both cases participants showed an effect of stereotype on behaviour. Participants who were primed with old faces both walked more slowly and performed worse in the memory task. Finally participants completed a self-characterisation task in which they were presented with a list of words and asked whether each described them. Wyer et al. (2011) found that participants who had been primed with the elderly faces were more likely to describe words connected with the stereotype of elderly people as self-descriptive. Further the amount of change in self-concept played a mediating role on the power of the elderly stereotype to affect walking speed suggesting that the observed changes in behaviour due to stereotype activation are caused, at least in part, by the influence of the activated stereotype on the self-concept (for further commentary on the role of the self-concept in behavioural priming see Wheeler, Demarree and Petty, 2007).

The two experiments reported in the current chapter sought to further explore this link between stereotype activation and self-concept by manipulating participants' perception of their bodily self through multisensory stimulation and examining the consequences of this induced ownership on slowing down motor imagery (MI). Using video stimuli similar to those used in experiment 2.2, participants received either synchronous or asynchronous VT-stimulation on their own hand and the hand of an elderly person. It was hypothesised that synchronous VT-stimulation would lead to a feeling of body ownership over the old hand, and that this would result in an association between the hand of the participant and the elderly stereotype attribute of slowness and would thus lead to slower movement speeds when the participant imagined moving their hand. One important difference between the previous studies on stereotype activation reported above and the present one is that in the present study both the experimental group and the control group were exposed to identical visual stimuli evoking the elderly stereotype. The only difference between the experimental and control conditions was whether VT-stimulation was synchronous or asynchronous and thus whether multisensory evidence would suggest that the seen elderly hand belonged to the participants or not.

One practical limitation of the use of passive multisensory stimulation to induce feelings of ownership over an elderly hand is that any actual movement of the participants own hand will cause a divergence in the visual perception of the elderly hand and kinaesthetic and proprioceptive perception of the participants own hand which leads to the disruption of the experience of ownership over the elderly hand. In order to avoid the possibility of such a disruption destroying the effect of multisensory induced ownership on movement speed that was under investigation it was decided that, rather than measure participants actual movements, participants were given a MI task and the speed of their imagined movements was measured.

The use of MI rather than actual movements in the current study can be justified due to the close links between imagined actions and actual action execution (for a review see Jeannerod, 2006). A large number of studies have shown that the time taken for subjects to perform imagined actions is highly correlated with the time taken to perform actual actions (Crammond, 1997; de Lange, Roelofs, & Toni, 2008; Decety & Michel, 1989; Jeannerod, 1994; Parsons, 1994; Sirigu & Duhamel, 2001; Sirigu et al., 1996; Stevens, 2005). It has also been shown that the amount of imagined effort used during MI is correlated with physiological measures such as cardiac and respiratory rhythms (Decety, Jeannerod, Germain, & Pastene, 1991).

The close relationship between MI and actual motor performance displayed in the experiments reviewed here has been explained by the fact that MI draws on many of the same neural systems that are involved in the execution of actions. In particular the evidence that the current state of one's body can influence MI appears to support the idea that MI involves the generation of a full action plan which is then inhibited from being transmitted to the body proper (Grush, 2004; Jeannerod, 2001). This interpretation of MI as involving action simulation has been supported by a number of neuroimaging studies that have found overlapping activation in brain areas involved in action execution and MI (Lorey et al., 2011; Lotze et al., 1999; Oosterhof, Tipper, & Downing, 2012).

Of particular interest to the current study, given its aim of manipulating stereotype associations through a change in body representation, several studies have found that changes in the current state of the body can lead to changes in performance in MI tasks (de Lange, Helmich, & Toni, 2006; Parsons, 1994; Saimpont, Malouin, Tousignant, & Jackson, 2012; Shenton, Schwoebel, & Coslett, 2004; Sirigu & Duhamel, 2001). Parsons (1994) found that participants were slower to decide whether an image of a hand was a left or right hand, a task that had previously been shown to involve implicitly imagining rotating one's own hand (Parsons, 1987; Sekiyama, 1982), when their own hands were in an uncommonly adopted posture, e.g. hands held back to back the palms facing outwards, than when their hands were placed palms down on the table. In the same paper Parsons demonstrated that this increased time was correlated to the greater time taken when participants were required to actually rotate their hands starting from either posture. De Lange et al. (2006) found that the effect of posture was effector specific, when the participant's own left hand was in a less natural position they showed slower reaction times when judging the laterality of a left hand compared to a right hand and vice versa when it was their right hand that was in the unnatural posture. Finally Saimpont et al., (2012) demonstrated that both young and elderly participants were more accurate in imagining their walking speed when standing up compared to when sitting down.

These findings, which suggest that current embodiment can have an effect of participant's MI, together with the findings on the effects of exposure to stimuli related to the elderly on movement detailed above, make it reasonable to hypothesise that changing participants' representation of their own hand, such as using multisensory stimulation to make participants feel that their own hand is older than it actually is, may have the effect on their performance in a MI task.

The two experiments reported here sought to test whether a change in the apparent age of the participant's own hand, as induced by multisensory stimulation, would be reflected in decreased speed during a MI task. In these experiments a modified version of the visually guided pointing task (Danckert & Goodale, 2001; Decety & Michel, 1989; Fitts, 1954; Maruff et al., 1999; Proteau, Marteniuk, Girouard, & Dugas, 1987) was employed as the MI task. The only change from the regular version of this task made in the current study is that, due to the constraints of the RHI setup participants were not given any visual cue to the position of their own hand.

Experiment 4.1 aimed to investigate whether induced ownership of an elderly hand would lead to behavioural priming that as reflected in decreased speed of MI using a between subjects design. In addition to this main hypothesis, experiment 4.1 also sought to replicate the effect of synchronous multisensory stimulation on implicit attitudes towards an outgroup observed in experiments 2.1 and 3.1 by examining whether participants who experienced synchronous stimulation over the elderly hand showed a reduced bias against the elderly in the age IAT.

4.2. Experiment 4.1

4.2.2. Methods

4.2.2.1. Design

The study used a between participants design, with one experimental factor namely the synchrony of visual-tactile stimulation (synchronous, asynchronous). The dependent variables were participants' reaction times in the post V-T stimulation MI task, participants' responses to four statements on a 7 point Likert scale taken from Longo, Schüür, et al. (2008) and participants scores on a post -stimulation "Age IAT". In order to have a baseline measure of participants' baseline speed of MI participants also carried out a pre-VT stimulation MI task.

4.2.2.2. Procedure

Participants attended one experimental session. They first completed a demographic questionnaire and the Edinburgh Handedness questionnaire.

Following this, participants took part in an adapted version of the visually guided pointing task (VGPT; Fitts, 1954; Proteau et al., 1987). Participants were told to sit at a table which had two screens embedded in it (see Figure 4.2). They were told to place their right hand flat on the table underneath the screen on the right and to place their left hand on a mouse on the left side of the table. Participants were then told that in the experiment they would see a white square appearing on the screen and that they should imagine that they were moving the index finger of their right hand from its current position to the position of the white square. It was emphasised that participants should actually keep their right hand still at all times during the task. Participants were told to use their left hand to press the right mouse button once when they imagined lifting their index finger and once again when they imagined their finger touching the target. After the right mouse button was pressed twice there was a 1 second delay before a white square appeared on the screen again. In order to prevent habituation the square appeared in one of three places on the screen, either 59, 45.5, or 32 cm away from the location of the participant's index finger. Stimuli for the study were presented using Presentation® software (Version 16.03, www.neurobs.com).

Participants first carried out a practice session of six trials to familiarise themselves with the task. They then completed the pre V-T stimulation MI task which consisted of thirty trials, ten for each of the three different distances. Following this, participants were asked to direct their attention to the video screen that was placed above their own right hand. Participants then viewed a 2 minute video of a hand belonging to a 90 year old female being stroked with a paint brush at a rate of 1 Hz (see Figure 4-1). Given that previous research has found that the larger the observed hand the greater the strength of the RHI (Pavani & Zampini, 2007) the videoed hand was zoomed and expanded to fill the whole screen (size: 31cm x 18cm). In the synchronous condition the participant's hand was brushed at the same time as the hand in the video, while in the asynchronous condition it was brushed 180° out of phase. Following the two minutes of VT stimulation participants then carried out the MI task again.

Following this, participants carried out a computer administered version of the age-IAT. The associations between stimuli and response key and the order of associations (i.e. positive words and young faces or positive words and old faces) were counterbalanced across participants (Greenwald et al., 1998, 2003). The data from the IATs were analysed using the improved IAT scoring algorithm recommended by Greenwald et al. (2003) with positive values indicating a greater bias towards young people and negative values indicating a greater bias towards old people.

Finally participants completed the four item Embodiment questionnaire, used in the studies in chapter 3, indicating the extent to which they experienced embodiment over the elderly hand. The questions were presented using Presentation® software (Version 16.03, www.neurobs.com).

4.2.2.3. Participants

21 participants (mean age ± *SD*: 21 ± 1.6, 4 male) gave their informed consent to participate and were paid for their participation. All participants were under 35 years

of age. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

4.2.2.4. Analysis of Behavioural Data

Participants times on each of the MI trials was calculated by subtracting the time of their first press of the mouse button from the time of their second press of the mouse button. Mean timings for the each of the three distances were calculated for pre and post VT-stimulation session for each participant. Trials that were greater than 3 standard deviations from these means were excluded from the analysis.

In order to ensure that participants had understood the task properly, MI times were checked to see whether they had the correct pattern of MI timing across the three distances in the pre VT stimulation condition. Those participants who did not have a greater mean time in the far trials compared to the middle trials and a greater mean time in the middle trials compared to the near trials were not considered to have correctly understood the task, as they reported taking more time to imagine moving to a shorter distance compared to a longer one. These participants were removed from the analysis of the MI task leaving a sample of 13 participants (mean age ± *SD*: 20 ± 1.5, 2 male, 6 asynchronous condition) for the MI analysis.

4.2.3. Results

4.2.3.1. Introspective Rating of the RHI

In order to ensure that our manipulation of the synchrony of VT stimulation had successfully led to differences in the perceived embodiment of the elderly hand, independent sample *t*-tests were carried out on each of the four RHI questions (See figure 4-3).

For the first question, “It seemed like I was looking directly at my own hand.” responses were significantly higher in the synchronous group (M = 2.5, SD = 0.71) than in the asynchronous group (M = -1.73, SD = 1.85), $t(13.1) = 7.04$, $p < .001$, SED = 0.6. Levene’s test indicated unequal variances ($F = 7.3$, $p < .05$), so degrees of freedom were adjusted from 19 to 13.1. For the second question, “It seemed like the touch I felt was caused by the paintbrush touching the hand in the video." responses were significantly higher in the synchronous group (*M* = 2.5, *SD* = 0.85) than in the asynchronous group (*M* = -1.45, *SD* = 2.25), $t(13.02) = 5.42$, $p < .001$, SED = 0.73. Levene's test indicated unequal variances ($F = 10.52$, $p < .01$), so degrees of freedom were adjusted from 19 to 13.02.

For the third question, "It seemed like the hand in the video was my hand." responses were significantly higher in the synchronous group (*M* = 1.8, *SD* = 1.03) than in the asynchronous group (*M* = -1.55, *SD* = 2.34), $t(14.03) = 4.3$, $p < .01$, SED = 0.78. Levene's test indicated unequal variances ($F = 7.38$, $p < .05$), so degrees of freedom were adjusted from 19 to 14.03. For the fourth question, "It seemed like the hand in the video began to resemble my own hand" responses were significantly higher in the synchronous group (*M* = 1.9, *SD* = 0.74) than in the asynchronous group (*M* = -1.45, *SD* = 2.11), $t(12.61) = 4.94$, $p < .05$, SED = 0.68. Levene's test indicated unequal variances ($F = 6.1$, $p < .05$), so degrees of freedom were adjusted from 11 to 12.61.

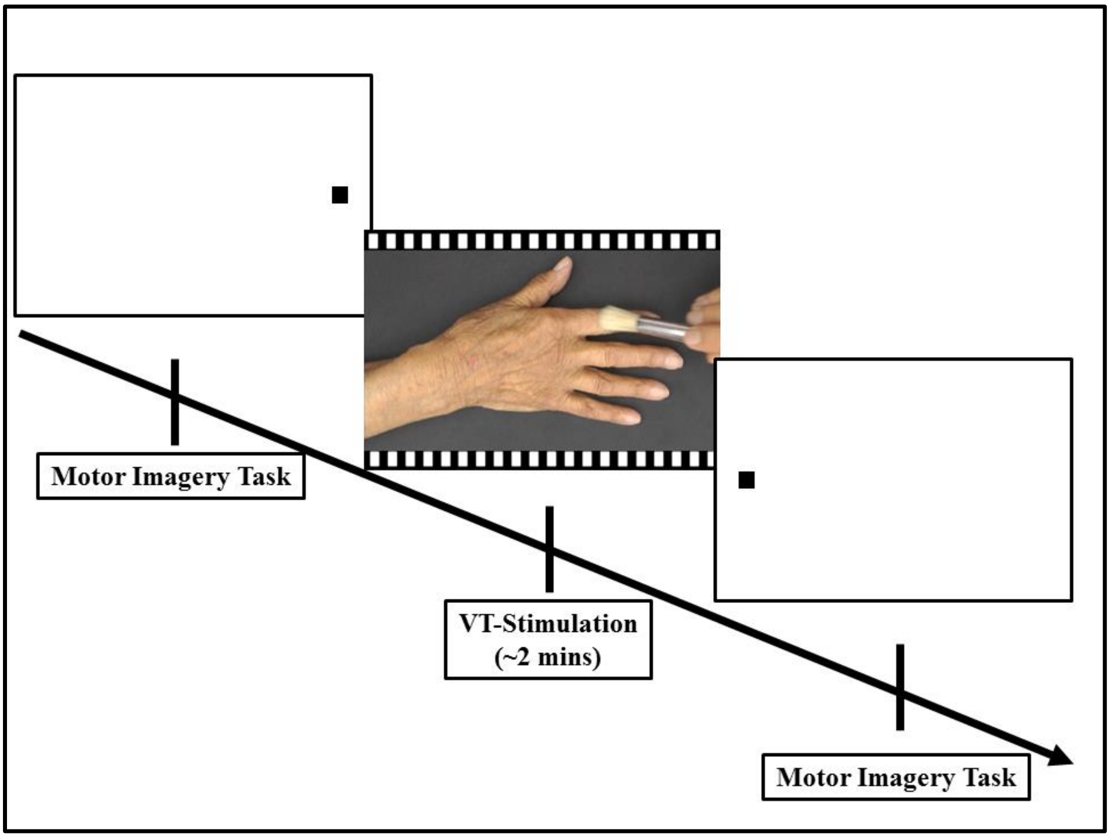

Figure 4-1. Trial structure of experiments 4.1 and 4.2.

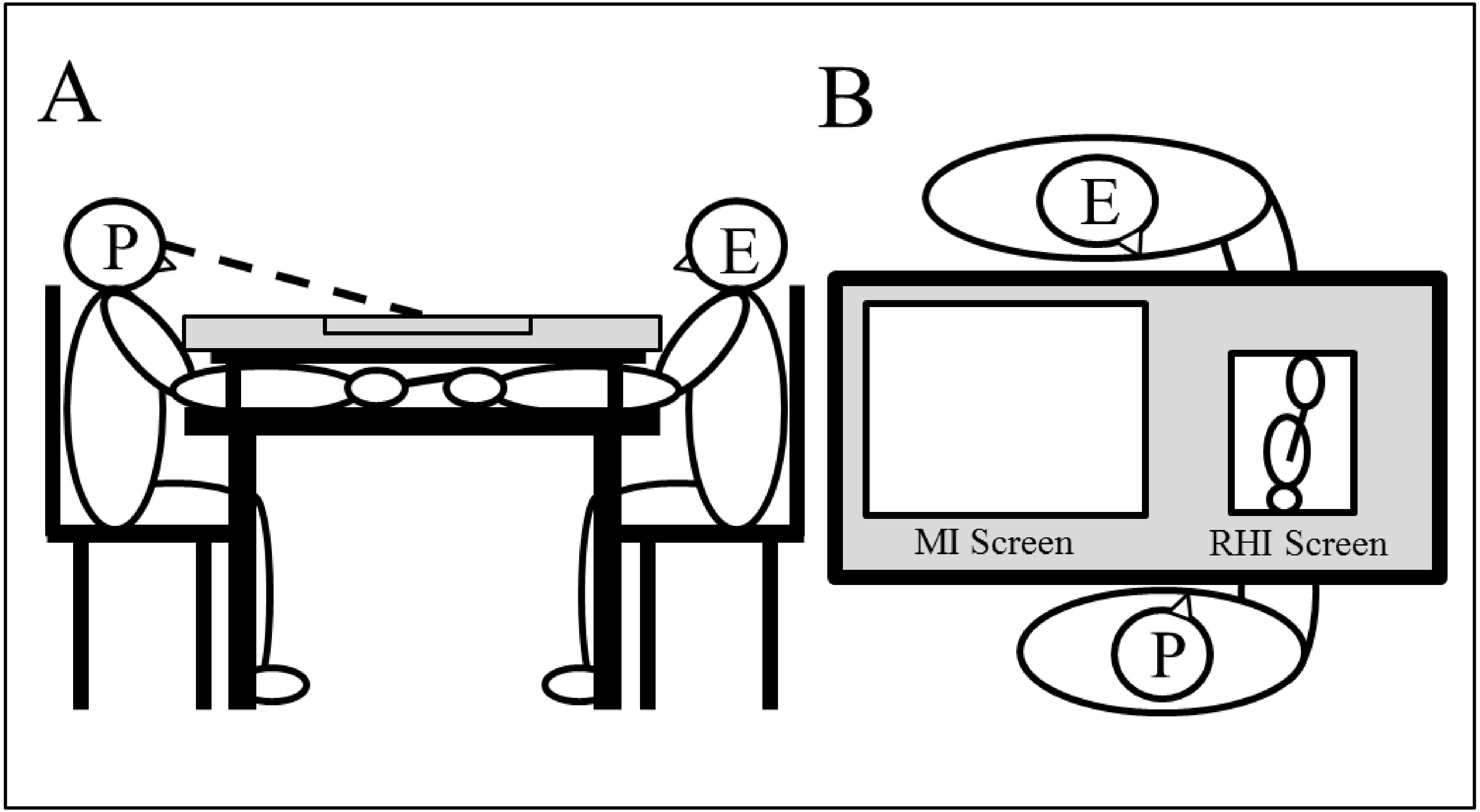

Figure 4-2. Experimental setup for experiments 4.1 & 4.2 as seen from a horizontal (A) and vertical (B) viewpoint (E = experimenter, P = participant).

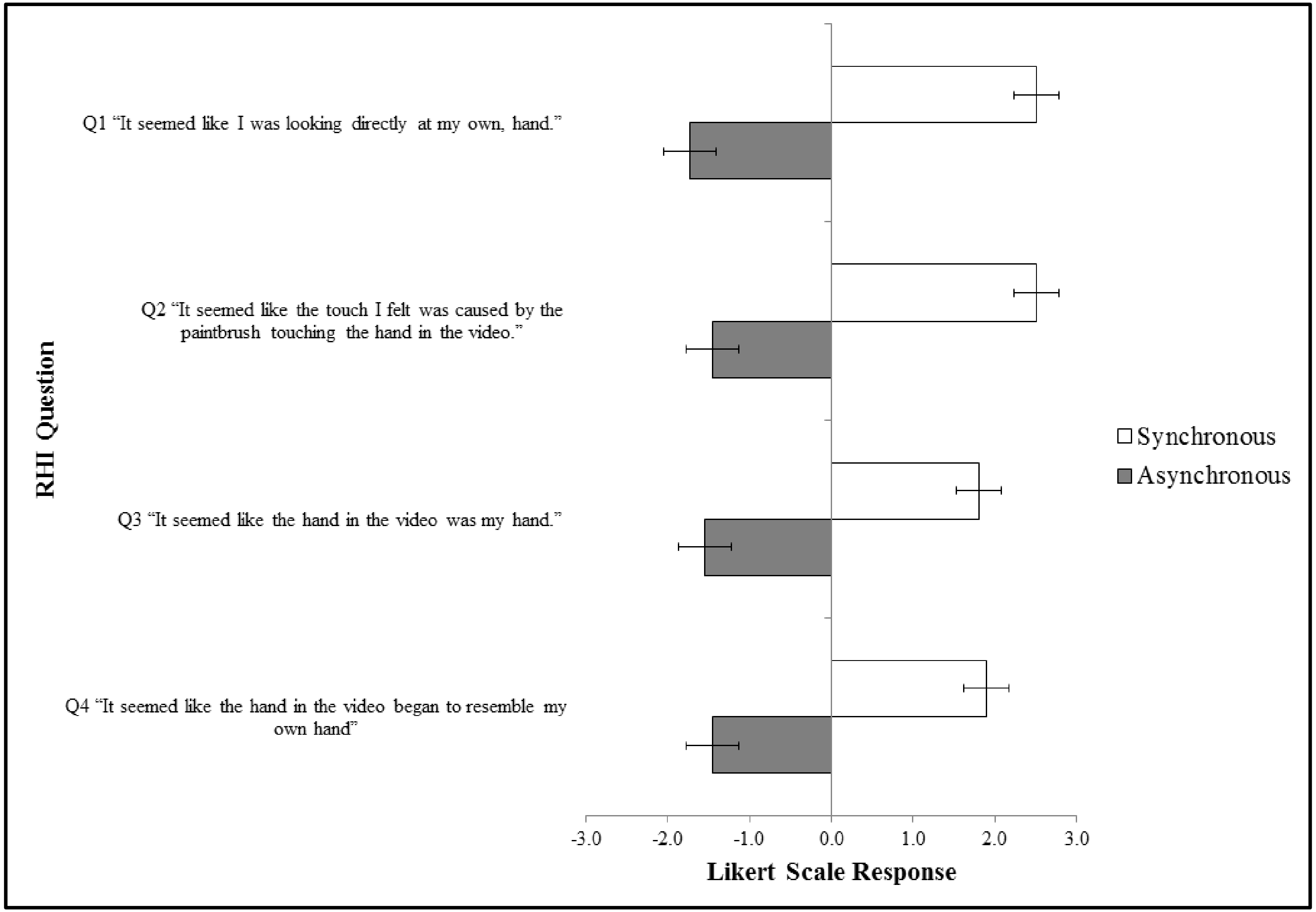

Figure 4-3. Mean Likert scores for each RHI question across synchronous and asynchronous groups. Error bars represent SEM.

4.2.3.2. Effect of VT Stimulation of An Elderly Hand on Speed in MI Task

In order to ensure that there were no significant differences in baseline MI task performance between the two groups of participants, an independent sample *t*-test was carried out on the average score on the MI task of the 13 participants who followed the task instructions successfully with time in the pre VT-stimulation MI task as the dependent variable and synchrony (synchronous/asynchronous) as the independent variable. There was a significant effect of synchrony, $t(11) = 2.43$, $p < .05$, with faster times in the asynchronous condition ($M = 1199$, $SD = 274$) than in the synchronous condition ($M = 1955$, $SD = 716$).

To investigate the effect of synchrony of multisensory stimulation between participant's hands' and an elderly hand on participants speed in a MI task, a between subject analysis of covariance was carried out with post VT- stimulation MI times as the dependent variable, synchrony (synchronous/asynchronous) as the independent variable and pre VT-stimulation MI times as the covariate. The ANCOVA found an almost significant effect of synchrony, $F(1,10) = 4.38$, $p = .063$, with faster post stimulation MI times in the asynchronous condition ($M = 1280$, $SD = 513$) than in the synchronous condition ($M = 1646$, $SD = 701$) (see figure 4-4).

4.2.3.3. Effect of embodiment over an elderly hand on speed in MI task

To investigate the effect of experiencing embodiment over an elderly hand on participants subsequent speed in a MI task scores in the four introspective questions were averaged together to create an embodiment index. A three-step hierarchical linear regression was then carried out with post-stimulation MI time as the dependant variable. Synchrony of VT-stimulation, embodiment index, and pre-stimulation MI time were entered as predictor variables in the first step, all two-way interaction terms entered in the second step and the three-way interaction entered as a third step. The overall model fit was significant at the first step, $F(1, 12) = 16.03$, $p < 0.01$. Pre-stimulation MI time was the only significant predictor and adding the interaction terms to the model in Steps 2 and 3 of the regression did not significantly improve the model fit (see Table 4-1).

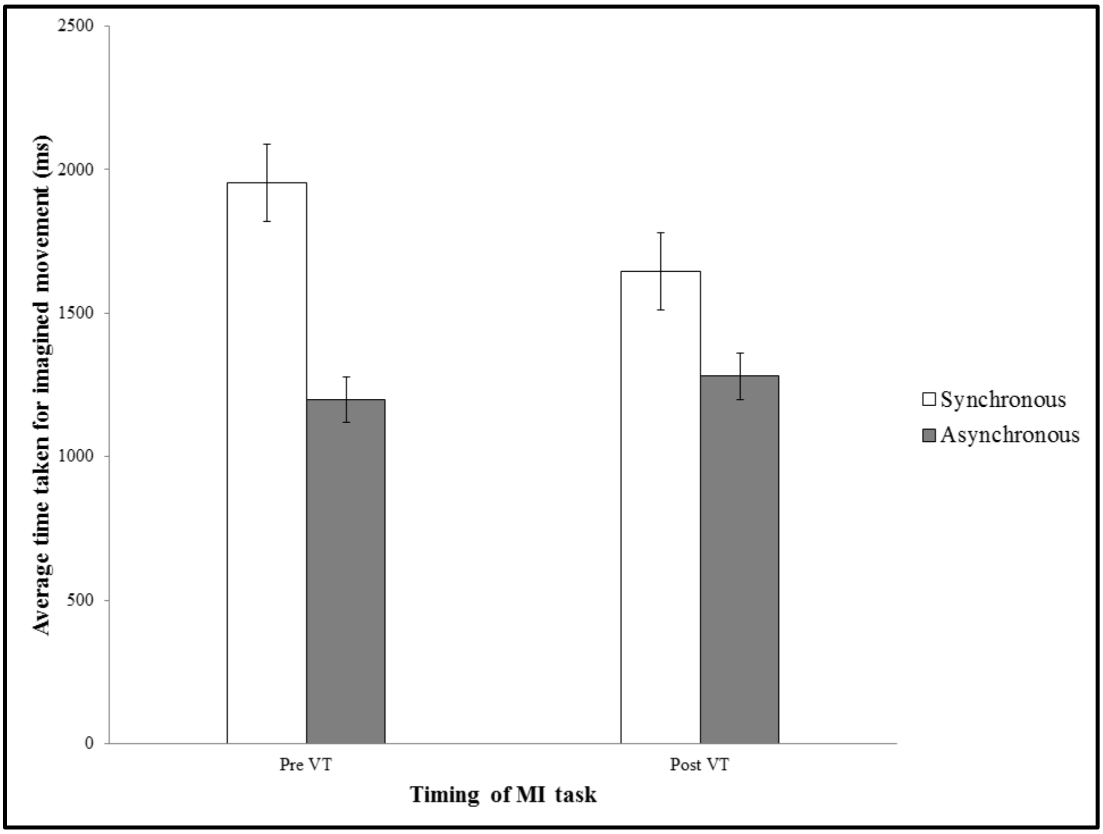

Figure 4-4. Mean time taken for imagined movement before and after VT-stimulation across synchronous and asynchronous groups. Error bars represent SEM.

4.2.3.4. Effect of VT Stimulation of an Elderly Hand on Implicit Attitudes Towards the Elderly

To investigate the effect of multisensory stimulation on participants' implicit attitudes towards the elderly, an analysis of variance was carried out with participant's score on the post-stimulation "Age IAT" as the dependent variable, and synchrony of VT-stimulation (synchronous/asynchronous) as the independent variable. No significant difference in implicit bias was found between the synchronous (M = 0.4, SD = 0.44) and asynchronous conditions (M = 0.54, SD = 0.47), $t(11) = 0.68$, $p > .05$, SED = 0.33 (see Figure 4-5).

Table 4-1. Summary of three-step hierarchical regression analysis for variables predicting with post-stimulation MI times.

Variable	**B**	***p***
Step 1		
Pre-VT MI Time	1.07	< .001
Synchrony	-0.25	.874
Embodiment Index	-0.01	.684
Step 2		
Pre-VT MI Time	0.91	.176
Synchrony	-1.85	.186
Embodiment Index	1.61	.11
Pre-VT MI Time * Synchrony	1.65	.353
Pre-VT MI Time * Embodiment Index	-2.47	.098
Embodiment Index * Synchrony	0.94	.172
Step 3		
Pre-VT MI Time	0.67	.301
Synchrony	0.02	.993
Embodiment Index	2.1	.06
Pre-VT MI Time * Synchrony	0.06	.978
Pre-VT MI Time * Embodiment Index	-3.29	.054
Embodiment Index * Synchrony	-1.48	.453
Pre-VT MI Time * Embodiment Index * Synchrony	2.7	.22

Note. r^2adjusted = .790 for Step 1; Δr^2 = .077 for Step 2 ($p > .05$), Δr^2 = .023 for Step 3 ($p > .05$). * = $p < .05$.

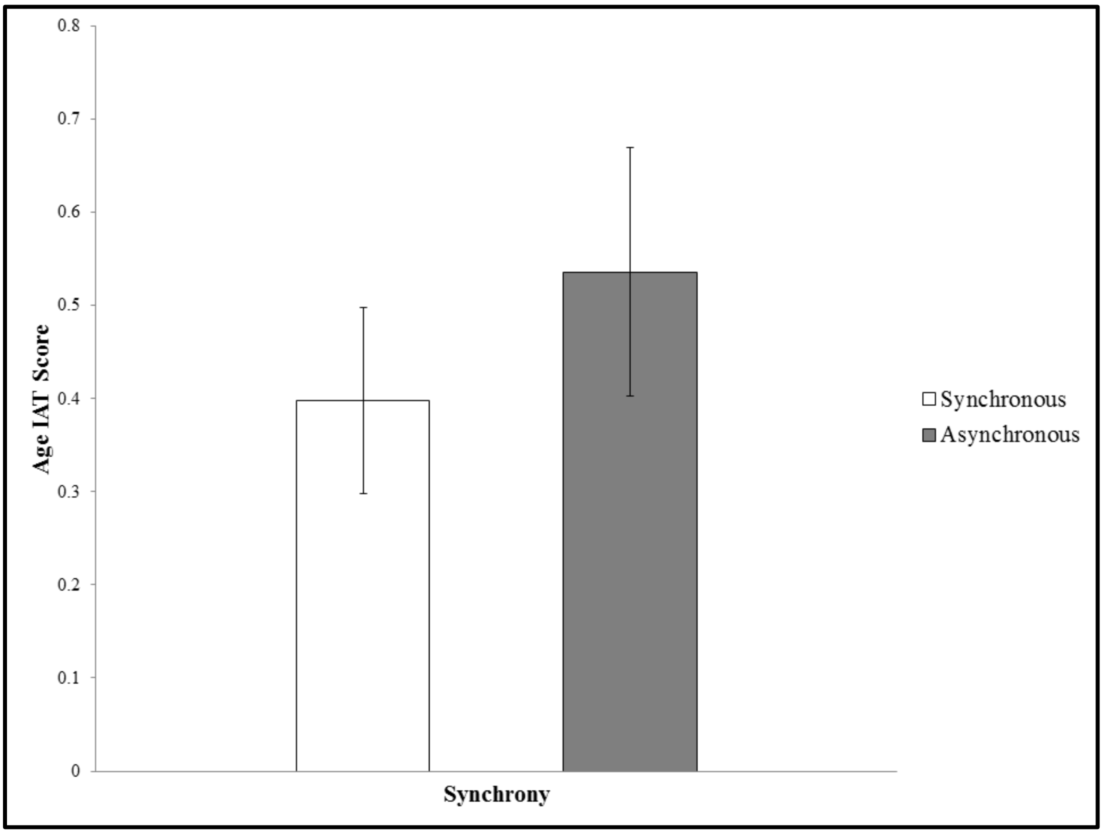

Figure 4-5. Age IAT scores after VT-stimulation across synchronous and asynchronous groups. Error bars represent SEM.

4.2.4. Discussion

Experiment 4.1 sought to investigate whether synchronous multisensory stimulation over the participants hand and the hand of an elderly person would lead to slower performance in a MI task than asynchronous VT stimulation did. While introspective reports indicated that synchronous multisensory stimulation successfully induced a feeling of ownership over the elderly hand, the predicted effect was not observed. In fact an almost significant effect (p=0.063) was found in the opposite direction, that is participants in the synchronous condition actually imagined moving their hand towards the target faster after VT stimulation that they had before VT stimulation.

There are several possible explanations for such a finding. One is that, rather than creating a stronger link between old age and the self, experiencing synchronous visual tactile stimulation over the old hand in fact led to a contrast effect in which the participant attempted to distance themself from the negative feeling of being old by imagining their subsequent movements to be faster, thus reaffirming that they themselves were not actually old.

Such contrast effects have been known for some time and are considered to be a common response to observing an exemplar of a particular stereotype. For example Herr (1986) demonstrated that priming the trait hostility caused a person seen by the participant afterwards to be judged as more hostile compared to a control condition, but priming an exemplar of hostility such as Adolf Hitler led to the person being judged as less hostile. Of direct relevance to the hypothesis of the current study Dijksterhuis et al. (1998) conducted a study in which participants were first primed with elderly stimuli or neutral stimuli as in Bargh et al. (1996) but then gave participants either a series of questions about the Princess Juliana, the Dutch Queen Mother and an elderly exemplar, or else a series of questions about Belgium. The researchers found that those participants who had answered questions about the elderly exemplar showed a reverse in the behavioural effect found in Bargh et al., walking faster on leaving the experiment than those who had not been primed with the elderly stereotype at all. This distinction between exemplars of a stereotype and the stereotype itself is of some relevance to the current experiment, in the current study participant's observed an actual elderly hand being stroked which might be considered more of an exemplar of an elderly person rather than the trait of being elderly itself.

In addition to the possibility that the stimuli being used in the current task are an exemplar of the trait elderly rather than simply a reflection of being elderly in general the fact that in the current study participant's sense of bodily selfhood was directly manipulated may also be a relevant. Schubert and Häfner (2003) demonstrated that priming participants with self relevant words (e.g. me, I, myself) before asking them to think about either an intelligent (professor) or unintelligent (hussy) stereotype led to a contrast effect in participants subsequent rating of their own intelligence. In contrast participants who were primed with other relevant words (e.g. his, her, their) rated themselves as marginally more intelligent if asked to think about a professor than if asked to think about a hussy. It is possible that in the current study the feeling of a change in participant's own body states produced by synchronous VT-stimulation acted in a similar way as the self-relevant words did in Schubert and Häfner's study in producing a focus on the self and thus prompted participant's in the synchronous condition to imagine moving faster in order to differentiate themselves from the elderly hand that they had experienced as their own.

While it is possible that the almost significant speeding up of imagined movements in the synchronous condition was due to a contrast effect, such an interpretation is somewhat at odds with the interpretation given for the pattern of results in experiment 3.1. In that study synchronous VT stimulation over a black hand led to more positive implicit attitudes towards black people while asynchronous VT stimulation led to less positive implicit attitudes. This finding was interpreted as indicating that asynchronous stimulation had the effect of increasing the differentiation between self and other and thus to a greater perception of black people as an out-group. Following that line of reasoning it might have been expected that any contrast effect found would be in the asynchronous condition in which the touch experienced on one's own hand was distinct and contrasted from the touch observed on the elderly hand.

However, an alternative explanation of the current findings is suggested by the fact that the almost significant difference between the two conditions was actually due to the significant difference found in the pre VT stimulation baseline speeds of MI. This raises the possibility that somehow participants in the synchronous condition were primed to perform more slowly during the baseline task before they ever observed the elderly hand.

This possibility is suggested by the controversial recent study carried out by Doyen et al. (2012). The authors sought to replicate the original finding of Bargh et al.'s study (1996) but correcting for two major weaknesses, the fact that the experimenter who administered the task was not blind to the condition participants were in and the fact that the time taken for walking were measured by a second experimenter with a stop watch and so vulnerable to human error. Their own study corrected these flaws by using a double blind method for both experimenters and by measuring walking time with two lasers. In their initial study they failed to replicated the effect of old age priming on walking speed so in a second experiment they tested whether experimenter’s knowledge of the condition could have had an effect on participants walking speed by giving the experimenter either correct or incorrect information about whether participants were primed with neurtral or elderly words. In this experiment they did find that the speed at which the participant walked changed depending on condition but, crucially, it was the primes that the experimenter thought the participant had received rather than the primes they had actually received that explained the pattern of results. Based on these finding Doyen,et al. (2012) hypothesised that the reported behavioural priming effects from Bargh et al.’s study were actually due to participants unconsciously picking up on and mimicking cues unwittingly given by the experimenter.

The setup of the current study allowed for a similar situation to occur. Due to the nature of the task it was necessary for the experimenter to know which condition a participant was assigned to before the task began (so that they could deliver the correct type of multisensory stimulation). Moreover before participants carried out the pre VT stimulation MI task the experimenter demonstrated the type of movement that they were supposed to imagine making during the task. It is possible therefore that the experimenter unwittingly moved slightly more slowly when demonstrating the action to participants in the synchronous condition and therefore biased them to move more slowly in the pre VT-stimulation MI task than participants in the asynchronous condition. By the time that participant’s had received multisensory stimulation over the elderly hand and started the post VT-stimulation MI task the effect of this experimenter effect may have faded leading to similar performance between the synchronous and asynchronous groups. To differentiate between these two possible explanations of the finding of experiment 2.1 a second study was conducted which used the same basic paradigm, but employed a within participants design. The logic behind this change was that if the difference in pre-scores was due to cues from the experimenter, then a with-in subject design should remove the effect as each participant would be given the instructions on the task only once and would then perform the MI task before and after both synchronous and asynchronous stimulation. If however the faster movement after synchronous, but not asynchronous, VT stimulation was due to a contrast effect being produced by synchronous stimulation then it should still be present even after the design of the study was altered.

4.3. Experiment 4.2

4.3.1. Methods

4.3.1.1. Design

The study used a within participants design with one experimental factor, namely the synchrony of visual-tactile stimulation (synchronous, asynchronous). The dependent variables were participants' reaction times in the post V-T stimulation MI task and participants' responses to four statements on a 7 point Likert scale taken from Longo, Schüür, et al. (2008). In order to have a baseline measure of participants' baseline speed of MI participants also carried out a MI task before receiving VT stimulation for each condition.

4.3.1.2. Procedure

Participants attended one experimental session. They first completed a demographic questionnaire and the Edinburgh Handedness questionnaire and the Age IAT, which was analysed in the same way as described in experiment 4.1.

Next participants were sat at the same setup as used in experiment 4.1 and were instructed to carry out the same MI task as in the previous study. In order to allow the experimenter to better monitor the task and ensure that participants were following the instructions correctly a modification was made to the way that trials were cued. In this experiment after each trial, the experimenter cued the next trial by pressing a separate button, following this there was a 1 second delay before the start of the next trial.

Following completion of the MI task participants were asked to direct their attention to the video screen that was placed above their own right hand. Participants then viewed the same VT stimulation video as in experiment 4.1. In the synchronous condition the participant's hand was brushed at the same time as the hand in the video, while in the asynchronous condition it was brushed 180° out of phase. Following the two minutes of VT stimulation participants then carried out the MI task again. Participants then left the MI setup and completed the same embodiment questionnaire that was used in experiment 4.1.

Participants then returned to the MI setup and again completed the 30 trial pre VT-stimulation MI task. Following this they received VT-stimulation in the stimulation condition that they had not previously experienced and then completed the MI task again. They then completed the embodiment questionnaire again but this time for the second session of stroking. The order in which the two VT-stimulation conditions were experienced was counterbalanced across participants.

4.3.1.3. Participants

14 participants (mean age ± *SD*: 21 ± 1.5, 5 male) gave their informed consent to participate and were paid for their participation. All participants were under 35 years of age. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

4.3.1.4. Analysis of Behavioural Data

Participants' average times on each of the MI trials was calculated as in experiment 4.1. In order to ensure that participants had understood the task properly it was checked whether participants had the correct pattern of MI timing across the three distances in the pre VT stimulation task. Those participants who did not have a greater mean time in the far trials compared to the middle trials, and a greater mean time in the middle trials compared to the near trials in the first condition that they completed were considered to not have correctly understood the task, as they reported taking more time to imagine moving to a shorter distance compared to a longer one. These participants were removed from the analysis of the MI task leaving a sample of 12 participants (mean age ± *SD*: 21.2 ± 1.5, 5 male) for the MI analysis.

4.3.2. Results

4.3.2.1. Introspective Rating of the RHI

In order to ensure that our manipulation of the synchrony of VT stimulation had successfully led to differences in the perceived embodiment of the elderly hand, paired sample *t*-tests were carried out on each of the four RHI questions (See Figure 4-6).

For the first question, "It seemed like I was looking directly at my own hand." responses were higher in the synchronous condition (M = 0.86, SD = 1.56) than in the asynchronous condition (M = -0.79, SD = 2.46), $t(13) = 3.74$, $p < .01$. For the second question, "It seemed like the touch I felt was caused by the paintbrush touching the hand in the video." responses were higher in the synchronous condition (M = 0.93, SD = 1.86) than in the asynchronous condition (M = -1.36, SD = 1.65), $t(13) = 3.77$, $p < .01$.

For the third question, "It seemed like the hand in the video was my hand." responses were higher in the synchronous condition (M = 0.43, SD = 1.91) than in the asynchronous condition (M = -1.07, SD = 1.98), $t(13) = 4.17$, $p < .01$, SEM = 0.36. For the fourth question, "It seemed like the hand in the video began to resemble my own hand" no significant differences were found responses in the synchronous condition (M = 0.29, SD = 1.98) and the asynchronous condition (M = -0.5, SD = 2.03), $t(13) = 1.44$, $p > .05$.

In order to investigate whether pre-existing implicit attitudes could predict the extent to which participants experienced ownership for the elderly hand, participants' scores in the four introspective questions for the synchronous condition were averaged together to create an embodiment index. This embodiment index as the dependant variable was then entered in a linear regression with pre-stimulation Age IAT score as the predictor. The overall model fit was not significant, $F(1, 13) = 1.34$, $p > .05$, r^2adjusted = .01.

4.3.2.3. Effect of VT stimulation of an elderly hand on speed in MI task

In order to ensure that there were no significant differences in baseline MI task performance between the two groups of participants, a paired sample *t*-test was carried out on the average score on the MI task of the 12 participants who followed the task instructions successfully with time in the pre VT-stimulation MI task as the dependent variable and synchrony (synchronous/asynchronous) as the independent variable. No significant differences were found between the synchronous (M = 1291, SD = 533) and asynchronous conditions (M = 1282, SD = 524), $t(11) = 0.16$, $p > .05$.

To investigate the effect of synchrony of multisensory stimulation between participant's hands' and an elderly hand on participants speed in a MI task, a repeated measure analysis of covariance was carried out with post VT- stimulation MI times as the dependent variable, synchrony (synchronous/asynchronous) as the independent variable and pre VT-stimulation MI times as the covariate. The ANCOVA found no significant differences between the synchronous (M = 1271, SD = 489) and asynchronous conditions (M = 1302, SD = 427), $F(1,21) = 2.9$, $p > .05$, (see Figure 4-7).

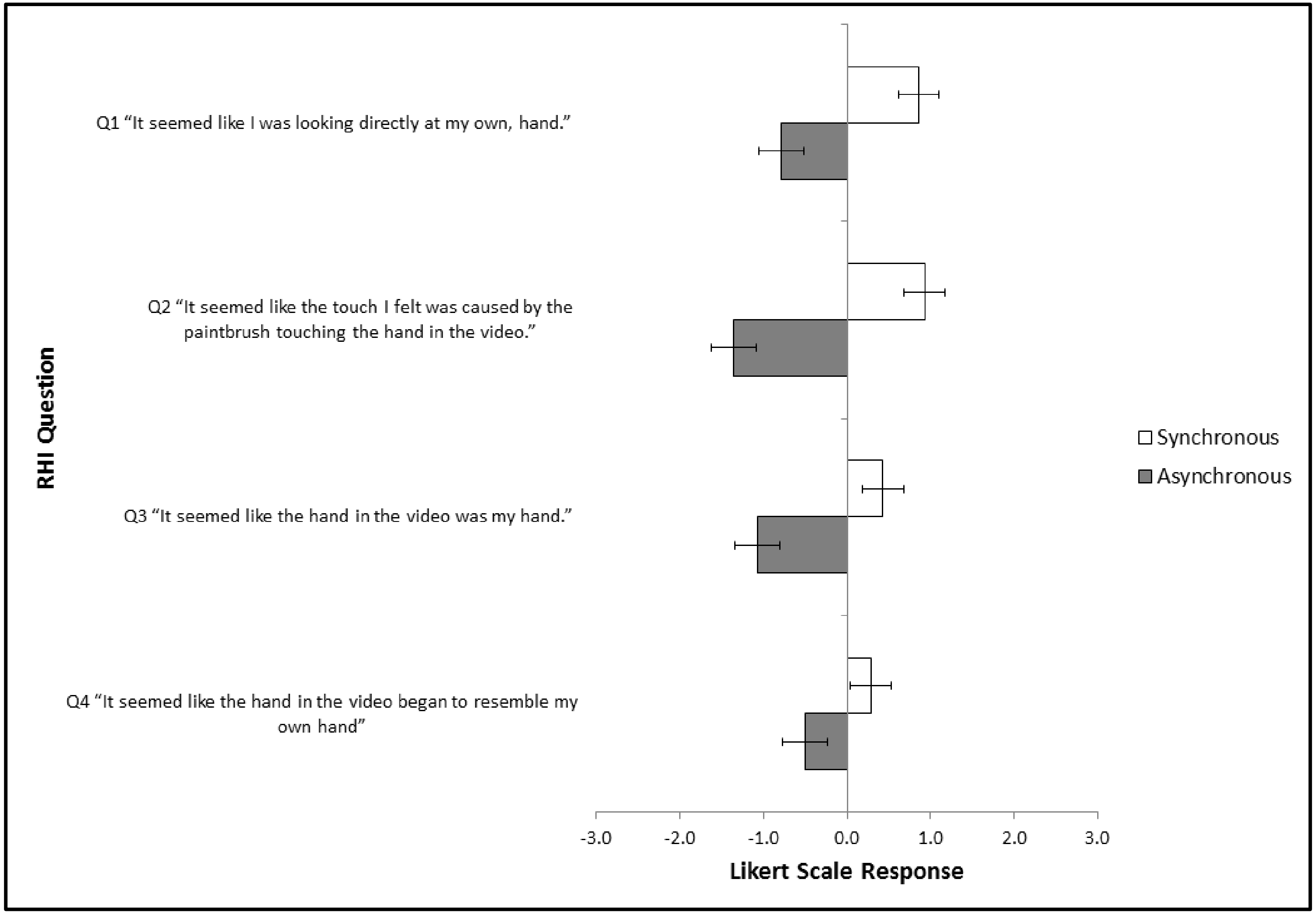

Figure 4-6. Mean Likert scores for each RHI question across synchronous and asynchronous conditions. Error bars represent SEM.

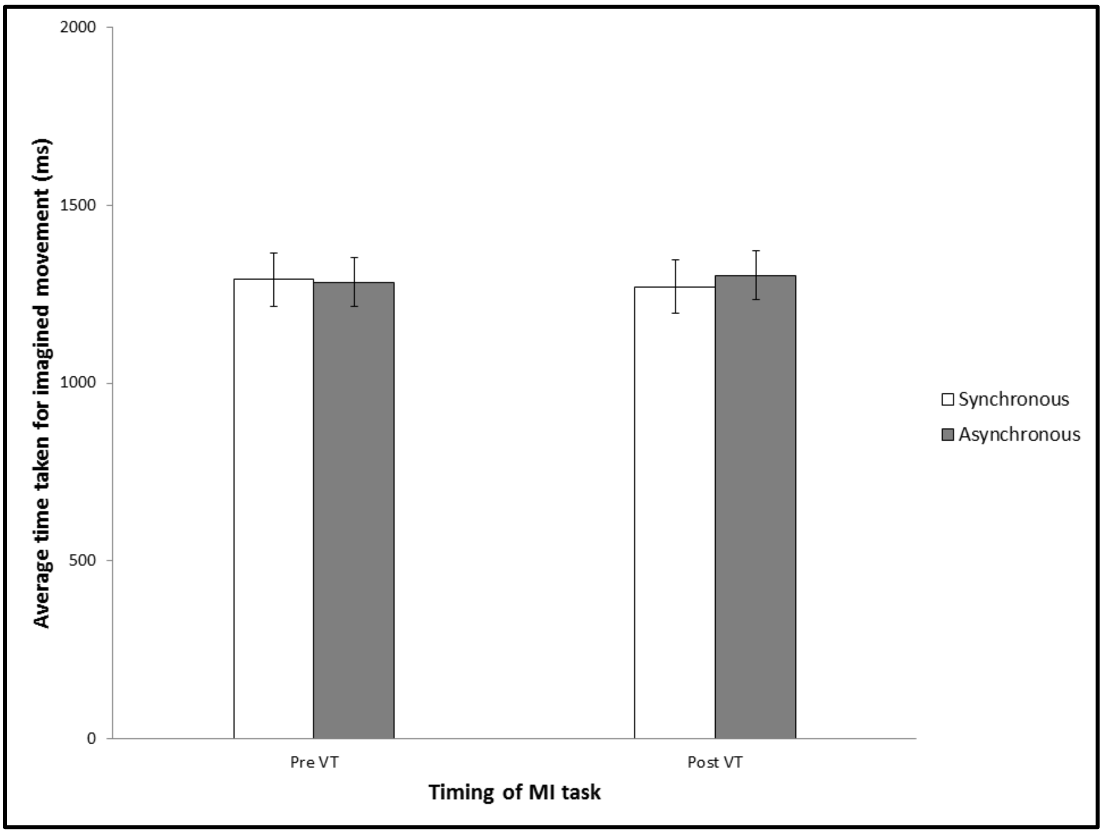

Figure 4-7. Mean time taken for imagined movement before and after VT-stimulation across synchronous and asynchronous conditions. Error bars represent SEM.

Table 4-2. Summary of two-step hierarchical regression analysis for variables predicting with post-stimulation MI times in the synchronous condition.

Variable	**β**	***p***
Step 1		
Pre-VT MI Time	0.97	< .001
Embodiment Index	0.07	.016
Step 2		
Pre-VT MI Time	0.96	< .001
Embodiment Index	0.08	.041
Pre-VT MI Time * Embodiment Index	-0.02	.651

Note. r^2adjusted = .99 for Step 1; $\Delta r^2 = 0$ for Step 2 (p > .05).

Table 4-3. Summary of two-step hierarchical regression analysis for variables predicting with post-stimulation MI times in the asynchronous condition.

Variable	**β**	***p***
Step 1		
Pre-VT MI Time	0.9	< .001
Embodiment Index	0.06	.673
Step 2		
Pre-VT MI Time	0.8	.011
Embodiment Index	0.33	.58
Pre-VT MI Time * Embodiment Index	-0.26	.64

Note. r^2adjusted = .81 for Step 1; $\Delta r^2 = 0$ for Step 2 ($p > .05$).

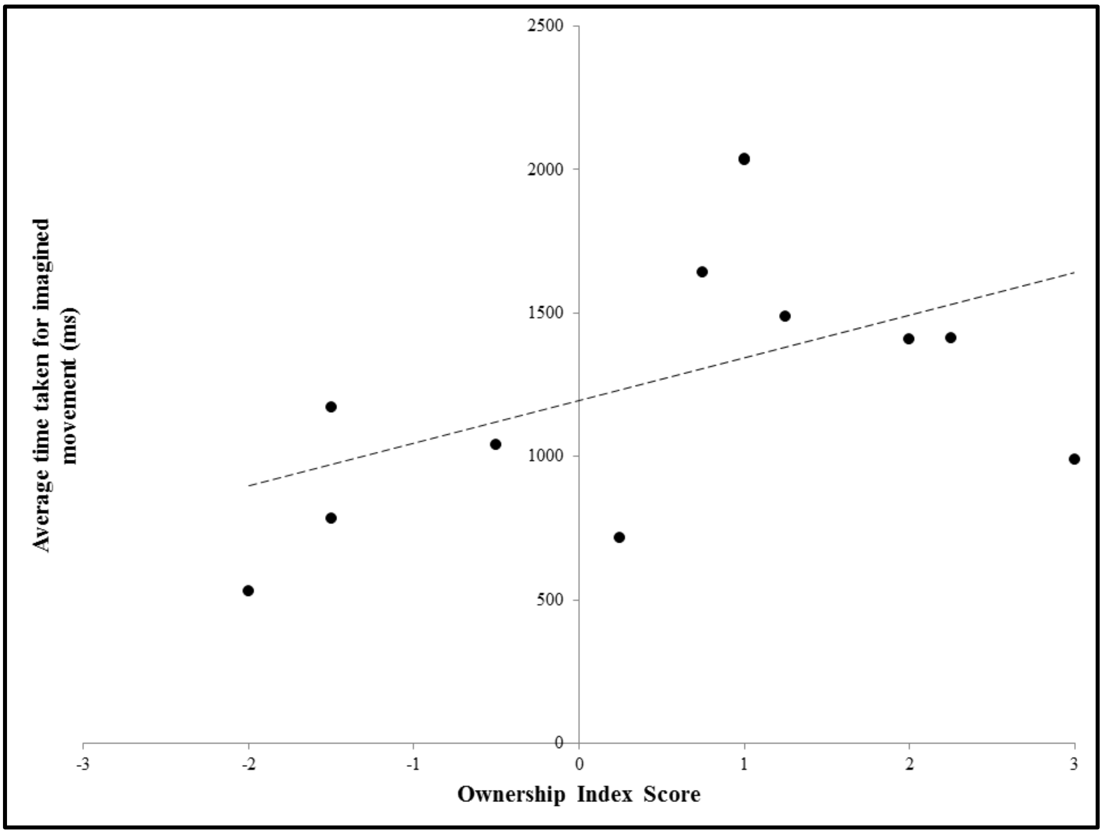

Figure 4-8. Introspective reports of ownership against post VT-stimulation imagined movement time after synchronous stimulation.

4.3.3. Discussion

Experiment 4.2 found no significant differences between the time taken in a MI task after synchronous and asynchronous VT-stimulation over an elderly rubber hand. This finding suggested that the almost significant effect found in experiment 4.1 was probably caused by experimenter cues biasing scores in the pre VT-stimulation trial rather than being due to a contrast effect being induced. However the experiment did find that, along with participant's speed of MI prior to VT-stimulation, the amount of ownership experienced over the elderly hand in the synchronous condition significantly predicted the speed of imagined movement in the subsequent MI task, with greater ownership predicting slower imagined movements.

4.4. General Discussion

The experiments reported in this chapter sought to investigate first whether synchronous VT-stimulation over an elderly hand would lead to a change in perceived ownership of the elderly hand and second whether this multisensory induced ownership of an elderly hand would have the effect of slowing down participants' imagined movement speed during a MI task. The results of both experiments suggested that synchronous VT stimulation could induce the feeling of body ownership over the elderly hand, as in both experiments participants gave significantly higher responses to the ownership questions in the synchronous condition as opposed to the asynchronous condition.

Regarding the second question of whether multisensory induced ownership of an elderly hand would affect participants imagined movement speed, the results of the current study offered partial evidence in support of the hypothesis that it does. In experiment 4.1 it was found that, adjusting for baseline there was an almost significant *decrease* in the time taken to perform the reaching task in the synchronous condition compared to the asynchronous condition, meaning that experiencing synchronous multisensory stimulation had actually led participants to imagine moving more quickly than had experiencing asynchronous stimulation. In addition no relationship was found between participants' rating of body ownership and their speed of imagined movement in the MI task. Experiment 4.2 was conducted using a within subject design to ensure that this increase in speed of imagined movement was not due to any unconscious cues given by the experimenter during the pre-VT stimulation MI task. The results of experiment 4.2 showed no significant differences in speed in the MI task between the synchronous and asynchronous conditions suggesting that the almost significant increase in imagined movement speed found in experiment 4.1 was due to an experimenter effect. However, when data from the synchronous condition was examined it was found that, taking into account participants speed in the pre-stimulation condition, the amount of ownership experienced over the elderly hand significantly predicted the time taken to complete the imagined movements in the post-stimulation condition. This finding suggests that, in line with the original hypothesis, experiencing body ownership over an elderly hand can slow down the imagined speed of one's own hand movements. The implications of these findings will now be discussed.

The experiments reported in this chapter make a novel contribution to the literature by showing, for the first time, that synchronous multisensory stimulation is capable of inducing the feeling of body ownership over a hand with the appearance of a different age than that of the participant. Taken together with the results of experiments 2.1 and 2.2, which demonstrated that it was possible to induce body ownership over a hand of a different skin colour to that of the participant, the current study further demonstrates the relatively low importance of the surface visual features of the foreign hand for the induction of a sense of body ownership over it. In terms of the comparator model of body ownership but forward by Tsakiris (2010) the results of this study suggest that the age of the foreign hand, like other surface level features, is involved as a comparator only at a very late stage in processing, if at all.

It is important to note however that in neither experiment in the current chapter was the amount of ownership felt over the old hand directly compared to the amount of ownership felt over a hand of a more similar age to that of our participants. At this point therefore it is unclear whether the pattern of effect found in chapter 2 for hands of a different skin colour, i.e. an effect of the age of the hand on introspective ratings of body ownership but not on proprioceptive drift or SCR results, would hold in this case. Future research using a within subjects design and employing behavioural and physiological measures of embodiment would help to further address this question.

The second important finding to come out of these studies is the significant relationship between the experience of ownership over the elderly hand and the speed of imagined movements found in the synchronous condition in experiment 4.2. This finding suggests, in line with the findings of previous studies (Bargh et al., 1996; Branaghan & Grey, 2010; Cesario et al., 2006; Chambon et al., 2008; Ginsberg et al., 2012; Kawakami et al., 2002; Wyer et al., 2011) that increased association between one's self and exemplars of the elderly stereotype can lead to a change in movement speed as a consequence of the stereotypical association between slowness and old-age. A novel results of the current study is that while in previous studies the effect of elderly primes were compared to that of neutral primes(Bargh et al., 1996; Branaghan & Grey, 2010; Cesario et al., 2006; Chambon et al., 2008; Kawakami et al., 2002; Wyer et al., 2011) or primes of a different stereotype (Ginsberg et al., 2012; Kawakami et al., 2002) in the current study the stimuli used in the experimental and control conditions were identical and only the shared sensory stimulation between that stimuli and the participant's differed. Moreover it was the amount of embodiment of the elderly hand in the synchronous condition, rather than a pure difference between conditions, that predicted a slower movement speed in the subsequent MI task.

In addition the current finding builds on the finding by Wryer et al. (2011) in showing that the effect of stereotype priming on behaviour is mediated by the association between the primed stereotype and the self. However, an important distinction between the current study and that of Wryer et al.'s is that in their case this association was between the primed stereotype and participant's self-concept, while in experiment 4.2 the association was between the participant's own body and the elderly hand. Thus the current finding again underlines the strong links between changes in bodily selfhood and changes in more cognitively complex forms of self-identification that has previously been shown in study 3.1.

The current study also demonstrates a link between stereotype activation and MI, adding MI to the already reported effects of stereotype activation on a wide range of different tasks including driving speed in a driving simulator (Branaghan & Grey, 2010), ratings of the perceived speed of a stick figure (Aarts & Dijksterhuis, 2002) and perception of time (Chambon et al., 2008). In addition by showing that stereotype activation can influence imagined as well as actual motor behaviour the current study's findings further emphasise the close links between MI and actual motor performance (Decety & Michel, 1989; Jeannerod, 1994; Lorey et al., 2011; Maruff et al., 1999; Oosterhof et al., 2012).

One apparent weakness of the results of the current study is the failure to find any effect of embodiment scores on post-VT stimulation MI in study 4.1. However, this failure to find an effect is not surprising given the significant difference in pre-stimulation MI between those in the synchronous and asynchronous groups in experiment 4.1, which led to an almost significant difference between the adjusted post-stimulation MI times, with synchronous stimulation leading to faster reaction times than asynchronous stimulation.. It seems likely, given the failure to replicate this effect in experiment 4.2,that the difference in pre-stimulation MI times in experiment 4.1 was due to subtle cues from the experimenter, which may have inadvertently disrupted any potential link between experienced ownership over the elderly hand and post-stimulation MI times.

Finally I will briefly discuss two potential ways that the findings in this study can be expanded upon in the future. One potentially fruitful direction for future research would be to investigate whether the current result showing an effect of body ownership on MI times also holds for actual motor actions. This could be examined by using a visuomotor version of the rubber hand illusion (Riemer et al., 2013; Sanchez-Vives et al., 2010; Slater, Perez-Marcos, Ehrsson, & Sanchez-Vives, 2008). In this study one could manipulate the congruency of the visually perceived movements of an old hand and the voluntary movements of a participant would be able to modulate MI or motor performance in the expected direction. The most obvious way to achieve this is using a virtual reality setup of the kind employed by Slater and colleagues (Banakou et al., 2013; Kilteni, Normand, Sanchez-Vives, & Slater, 2012; Peck et al., 2013; Slater, Perez-Marcos, Ehrsson, & Sanchez-Vives, 2009). In such a setup the appearance of an elderly arm, or even a full elderly avatar, would be able to be linked to the movements of the participant, the counterpart of the synchronous condition used in the current experiments, or else the movements of the avatar would be autonomous from those of the participant, the counterpart of the asynchronous condition in the current experiments. Indeed this virtual reality technique has already been used to manipulate adults into feeling that they are in a child's body and been shown to lead to more positive implicit attitudes towards children (Banakou et al., 2013).

The second potential avenue of research is to investigate whether giving elderly people the feeling of body ownership over a younger hand would lead to an increase in their MI. Saimpont, Malouin, Tousignant and Jackson (2013)reviewed studies on MI in the elderly and highlighted the potential benefits of MI training in maintaining and enhancing motor abilities. If it is indeed the case that body ownership of a young hand could speed up elderly participants imagined movements then such an intervention could also prove beneficial in improving the speed of actual body movements in the elderly.

To conclude the two experiments reported in this chapter demonstrated first that it is possible for participants to experience the feeling of body ownership over a hand that is considerably older than their own. In addition experiment 4.2 demonstrated that those participants who showed greater embodiment of the elderly hand subsequently showed slower imagined movements, suggesting that experiencing body ownership over an elderly hand can have similar effects on behaviour as being primed with stimuli related to elderly stereotypes.

Chapter 5. Trust in Me: Investigating the Relationship between Trust and Body Representation[4]

"Trust thyself: every heart vibrates to that iron string"

Ralph Waldo Emerson, (1841, p. 52)

5.1. Introduction

The studies detailed so far in this thesis have been concerned with the power of multisensory-induced changes in body representation to create an association between the self and a different social group, be that a racial out-group or the elderly. In the final two experimental chapters of the thesis I will shift my focus away from social groups and instead examine the relationship between representations of one's own body and interpersonal interactions. In the current chapter I present two studies that focused on examining the relationship between the representation of one's own face and judgements on the trustworthiness of others.

The move from investigating the importance of body representations in the experience of social groups to investigating the importance of body representations when interacting with a specific individual necessitates a move away from hand centred body representations and towards representations of the face. The face is by far the most distinguishing and recognisable part of both one's own body and the bodies of other people and is also the most important part of the body for social interaction (Zebrowitz & Montepare, 2008). Indeed the ability to recognise one's own face in the mirror is considered to be a key milestone in the development of a

[4] Experiment 5.3 is published as:

Farmer, H., McKay, R. & Tsakiris, M. (2014) Trust in me: trustworthy others are seen as more physically similar to the self. *Psychological Science*, *25*(1), pp. 290-292.

self-concept as it requires the ability to match the image of one's face seen from an external perspective with an internal representation of the self (Verosky & Todorov, 2010), thus demonstrating the bridging of a gap between the way that we perceive ourselves and the way that others see us which is vital for later social cognitive processes such as perspective taking.

There is considerable evidence for the rapid and unconscious processing of both the identity of a face (X. Zheng, Mondloch, & Segalowitz, 2012) and of facial expression (Batty & Taylor, 2003; Eger, Jedynak, Iwaki, & Skrandies, 2003; Fox et al., 2000; Hansen & Hansen, 1988; Smith, 2012). In addition there is evidence for strong links between the visual observation of emotional expressions on another person's face and motor systems involved in the display of the same expression on one's own face. People automatically mimic the facial expressions of others (Dimberg & Thunberg, 1998; Hess & Blairy, 2001; Sato & Yoshikawa, 2007) and this mimicry occurs even in situations where the other's facial expression is only unconsciously perceived (Dimberg, Thunberg, & Elmehed, 2000).

Another source of evidence for the importance of faces in social interaction comes from findings that social deficits are often liked to problems in forming or processing facial features and expressions. For example, it has been suggested that part of the explanation for the social deficits found in people with autism is due to their abnormal processing of social and emotional information from faces (Adolphs, Sears, & Piven, 2001). A similar account has been put forward to explain some of the difficulties with social interaction observed in people with schizophrenia (Marwick & Hall, 2008). Further evidence for the intrinsically social nature of faces are the facts that people with social phobia avert their attention away from faces (Y.-P. Chen, Ehlers, Clark, & Mansell, 2002) and show neural differences from healthy controls across a range of brain areas involved in face processing (Amir et al., 2005; Gentili et al., 2008; Phan, Fitzgerald, Nathan, & Tancer, 2006; Stein, Goldin, Sareen, Zorrilla, & Brown, 2002). Of course this relationship between facial expressions and social interaction can also be disrupted in the other direction. This appears to be the situation of people with Moebius syndrome, a congenital condition which causes an inability to form facial expression, who often report feelings of decreased social competence due to their inability to facially express their thoughts and emotions expressions during social interaction (Bogart & Matsumoto, 2010; Cole, 2009).

The large amount of evidence for the social nature of face stimuli makes it unsurprising that facial appearance is often and automatically used as a guide to a person's character and personality (Berry & McArthur, 1986; Todorov, 2008). Hassin and Trope (2000) point out that, at least until very recently the face of an interaction partner has almost always been visible during social interaction and that facial features, unlike facial expressions, are difficult to wilfully alter through behaviour. People generally feel that the facial features of others are a reliable guide to their character. Liggett (1974) reported that 90% of undergraduate students believed that the face is a valid guide to character while Hassin and Trope (2000) found that 75% of students held this belief. A number of studies have shown that these views do have an effect on real world decisions. Facial features can predict a number of important social outcomes including election results (Little, Burriss, Jones, & Roberts, 2007; Spezio et al., 2008; Todorov, Mandisodza, Goren, & Hall, 2005), promotion in the military (Mazur, Mazur, & Keating, 1984), the amount of money offered to people during economic games (Krumhuber et al., 2007; Stirrat & Perrett, 2010; R. K. Wilson & Eckel, 2006) and criminal sentencing decisions (Blair, Judd, & Chapleau, 2004).

Todorov and colleagues suggested that judgements of personality rely on two key dimensions of facial features; dominance, which is related to cues for physical strength such as maturity and masculinity; and valence/trustworthiness, which is related to the subtle resemblance of neutral faces to positive or negative expressions (Todorov, Said, Engell, & Oosterhof, 2008). Other studies have however pointed towards an additional factor that affects judgements of personality from faces, the similarity between one's own face and the observed face. Using computer generated images that merge a certain percentage of the participants face into the face of the person whose traits they have to judge, DeBruine and colleagues have shown that facial similarity leads to increased cooperation in both trust games (DeBruine, 2002) and common goods games (Krupp, DeBruine, & Barclay, 2008) and increased attributions of trustworthiness (DeBruine, 2005).

Hassin and Trope (2000) considered two different ways in which judgements of personality and faces could interact. The first way, reading from faces, involves using facial characteristics to make an inference about the character of the observed person while the second, reading to faces, takes place when verbal or behavioural information about the character of another person changes judgments about that person's facial features. In a series of experiments Hassin and Trope demonstrated that a person's facial characteristics could affect the interpretation of ambiguous verbal information about their character and their decision about a candidate's suitability for a job. They also found evidence for reading to faces showing that people described as being kind were perceived as more attractive and as being more "baby faced" than those who had been described as mean. Finally Hassin and Trope also found that two people described as having similar personalities were also rated as having more similar faces. A similar study by Paunonen (2006) found that people judge the face of a person described as honest as being more attractive and looking more physically fit than the same face when it was attributed to a person described as being dishonest.

Given the importance of faces for social cognition a number of recent studies have sought to investigate how multisensory stimulation can alter both the physical representation of the self-face and the sense of social closeness between self and other. These studies have used the paradigm of interpersonal multisensory stimulation (IMS) or "enfacement" developed by Tsakiris (2008) to examine these questions. In this paradigm participants watched another person receiving tactile stimulation while their own face was touched either synchronously or asynchronously with what they saw on the screen.

Tsakiris (2008) presented videos of the participant's face morphing into that of the person whose face they saw being stroked, i.e. going from 100% self to 100% other, or vice versa and instructed participants to stop the movie when they felt that the face was starting to look more like self than other, or vice versa, depending on the morphing direction displayed in the movie. It was found that after synchronous, but not asynchronous, stimulation participants showed a bias in recognizing their own face, judging a greater number of the frames as containing more self than other than they had in pre-stimulation trials. This indicates that IMS changes the mental representations of the self's physical appearance and leads to the face of the other being perceived as more similar to one's own. Several other studies have since replicated this finding of increased facial similarity using similar morphed images (Sforza, Bufalari, Haggard, & Aglioti, 2010; Tajadura-Jiménez, Grehl, & Tsakiris, 2012) and also using questionnaire measures (Mazzurega, Pavani, Paladino, & Schubert, 2011; Paladino et al., 2010; Tajadura-Jiménez, Longo, Coleman, & Tsakiris, 2012; Tajadura-Jiménez & Tsakiris, In Press). In addition Cardini, Tajadura-Jiménez, Serino, & Tsakiris (2013) showed that synchronous IMS led to an increase in the strength of the visual remapping of touch effect when applied to another person.

Direct evidence of a distinctly social effect of IMS was first reported by Paladino et al. (2010). The authors found that, compared to asynchronous visual tactile stimulation, synchronous stimulation caused participants to feel socially closer and more affiliated to the other person as well as viewing them as more physically similar to themselves. They also projected their own attributes onto the other more and showed greater conformity to the other's judgement about the number of letters on a screen. Several other studies have also highlighted the social aspects of IMS, Tajadura-Jiménez, Longo, et al. (2012) used questionnaire items to run a principal component analysis on the conscious experience of the changes in self-identification produced by IMS and identified changes to affective feelings towards the other as one of the three key components of the illusion with participants viewing the other as both more trustworthy and more attractive after synchronous stimulation. Maister, Tsiakkas and Tsakiris, (2013) demonstrated that the enfacement illusion also facilitates emotion recognition, specifically fearful facial expressions, while Beck, Bertini and Ladavas (2012) found that the effect of synchrony was abolished if the other person displayed a fearful facial expression. In addition Sforza et al. (2010) showed that individual differences in social cognition could affect how strongly self-other merging was perceived, with more empathic individuals showing a greater effect of self-other merging on the self-face recognition task. This link between empathy and self-other merging has also been found in studies using the RHI (Asai et al., 2011).

The ample evidence for the importance of face representation in social cognition and of the power of IMS to affect perceived physical and social closeness suggests that one potentially fruitful area of research would be to investigate the relationship between representations of one's own face and the faces of others and the amount of trust between self and others. Investigating this relationship is of value due to the importance of trust in social interaction. Trust is one of the most important components for the development and maintenance of happy, well-functioning relationships (Fehr, 1988; Regan, Kocan, & Whitlock, 1998; Simpson, 2007) and also plays a key role in promoting cooperation between group members and allowing the development of long term reciprocal exchanges that are a key part of larger societies (K. S. Cook & Cooper, 2003; Walker & Ostrom, 2009)

A number of models have been proposed to examine trust but one of the most influential is that developed by Mayer, Davis, and Schoorman (1995) which defines trust as the willingness of a trustor to be vulnerable to the actions of a trustee based on the expectation that the trustee will perform a particular action. A second model developed by Rousseau, Sitkin, Burt and Camerer (1998) defines trust as a psychological state comprising the intentions to accept vulnerability based on positive expectations of the actions of the trustee. Both of these models have two key components of trust the first being willingness to accept vulnerability and the second the expectation that the trustee will act so as to give the trustor a positive outcome. In addition Mayer et al. distinguished trust from trustworthiness which was based on three distinct characteristics of the trustee (ability, benevolence, and integrity) and also trust from trust propensity. Trust propensity is considered as the stable trait likelihood of trusting another person while trust itself is considered as a situational state of deciding to trust another person and is determined by a combination of trust propensity and the three aspects of trustworthiness applied to the other person.

In the studies reported here trust was measured (experiments 5.1 and 5.2) or manipulated (experiment 5.3) by means of a trust (or investment) game. Developed by Berg, Dickhaut and McCabe (1995) based on an earlier more complex version developed by Camerer and Weigelt (1988) the trust game involves a sequential exchange in which there is no contract to enforce agreements. Subjects are endowed with a starting amount of money, anonymously paired and assigned to either the role of trustor or trustee. At stage one of the game, the trustor may either pass nothing, or any portion of the endowment to the trustee. The trustor then keeps the remainder of the endowment and the experimenter triples the money that is passed onto the trustee. In stage two, the trustee may either pass nothing, or pass any portion of the money received back to the trustor. The amount passed by the trustor is said to capture trust, "a willingness to bet that another person will reciprocate a risky move (at a cost to themselves)", and the amount returned to the trustor by the trustee to capture trustworthiness (Camerer, 2003, p. 85).

Several studies have investigated the relationship between responses in the trust game and other more explicit measures of trust such as responses to trust questionnaires. Ashraf, Bohnet and Piankov (2006) investigated the factors associated with the amount returned in the trust game and found that the amount of money sent by the trustor to the trustee was best predicted by a model that included both the amount of money expected to be returned and unconditional kindness. Ashraf, Bohnet and Piankov also found that unconditional kindness, not reciprocity, was the most significant predictor of the amount of money returned in the game. In addition Chaudhuri and Gangadharan (2007) found a strong influence in the expected amount of money returned on the initial amount of money sent by the trustor. These findings suggest that the expectation of the trustee reciprocating trust and returning a reasonable amount of money is a key factor in the amount of money that trustors chose to send, a result which is in line with Mayer et al.'s (1995) emphasis on expectations of a positive outcome when defining trust.

Other studies by Glaeser, Laibson, Scheinkman and Soutter (2000) and Gächter, Herrmann and Thöni (2004) found that the amount sent by trustors during the first round of a trust game are correlated with survey questions on past trusting behaviour and a question on trust in strangers but not when examining trust towards institutions or familiar others. Naef and Schupp (2009) found a similar result using a different questionnaire as did Johansson-Stenman, Mahmud and Martinsson (2013) in a study examining offers in trust games between Bangladeshi villagers. These findings suggest that, at least in trust games involving strangers, in terms of the components of trustworthiness defined by Mayer et al. (1995) the amount of money returned in the trust game is best seen as measuring the benevolence, as opposed to ability or integrity, of the trustee.

The above review of the literature demonstrates both the importance of face representation and the power of trust games to measure changes in trust towards others and to impact on the perception of other's trustworthiness. The two studies reported here aimed to examine the existence of reciprocal relationship between face representation of self and other and trust as measured by the amounts given and received in the trust game.

In the terminology used by Hassin and Trope (2000) experiment 5.1 attempted to examine the effect of reading from faces by using IMS to increase the perceived similarity between participants' own faces and the faces of a partner in the trust game. It was hypothesised that participants acting as the trustor would send larger amounts of money to the trustee after experiencing synchronous IMS with them than when they had experienced asynchronous multisensory stimulation. Experiment 5.3 in contrast sought to investigate reading into faces by discovering whether learning, through a trust game interaction, that a person was trustworthy or untrustworthy affected the perceived similarity between the participants' own face and the face of the trustee. It was hypothesised that after learning that the trustee was trustworthy participants would perceive their own face to be more similar to that of the trustee than they would after learning that the trustee was untrustworthy.

5.2. Experiment 5.1

5.2.1. Introduction

Experiment 5.1 is, to the best of my knowledge, the first to test whether the experience of IMS would affect the amount of money sent while in the trustor role in a trust game. It was hypothesised that participants who received synchronous stimulation would offer larger amounts of money in the trust game than those who received asynchronous stimulation. This hypothesis was based on three considerations. The first is the finding that synchronous IMS leads to increased ratings of trust in the stimulation partner (Tajadura-Jiménez, Longo, et al., 2012). Based on this it seems reasonable to assume that behavioural measures of trust will also be affected by IMS. The second consideration is the known effect of synchronous movement to increase prosocial offers in the trust game and other economic games (Launay et al., 2013; Wiltermuth & Heath, 2009), based on this it is assumed that exposure to synchronous multisensory events in this study will result in similar effect. The third consideration is based on the finding that facial similarity leads to increased cooperation in trust games (DeBruine, 2002) and the finding that IMS leads to an increase in perceived facial similarity (Mazzurega et al., 2011; Paladino et al., 2010; Sforza et al., 2010; Tajadura-Jiménez, Grehl, et al., 2012; Tajadura-Jiménez, Longo, et al., 2012; Tajadura-Jiménez & Tsakiris, In Press; Tsakiris, 2008). Combining these findings suggests that the increase in facial similarity produced by IMS might increase the amount of money sent in the trust game.

5.2.2. Methods

5.2.2.1. Design

The study used a between subjects design with one factor: synchrony of VT stimulation (synchronous, asynchronous). The dependent variables were: the amount of money that participants sent to the trustee in the trust game; the amount of money they expected the trustee to return; their responses to nine statements on a 7 point Likert scale taken from Tajadura-Jiménez, Longo, et al. (2012), their ratings of how close they felt to the trustee using the Inclusion of Other in the Self (IOS) scale (Schubert & Otten, 2002) and their rating of how dominant they felt using the pictorial dominance scale (Bradley & Lang, 1994). The measure of dominance was to examine whether the greater feeling of interpersonal closeness to the other that was expected to be experienced in the synchronous condition would also lead to a feeling of greater efficacy due to being the member of a larger group.

5.2.2.2. Procedure

Participants attended one experimental session. They first completed a demographic questionnaire which asked their age, gender and ethnic background. Following this the rules of the trust game (presented as a social interaction in order to prevent any framing effects) were explained to the participant. In this game the participant took the role of the trustor and had to decide how much of a £5 endowment (in £1 increments) to transfer to the trustee, a photograph of whose face was presented on the screen during the trust decision. The interaction in the study used the 'strategy' method (Brandts & Charness, 2011). Participants were informed that the trustees had previously made a series of hypothetical back-transfer decisions, one for each of the possible transfers that the trustor could make and that they would be paid for the study based on these previously made decisions. Participants were also informed that the trustee would be paid for their part in the study based on the amount sent to them by a randomly selected participant meaning that their decision in the trust game could potentially affect the amount of money that the trustee was paid.

Following the explanation of the game participants were presented with six questions about how the trust game worked to ensure that they had understood all the key aspects of the trust game (see Table 5-1). Participants then viewed a video of the trustee, who was always a stranger of the same sex as the participant, being stroked on their left cheek by a cotton bud. Participants were stroked with a cotton bud on their own cheek either synchronously or asynchronously with respect to the strokes the participant could observe in the video.

The stimulation period lasted for two minutes after which the participants were requested to make their decision about how much money they wished to transfer to the trustee. Participants were then asked to state how much money they expected the trustee to return to them. Participants then completed a nine item enfacement questionnaire, three of these questions loaded on to the self-identification factor, three loaded on to the similarity factor, two loaded onto the affect factor and the final question being on feelings of affiliation (Tajadura-Jiménez, Longo, et al., 2012). Participants then rated: their relationship with the actor they played the trust game with using the Inclusion of Other in the Self scale (Schubert & Otten, 2002); how dominant they felt using a pictorial dominance scale (Bradley & Lang, 1994); their general trust for strangers using a scale developed by Naef and Schupp (Naef & Schupp, 2009) and their propensity towards risk taking using 10 point Likert scale. Finally participants viewed pre-recorded videos of the trustees stating how much money they had decided to return to the trustor and were paid for the study based on the amount of the pot the trustee had returned and whatever was left from their original endowment (see Figure 5-1).

Table 5-1. List of the 6 instruction questions and their correct answer.

Question	**Correct Answer**
"How many one pound coins will you be given at the start of the interaction?";	5
"How many one pound coins does the other person start the interaction with?"	5
"What is the maximum number of one pound coins you can transfer to the other person?"	5
"True or false: You must transfer some of the money to the other person? (Please enter "T" for true or "F" for false.)"	False
"If you transfer £3 to the other person, how much will they receive?"	£9
"If you transfer £3 to the other person and they return £5, how much will you leave the interaction with?"	£7

5.2.2.3. Participants

33 participants (mean age ± *SD*: 22.6 ± 3.7, 5 male, 16 asynchronous) took part in the study. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

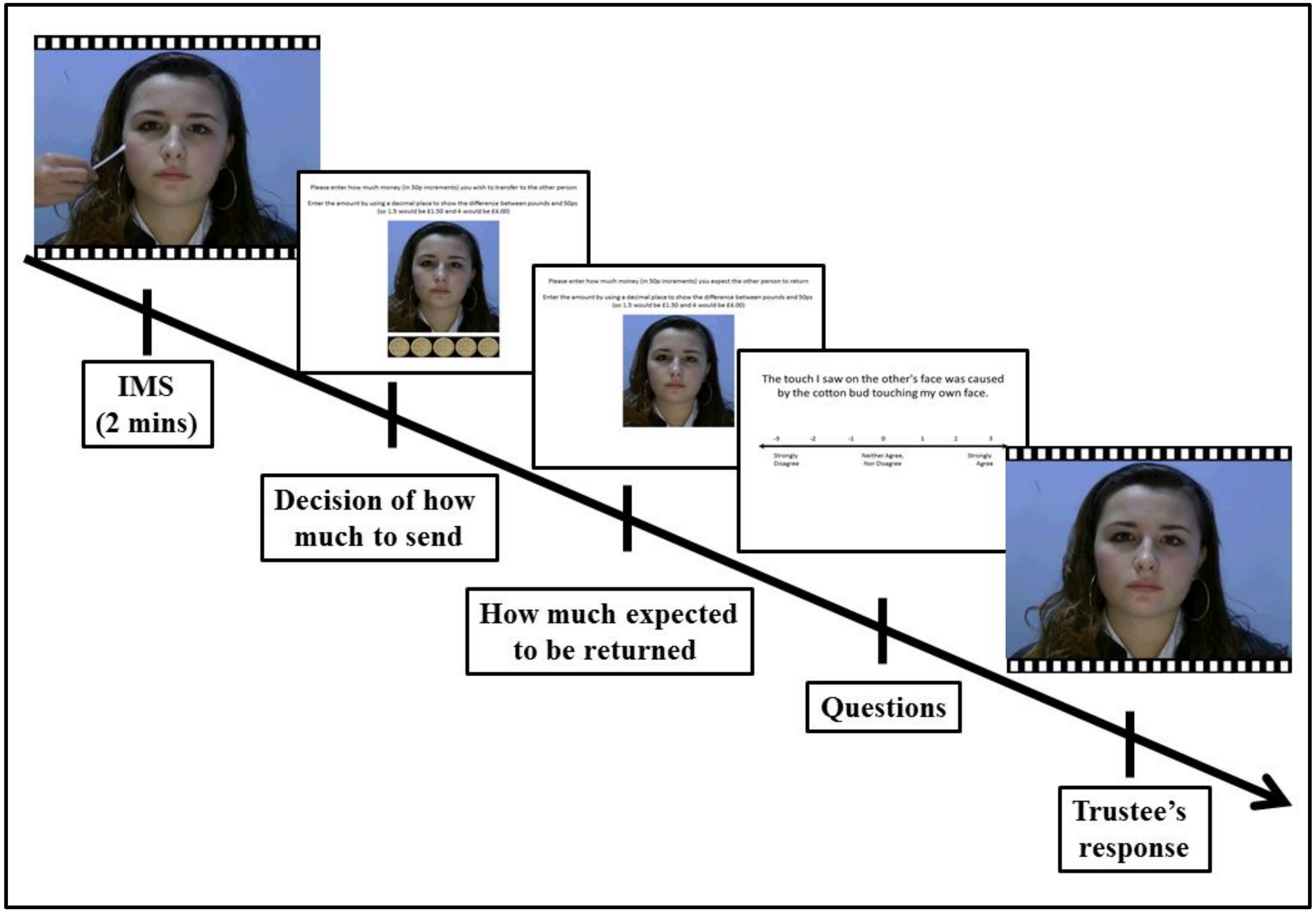

Figure 5-1. Procedure of Experiment 5.1.

5.2.3. Results

5.2.3.1. Participants Ratings of General Trust towards Strangers and Risk Taking

To test that there were no significant differences between the synchronous and asynchronous groups in their general trait trust towards strangers and willingness to take risk, independent sample t-tests were carried out on the mean response to the four questions in the trust questionnaire and the Likert scale rating of risk taking.

No significant difference between the two groups was found in either their general trust towards strangers, $t(31) = -0.91$, $p>.05$, (synchronous: M = 2.29, SD = 0.38; asynchronous: M = 2.42, SD = 0.43) or their rating of risk taking, $t(31) = -1.39$, $p>.05$, (synchronous: M = 5.71, SD = 1.93; asynchronous: M = 6.56, SD = 1.59).

5.2.3.2. Introspective Rating of the Enfacement Illusion

In order to investigate the effect of synchrony of IMS on participants' ratings of the enfacement illusion, independent sample t-tests were carried out for each of the 9 questions taken from Tajadura-Jiménez, Longo, et al.'s (2012) enfacement questionnaire with synchrony of IMS as the independent variable. Significant results at the two tailed level were found for two of the questions regarding their experience of enfacement and two other questions were significant at the one tailed level, (see Table 5-2).

To further investigate these effects the scores for the three questions that loaded onto the self-identification factor and the similarity factor of Tajadura-Jiménez, Longo, et al.'s (2012) principle component analysis and the two questions that loaded on the affect factor plus the affiliation question were separately averaged together and independent samples t-tests were run on the resultant 3 variables. In the affect and affiliation factor significantly higher ratings were found for the synchronous condition (M = 1.08, SD = 1.01) compared to the asynchronous condition (M = -0.06, SD = 1.26) at the two tailed level, $t(31) = 2.88$, $p < .01$. In the self-identification factor significantly higher ratings were found for the synchronous condition (M = 0.31, SD = 1.88) compared to the asynchronous condition (M = -0.48, SD = 1.76) at

Table 5-2. Summary of the results of t-tests conducted on the 9 Questions taken from Tajadura-Jiménez, Longo et al. (2012). (* = significant at the 1-tailed level, ** = significant at the 2-tailed level).

Question	**Factor**	**Synchronous Mean (*SD*)**	**Asynchronous Mean (*SD*)**	***t***	***p* (2-tailed)**
"The touch I saw on the other's face was caused by the cotton bud touching my own face"	Self-Identification	-0.76 (2.22)	-1.56 (1.59)	1.19	.234
"It seemed like the other's face began to resemble my own face"	Similarity	-0.35 (2.18)	-0.63 (1.75)	0.39	.696
"It seemed like I was in control of the other's face"	Self-Identification	-0.88 (1.93)	-1.68 (1.3)	1.41	.169
"It seemed like the face of the person in the video was similar to mine"	Similarity	0.41 (2)	-0.44 (1.93)	1.24	.225
"It seemed like my face was similar to the face of the person in the video"	Similarity	0.88 (1.8)	-0.38 (1.96)	1.92	.064*
"It seemed like the person in the video was attractive"	Affect	0.88 (1.05)	0.06 (1.69)	1.68	.103
"It seemed like the person in the video was trustworthy"	Affect	1.35 (1.32)	-0.13 (1.26)	3.29	.003**
"I felt that the other person was imitating me"	Self-Identification	-0.24 (1.68)	-1.31 (1.49)	1.94	.061*
"I felt affiliated with the person in the video"	None	1 (1.54)	-0.13 (1.59)	2.07	.047**

the one tailed level, $t(31) = 1.8$, $p < .05$. No significant difference was found between the synchronous condition ($M = -0.63$, $SD = 1.65$) and the asynchronous condition ($M = -1.52$, $SD = 1.12$) for the self-identification factor (see Figure 5-2).

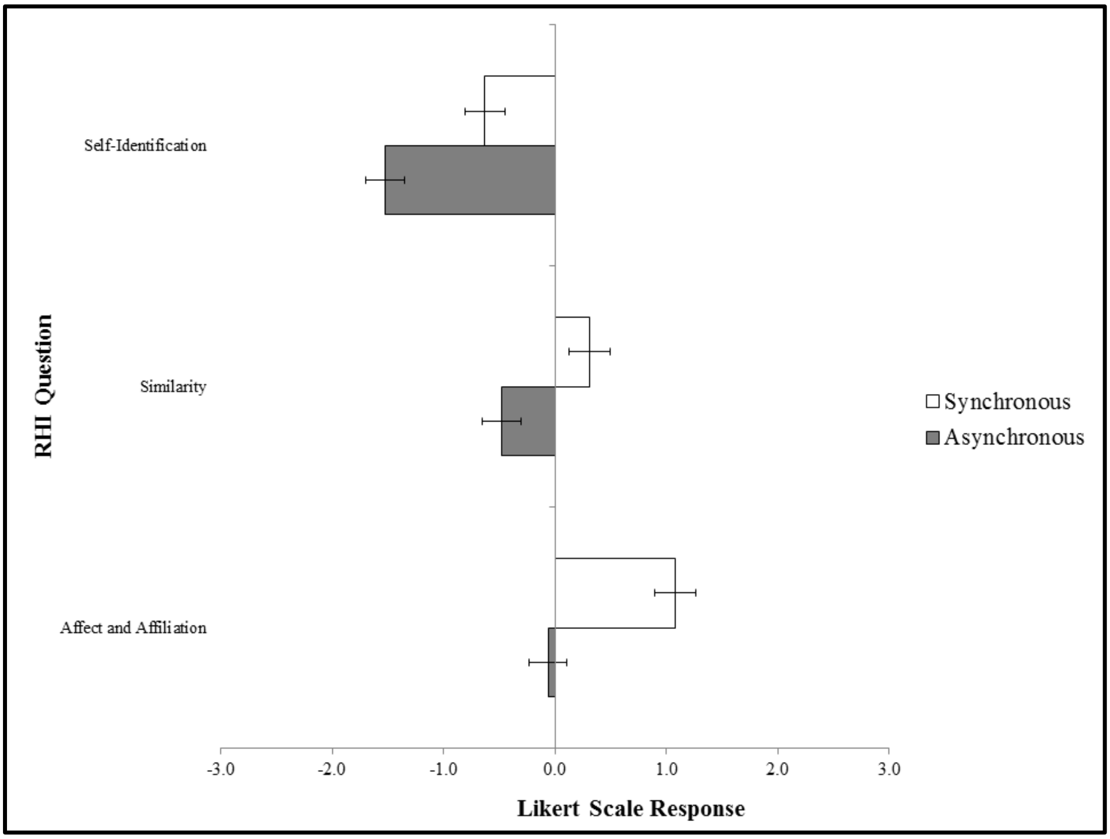

Figure 5-2. Mean Likert scores for each of the three factors across synchronous and asynchronous conditions. Error bars represent SEM.

5.2.3.3. Effect of Synchrony of IMS on Trust Game Decisions

To investigate the effect of synchrony of IMS on participant's trust decisions an independent sample t-test was carried out with the amount of money sent to the trustee in the trust game as the dependent variable and synchrony of IMS as the independent variable. No significant difference was found between the synchronous ($M = 2.41$, $SD = 1.28$) and asynchronous ($M = 2.38$, $SD = 1.26$) conditions $t(31) = 0.08$, $p > .05$,. In addition an independent sample t-test with synchrony of IMS as the independent variable and the amount of money that participants expected the trustee to return as the dependent variable was carried out to examine whether synchronous stimulation would lead to the expectation of a greater return than asynchronous stimulation. No significant difference was found between the synchronous ($M = 3.59$, *SD* = 3.39) and asynchronous (*M* = 3.36, *SD* = 1.75) conditions $t(31) = 0.23$, $p>.05$, (see figure 5-3).

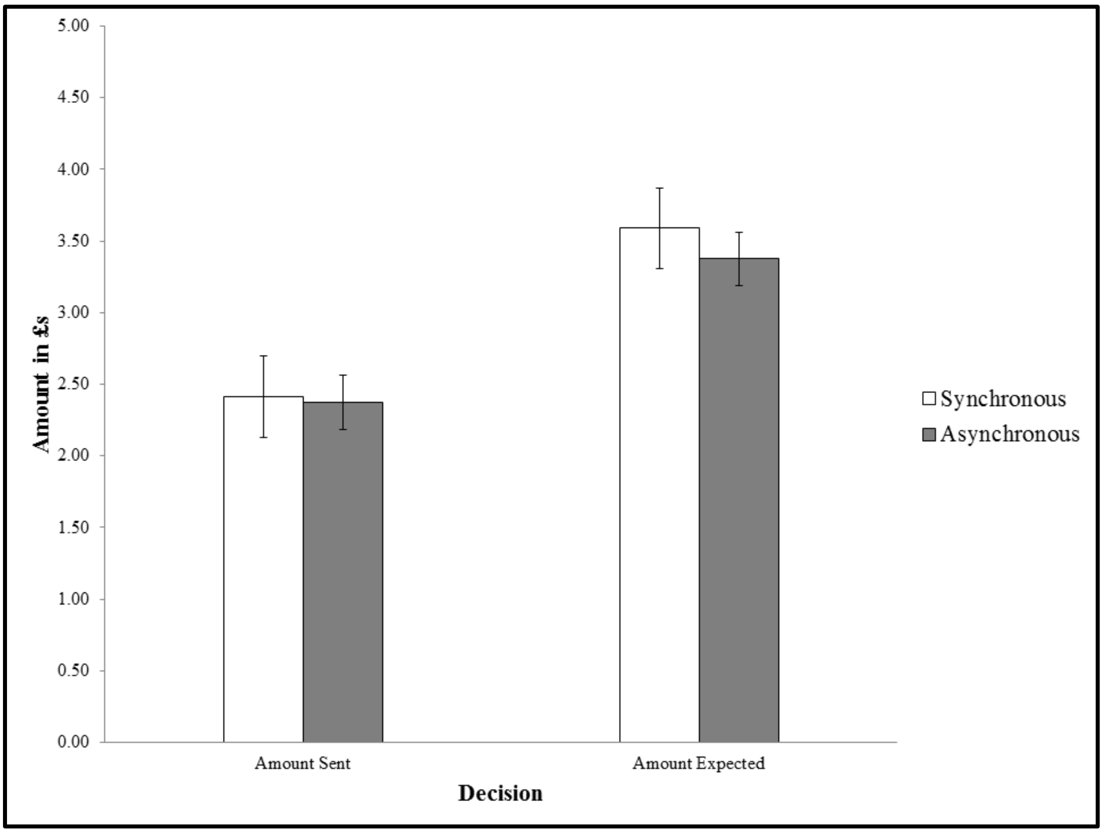

Figure 5-3. Mean amounts of money sent and expected to be returned across synchronous and asynchronous conditions. Error bars represent SEM.

5.2.3.4. Effect of Enfacement Scores on Trust Game Decisions

To investigate the effect of experiencing enfacement on participants' trust game decisions a two-step hierarchical linear regression was carried out with the amount sent to the trustee as the dependent variable. Synchrony of IMS, score on the trust questionnaire (Naef & Schupp, 2009) and scores in the three factors from the enfacement questionnaire were entered as predictor variables in the first step and the interaction terms between synchrony and each of the three factors were entered as predictor variables in the second step. The overall model fit was not significant at the first step, $F(5, 27) = 0.25$, $p > .05$, r^2adjusted = -.13 and adding the interaction terms to the model in Step 2 of the regression did not significantly improve the model fit. $\Delta r^2 = .12$.

5.2.3.5. Effect of Synchrony of IMS on IOS and Dominance Ratings

In order to investigate the effect of synchrony of IMS on participants' ratings of social closeness to the trustee and their feelings of dominance following IMS, independent sample t-tests were carried out on the IOS score and dominance ratings with synchrony of IMS as the independent variable in each. No significant differences were found in IOS score between the synchronous (*M* = 3.47, *SD* = 1.77) and asynchronous (*M* = 2.56, *SD* = 1.36) groups, $t(31) = 0.11$, $p > .05$. There was also no significant difference in dominance ratings between the synchronous (*M* = 5, *SD* = 1.7) and asynchronous (*M* = 4.25, *SD* = 1.53) groups, $t(31) = 0.19$, $p > .05$.

5.2.4. Discussion

It was hypothesized that observing touch being delivered to the face of another in synchrony with feeling touch on one's own face would lead people to see that person as more trustworthy than asynchronous touch would. The current study found limited evidence of this in so far as synchronous IMS led to higher ratings of trustworthiness and of affiliation with the VT stimulation partner, at least using the Likert scale measure, although no effect was found for the IOS ratings of social closeness. However, on the behavioural measure of trust, the amount of money sent to the other person in a trust game, there was no effect of the synchrony of IMS. This discrepancy between participants' ratings of trustworthiness and their willingness to trust the other in a behavioural task occurred despite the fact that participants took part in the trust game *before* they gave their ratings of trustworthiness about the other person, although not before discovering the amount of money that person had returned to them.

There are a number of possible reasons for this failure to find an effect of synchrony on our behavioural measure of trust. The first important point to note is that, in contrast to other studies that have investigated IMS (e.g. Paladino et al., 2010; Tajadura-Jiménez, Longo, et al., 2012)the scores on the enfacement questionnaire in the current study were relatively low with no significant difference between synchronous and asynchronous groups in their ratings of self-identification between themselves and the trustee. If the strength of the enfacement illusion plays a key role in the ability of IMS to affect trust game decisions then the failure of the current study to find an effect may be due to these weak enfacement scores.

Another possibility is that synchronous IMS has only a mild effect on social behaviour and that despite its effect on rating of trustworthiness the difference between synchronous and asynchronous IMS is not great enough to override other factors that come into play when making real decisions about how much to trust a person, such as judgements about trustworthiness based on the other persons facial characteristics. However this seems unlikely given that other studies have shown that synchronous action can lead to: increased cooperation in public goods games (Reddish et al., 2014; Wiltermuth & Heath, 2009); a positive change in attitudes towards a racial outgroup (Inzlicht et al., 2012) and increased performance in cooperative tasks (Valdesolo et al., 2010) and that synchronous VT stimulation can lead to increased conformity behaviour (Paladino et al., 2010), affect perceptual judgements of physical similarity (Sforza et al., 2010; Tajadura-Jiménez, Grehl, et al., 2012; Tsakiris, 2008) and lead to a positive change in attitudes towards a racial outgroup (see Chapter 3, study 3.1; Maister, Sebanz, Knoblich, & Tsakiris, 2013). Taking these findings into account it seems plausible that passive VT stimulation should be able to exert enough influence over behaviour for its effect on trustors' decisions to be significant.

A third possibility is that the remote nature of the trust game in the current study meant that participants did not conceptualise the trust game as necessarily involving any trust on their part. Participants were aware that the game used the strategy method and therefore that the other person's decision of how much to return had already been made and was not specifically directed towards them and this knowledge may have made them less likely to see the decision they made as involving any trust or real interpersonal interaction. Supporting this view is the fact that, ignoring any effects of synchrony, participants' score of the four item trust scale failed to predict either the offer they sent to the other person or the amount of money they expected the other person to return, The trust scale has been found to reliably track participants' offers in more conventional trust games (Naef & Schupp, 2009) which suggests that in the current study participants may not have based their decision about how much money to send the trustee on the same factors that drive decision making in a conventional trust game. Moreover participants were presumably also aware of an asymmetry between their own experience and that of the trustee in that, while they had experienced IMS with the trustee before making their decision, the trustee had had no such experience of IMS before making their decision of how much money to return. Given these considerations it is possible that making the trust interaction a real time and more obviously interpersonal situation might give a greater possibility of finding a significant effect of synchrony of VT stimulation.

A final possible explanation for the current study's failure to manipulate behavioural trust is that the one-shot nature of the task and the low number of increments that the money participants could offer in the trust game led to the study having insufficient power to find any behavioural effect of the manipulation of synchrony. This possibility is supported by data from Wiltermuth & Heath (2009)who found that synchronous action only led to significantly more cooperation than asynchronous action in the later rounds of a public goods game suggesting that part of the power of synchrony in improving cooperative behaviour is that it buffers participants against defection as the interaction continues. In addition Wiltermuth and Heath split the total allowance that participants were able to invest into the group into a greater number of increments than did the current study. It is therefore possible that, although no effect of synchronous VT stimulation on trust behaviour was found in the one shot game with only five increments used in the current study, if the trust game were to be played over several rounds or with smaller increments of money it would reveal a difference between the synchronous and asynchronous conditions.

These considerations lead to the development of a second experimental design to investigate the influence of synchronous multisensory stimulation on trust. This second study, which focussed on increasing the power of the key dependent variables of amount sent and amount expected in the current study is presented below as experiment 5.2

In conclusion the current study offered limited support for the idea that synchronous IMS could lead to an increase in trust towards one's stimulation partner by replicating the higher trustworthiness ratings after synchronous stimulation observed in Tajadura-Jimenez et al. (2012). The study also partially replicated the finding from Paladino et al. (2010) that synchronous interpersonal stimulation led to greater ratings of overall affiliation, although the current study failed to find an effect of synchrony on ratings of closeness using the IOS scale. However on the more important measure of actual behaviour in a trust game no effect of synchrony was observed. To examine whether this failure to find an effect was due to a lack of power in the design a second experiment was conducted in which participants played a series of trust games with ten different partners, with half of whom they received synchronous IMS with prior to the game and with the other half of whom they received asynchronous IMS with. In addition although the amount of money that participants had to send to each trustee was the same as in experiment 5.1 (£5) the number of increments they could offer it in was doubled from 5 to 10.

5.3. Experiment 5.2

5.3.1. Methods

5.3.1.1. Design

The study used a within-subjects design with one independent variable, the pattern of IMS (synchronous, asynchronous). The dependent variables were the amount of money participants sent to the trustees and the amount of money they expected trustees to return.

5.3.1.2. Apparatus and materials.

Fourteen videos of different female models receiving tactile stimulation to their left cheek were recorded. The faces of these models were then rated for attractiveness and trustworthiness by ten females who did not participate in the study. On the basis of these ratings ten of the videos were selected and split into two groups each with approximately equal overall attractiveness (group 1: M = 1.39, SD = 2.01; group 2: M = 1.51, SD = 2.43, $t(8) = -0.09$, $p > .05$) and trustworthiness (group 1: M = 4.79, SD = 0.68; group 2: M = 4.66, SD = 1.3, $t(8) = 0.2$, $p > .05$). For each participant one of these groups was presented in the synchronous condition and the other in the asynchronous condition. The pattern of stimulation applied to each group was counterbalanced across participants.

5.3.1.3. Procedure

Participants attended one experimental session. They first completed a demographic questionnaire which asked their age, gender and ethnic background. Following this the rules of the trust game (presented as a social interaction in order to prevent any framing effects) were explained to the participant. Participants were told they would play a series of trust games in the role of the trustor. As in experiment 5.1 the interaction used the 'strategy' method (Brandts & Charness, 2011). The current experiment did however have a number of changes to the trust game. Participants were given an endowment of £5 for each game but this time they could send this money in £0.50p increments, doubling the number of possible amounts that could be sent. In addition participants were informed that only one of the ten trustees had made a series of hypothetical back-transfer decisions and that they would be paid for the study based on these previously made decisions and their decision of how much to offer that trustee. Participants were not however told which of the ten trustees had actually made their decisions. This method ensured that participants had to treat each of the interactions as potentially involving a real decision. Participants were also informed that the trustee who had made the back transfers would be paid for their part in the study based on the amount sent to them by a randomly selected participant meaning that their decision in the trust game could potentially affect the amount of money that the trustee was paid.

Following the explanation of the game participants were presented with five of the six questions (question 3 was omitted) about how the trust game worked from experiment 5.1, to ensure that they had understood all the key aspects of the trust game (see Table 5-1). Participants then began their ten trust game interactions. In each interaction participants saw a video of one of the models, being stroked on their left cheek by a cotton bud. Participants were stroked with a cotton bud on their own cheek either synchronously or asynchronously with respect to the strokes the participant could observe in the video. The experimenter administering the VT-stimulation was cued as to the pattern of stimulation in each video by the appearance of a vertical (synchronous) or horizontal (asynchronous) line that appeared for two seconds prior to the presentation of each video and was naïve of the purpose of the study.

The stimulation period lasted for ninety seconds after which the participants were requested to make their decision about how much money they wished to transfer to the trustee. Participants were then asked to state how much money they expected the trustee to return to them (See Figure 5-3).They then moved on to the next video. At the completion of all 10 interactions participants were informed of how much money they had earned in the interactions, based on the amount of money that the trustee had returned and whatever was left from their original endowment, and were paid for the study based on this amount and an additional £5 for taking part in the study. They were also asked to complete a debriefing sheet consisting of five questions (see Table 5-3).

5.3.1.4. Participants

15 female participants (mean age ± *SD*: 23.9 ± 2.9) gave their informed consent to participate and were paid for their participation. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

Table 5-3. List of the 5 debriefing questions with examples of answers indicating an awareness of the hypothesis.

Question	**Example Answer**
"What do you think the purpose of this experiment (the whole thing) was?"	“I think I was supposed to give more money to the people who had their faces touched in synchrony with the touching of my face.”
"Did anything about the experiment seem strange to you?"	“That synchronous stroking makes the other persons face to feel like mine.”
"How did you decide how much money to send?"	No answers indicating awareness given by participants but an example would be “I gave more when there was synchronous stroking.”
"Did you think that any of the different parts of the study were related in any way? If yes how?"	“Yes simultaneous strokes can probably help empathise with strangers and we may be more likely to give more money as a resut.”
"Did anything in one part of the study affect your decisions in another part?"	“I tried to remember what I had given people before to make it fair. If I was being stroked at the same time as the person in the video I was more likely to give more money.”

5.3.2. Results

5.3.2.1. Effect of Synchrony of IMS on Trust Game Decisions

To investigate the effect of synchrony of IMS on participant's trust decisions, the mean value of the amount of money sent to the trustee and the amount of money expected to be returned by the trustee was calculated for both the synchronous and asynchronous conditions. A paired sample t-test was carried out with the mean amount of money sent to the trustee in the trust game as the dependent variable and synchrony of IMS as the independent variable. It was found that the amounts sent in the synchronous condition ($M = 2.77$, $SD = 0.85$) were significantly higher than those sent in the asynchronous condition ($M = 2.06$, $SD = 0.84$) conditions $t(14) = 4.13$, $p < .01$. A second paired sample t-test was carried out with the mean amount of money expected to be returned by the trustee as the dependent variable and synchrony of IMS as the independent variable. It was found that the amounts sent in the synchronous condition ($M = 3.43$, $SD = 1.67$) were significantly higher than those sent in the asynchronous condition ($M = 2.47$, $SD = 1.29$) conditions $t(14) = 3.83$, $p < .01$. These results indicated that the manipulation of synchrony of IMS in this study lead to a significant change in the amounts of money offered by participants (see Figure 5-4).

5.3.2.2. Checks of Participant Awareness of the Purpose of the Experiment

Due to the large difference between the results of experiment 5.2 and the possibility of a within-subject design increasing demand characteristics (Orne, 1962; Rubin & Badea, 2010) participants' responses to the five debriefing questions were coded for signs that participants had been aware of the purpose of the study. For questions 1, 2 and 4 participants were coded as having been aware of the purpose of the study if they had mentioned any link between the synchrony of the IMS and their decisions in the trust game. For questions 3 and 5 participants were marked as having been affected by the purpose of the experiment if they said that the synchrony of IMS had affected their decisions of how much to send each person. One sample t-tests were carried out on each of the five questions to determine whether the number of participants who showed knowledge of the purpose of the study was significantly different from 0. A significant difference from 0 was found for responses to question

1 (*M* = 0.6, *SD* = 0.51), *t*(14) = 4.58, *p* < .01, and question 4 (*M* = 0.6, *SD* = 0.51), *t*(14) = 4.58, *p* < .01, indicating that a majority of participants correctly identified the purpose of the study. No significant results were found for question 2 (*M* = 0.13, *SD* = 0.35), *t*(14) = 1.47, *p* > .05, question 3 (*M* = 0.13, *SD* = 0.35), *t*(14) = 1.47, *p* > .05, and question 5 (*M* = 0, *SD* = 0), *t*(14) = *0*, *p* > .05 indicating that participants did not feel that the pattern of multisensory stimulation played a significant role in their trust game decisions.

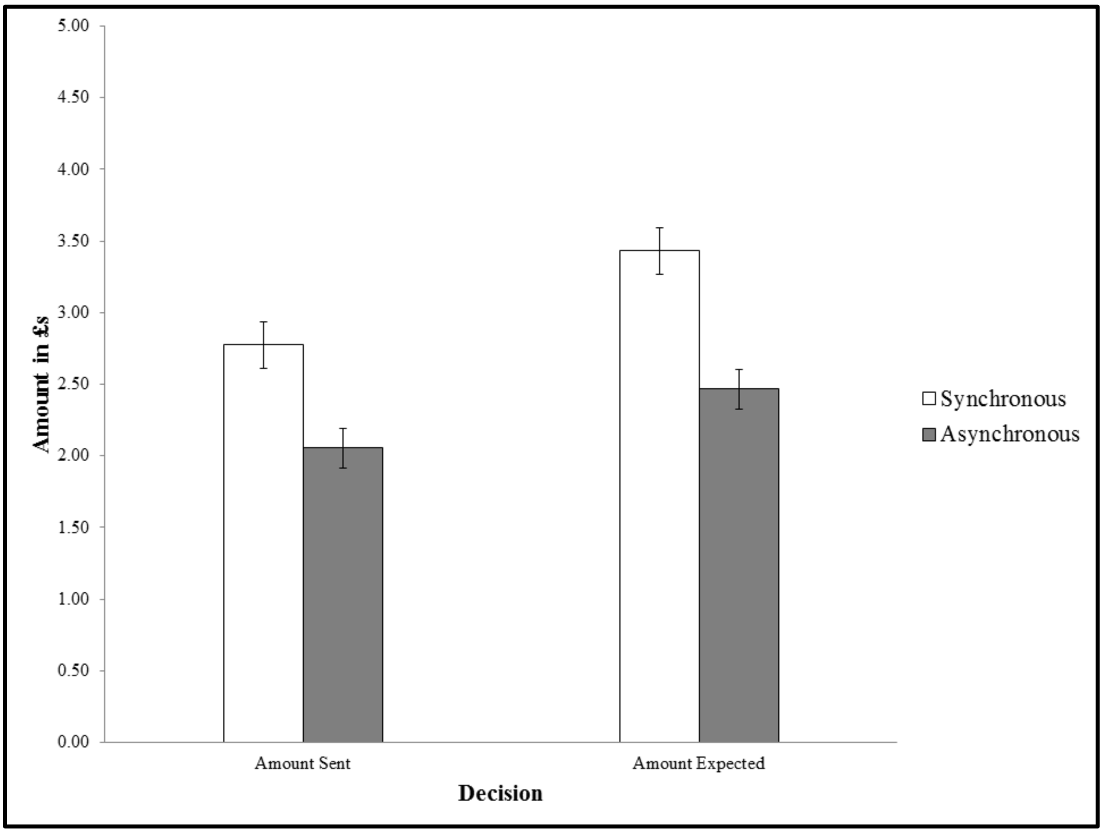

Figure 5-4. Mean amounts of money sent and expected to be returned across synchronous and asynchronous conditions. Error bars represent SEM.

5.3.3. Discussion

The results of experiment 5.2, in contrast to those of experiment 5.1, found that receiving synchronous IMS with a trustee lead participants to give them significantly more than did receiving asynchronous stimulation. Here I will briefly discuss the possible reasons for the discrepancy in results between the two studies and suggest potential explanations for it.

The finding of experiment 5.2 indicates that shared multisensory experience is capable of increasing levels of behavioural trust between self and other in addition to leading to higher rating of perceived trust as seen in Tajadura-Jiménez, Longo, et al. (2012) and experiment 5.1 of this chapter. The results of experiment 5.2 are also in line with similar results relating to the power of shared sensorimotor experiences to increase cooperation in group economic games (R. Fischer et al., 2013; Launay et al., 2013; Reddish et al., 2014; Wiltermuth & Heath, 2009). Given the power of multisensory stimulation to blur the physical boundaries between self and other (Paladino et al., 2010; Sforza et al., 2010; Tajadura-Jiménez, Grehl, et al., 2012; Tsakiris, 2008) the findings of the current study further demonstrate the close links between perceptions of bodily similarity and social similarity as reflected in behavioural judgements of trustworthiness.

The positive findings of experiment 5.2 have to be qualified however by the failure of experiment 5.1 to find a significant effect of synchrony in a between subject design. There are several differences in the design of the two studies that may have been the cause of this discrepancy in findings. For one thing, participants in experiment 5.2 played a much larger number of individual trust games each than did participants in experiment 5.1. More importantly, participants in experiment 5.2 had the money they were about to send split into twice as many increments than did participants in experiment 5.1.

This difference in increments may be the key to the discrepancy in findings between the two experiments reported above. Notably, despite the high significance of the difference between synchronous and asynchronous conditions between the two groups in experiment 5.2, the actual difference in the amount offered between the two conditions was less than £1. Since £1 was the minimal increment that participants could offer in experiment 5.1 it is possible that any effect of synchrony on trust game decisions in that study was not found due the decreased range of distinctions that participants could make in the amount of money they offered the trustee.

However, the results of the analysis of participants' debriefing questionnaire responses for experiment 5.2 do raise another possibility, that the difference between the two studies may be due to the increased risk of demand effects when using a within participants design (Orne, 1962; Rubin & Badea, 2010). The results of the debriefing questionnaire in experiment 5.2 showed that, despite the fact that the study used a double blind design, the majority of participants did guess the purpose of the study even though none of the participants reported that the synchrony of IMS played a part in their decision of how much money to send. No similar debriefing questionnaire was used in experiment 5.1, meaning that it is not possible to know how many of the participants in that experiment surmised its purpose. However, the fact that that experiment used a between participants design and that participants only played one trust game rather than a series of games means that it was significantly more difficult for participants in experiment 5.1 to guess what the study's purpose was. In order to determine whether the findings from the current study are genuine or due to demand effects a new study which has the same basic procedure as experiment 5.2 but with a between rather than within subject design is currently being conducted. This study should make it possible to determine which of the two possible explanations for the difference in findings between experiments 5.1 and 5.2.

5.4. Experiment 5.3

5.4.1 Introduction

The aim of experiment 5.3 was to investigate whether learning about whether an interaction partner was trustworthy or untrustworthy, as measured by the amount of money returned by them in the trustee role in a trust game, would affect participants' perceptual judgements of similarity between their own face and the face of the interaction partner.

In the introduction to this chapter I reviewed the considerable literature indicating that facial appearance is used as a guide to a person's personality traits such as trustworthiness (Todorov, 2008). Of particular note to the current experiment are the findings that facial similarity leads to increased cooperation in both trust games (DeBruine, 2002) and common goods games (Krupp et al., 2008)and increased attributions of trustworthiness (DeBruine, 2005). These findings strongly suggest that we show a social bias towards favouring those who appear to be physically similar to ourselves with interesting behavioural effects. For example, people are more likely to vote for a politician that looks similar to them (Bailenson, Garland, Iyengar, & Yee, 2006; Bailenson, Iyengar, Yee, & Collins, 2009).

The cognitive mechanism which underlies this preference for people with similar faces is unclear. In the literature so far two interpretations of these findings have been made. The first is based on the kin selection literature and suggests that since facial similarity is a cue to relatedness, peoples' preference to similar others is due to the fact that those who look more similar to one's self are more likely to be close relatives. Support for this interpretation comes from the fact that self-resemblance increased attributions of trustworthiness to both self and opposite sex faces (DeBruine, 2002, 2005) but only increased attributions of attractiveness to same-sex faces (DeBruine, 2004a). Another study supporting the kin selection interpretation found that men, but not women, show a preference towards infants' faces that are more similar to their own (DeBruine, 2004b). This is predicted by evolutionary biology because while a woman can be confident that a child is theirs, for a man physical similarity is one of the key ways to determine paternity.

The second interpretation of these findings proposes a more general cognitive bias in favour of automatic positive associations towards the self and self-related stimuli (Greenwald & Banaji, 1995; Mezulis et al., 2004). This positive self-bias has been shown to extend to the letters in one's name (Koole, Dijksterhuis, & van Knippenberg, 2001); a brand of soft drink (Prestwich, Perugini, Hurling, & Richetin, 2010); the personality traits of politicians (Vecchione, González Castro, & Caprara, 2011); the avatars of other players in the computer game World of Warcraft (Lortie & Guitton, 2011) and to other members of a novel ingroup (Otten, 2003). Verosky and Todorov (2010) suggest that the attribution of positive traits to faces that look similar to our own is another example of this positive bias towards the self.

In favour of the self-bias account Bressan & Zucchi (2009) showed that when pairs of twins saw pictures of faces that had been subtly morphed either with their own face or that of their twin and asked them which face they would prefer in prosocial contexts they significantly favoured the faces that had been morphed with their own over those morphed with their twin even in the case of monozygotic twins who were genetically identical. Therefore, it is the closeness of the other person's face to one's own rather that the faces of one's kin that is important in driving the effect. It is however important to be note that the kin selection and positive self-bias accounts of the facial similarity effect are not necessarily mutually exclusive. Indeed given that our self-concept often expands to embrace our family members (Polkinghorne, 1991) it could be argued that positive self-bias is the proximal mechanism through which kin selection acts.

While the effects of existing similarity between self and others are well-documented, little is known about whether the perceived similarity between self and others can change as a result of self-other interactions. Thus, while we perceive a face that is similar to ours as more trustworthy, the reverse direction of causation has not been investigated. Would a person who treats us in a trustworthy way be perceived as being more physically similar to us? Given the evidence for the mutability of perceived facial similarity and for the close relationship between judgements of physical similarity and judgments of social similarity (Paladino et al., 2010; Tsakiris, 2008) the present experiment sought to investigate whether a simple social interaction during an economic game that does not directly alter physical self-other boundaries can also change the perceived similarity between self and others.

Both the positive self bias and kin selection interpretations of the link between trust and facial similarity give some reason to suggest that it should. People have a general bias towards positive information about themselves (Kruger & Dunning, 1999; S. E. Taylor & Brown, 1988). Of particular relevance to the current study are the findings that people view themselves as more trustworthy than the average person (Flynn & Lake, 2008) and view their face as more attractive than it actually is (Epley & Whitchurch, 2008). Given this bias one would expect people to view a trustworthy person as more similar in personality to themselves and this feeling of social similarity might then extend to the feeling of greater physical similarity. On the kin selection interpretation it might be argued that the experience of another's face being similar to one's own can be thought of as the felt output of a computational system that utilizes direct, phenotypic cues (e.g., objective facial features) and indirect, contextual cues (e.g., co-residence early in life; Debruine et al., 2011; Penn & Frommen, 2010) to gauge genetic kinship (cf. Kurzban, Duckworth, Kable, & Myers, 2013). If evidence of cooperative intent in others serves as a contextual cue to kinship, then a person who behaves in a trustworthy way towards us may be perceived as more physically similar to us. This process would have adaptive value as it would in turn lead to the activation of kin selection based adaptations for greater cooperation with those who seem similar to us and thus encourage further cooperation with people who had previously proved themselves trustworthy.

A number of studies previous have touched on the question of how social information about others might affect perceived facial similarity. Hassin and Trope (2000) and Paunonen (2006) both found that verbal information about a person's personality traits can affect judgements about that person's facial features. Notably, Hassin and Trope found that people who were described as having similar personalities were also perceived as having more similar faces.

There are however, several limitations in these studies. First neither examined the effect of social information on perceptions of self-similarity. People have much more exposure to and therefore greater familiarity with their own facial appearance than they do with novel faces and any effects reported might not be applicable when considering a highly familiar face Second both studies asked participants to give rating responses which leaves open the possibility that the effects observed are due to changes in explicit judgements rather than in perception. The conscious and explicit nature of the measures used in these studies also increases the possibility that the findings of these studies are due to demand characteristics (Orne, 1962). Finally both studies used verbal descriptions of the personality of the people whose faces were rated rather than direct interaction between the person and the participant. Thus it remains unclear whether behavioural evidence of a person's personality would have the same effect as verbal information.

Another study that touched on this question was carried out by Verosky and Todorov (2010) who morphed together a computer generated version of participants' faces with computer generated faces that had been set to appear either trustworthy or untrustworthy. They then presented participants with these while in an MRI scanner and asked them to decide whether the morph looked like them or the other face while monitoring BOLD response. Verosky and Todorov found that participants were more likely to identify the trustworthy than the untrustworthy morphs as looking like the self and also showed that a number of brain areas seemed to differentiate more between the self-face and the untrustworthy face than they did between the self-face and the trustworthy face.

Verosky and Todorov's (2010) study also suffered from a number of methodological issues. First the faces used in the study were all computer generated meaning that their ecological validity is somewhat dubious. A second and more important issue with the study is that the trustworthiness of the computer generated faces was not based on any actual information about trustworthy behaviour but rather was based on physical properties of the faces that have been found to correlate with judgements of trustworthiness. This makes it impossible to generalise from these finding to claims about the effect of past experience of a persons' trustworthiness on judgements of facial similarity.

A recent study by Teneggi, Canzoneri, di Pellegrino, and Serino (2013) also touched on the hypothesis being tested in the current experiment. The authors found that after playing an economic game with another person, the boundaries of peripersonal space between self and other merge, but only if the other behaved cooperatively. This finding shows that an economic game manipulation can affect bodily perceptions of self and other and thus offers support for the current experiments hypothesis that economic games could affect judgments of physical similarity.

The current study attempted to improve on the limitations of the previous studies discussed above by examining how judgements of facial similarity were affected by taking part in a social interaction (trust game) in which the other person either rewarded or betrayed the participant's trust by returning to them either a large or small amount of the total pot of money. In order to increase ecological validity morphs using photographs of the faces of the participants and their interaction partners were used. To minimise the possibility that the results found were due to demand characteristics, rather than genuine changes in participants' perception of facial similarity, physical similarity was measured by using the self-face recognition task developed by Tajadura-Jiménez, Grehl, et al. (2012). This task uses a hybrid staircase procedure to estimate the point at which participants were unable to determine whether the morphed face contained more of their own face or more of their interaction partner's face.

5.4.2. Methods

5.4.2.1. Design

The study used a within-subjects design with one independent variable. The independent variable was the trustworthiness of the other player (trustworthy, untrustworthy). The dependent variable was participants' scores in a post-interaction self-recognition task and participants' responses to the Inclusion of the Other in the Self (IOS) scale (Schubert & Otten, 2002).

5.4.2.2. Apparatus and Materials

Participants were required to come to an initial session approximately one week prior to the experimental session. During the initial session a digital photograph of the participant's face with a neutral facial expression was taken, and then converted to gray scale and mirror transposed (Keenan et al., 1999). A black template was used to remove non-facial attributes (e.g., background, hair, ears). Subsequently, a computerized morphing procedure was implemented (Abrasoft Fantamorph) to produce a sequence of photos in which the participant's face was merged with another person's face in 1% morphing transitions. This sequence of photos had as end points the original photos of the participant's face and the other person's face. The one hundred photos were saved as individual images.

5.4.2.3. Procedure

Participants were attended two sessions no more than fourteen days apart. In the first, participants had a photo of their face taken in order for the morphed photos to be created. They then had to rate 5 gender-matched faces on attractiveness, trustworthiness and similarity to the participant's own face using a seven point Likert scale. Two of the faces were those of the two trustees while the other three were faces taken from the Karolinska database (Lundqvist, Flykt, & Öhman, 1998; Oosterhof & Todorov, 2008). Finally participants completed the interpersonal reactivity questionnaire (Davis, 1980, 1983) and a four item questionnaire to investigate their feelings of trust towards strangers (Naef and Schupp, 2009).

In the second session (see Figure 5-5), participants played two trust games in the role of trustor, each with a separate gender matched trustee. In each game a photograph of the trustee was presented on the screen, and participants decided how much of a £2.50 endowment (in £0.50 increments) to transfer to the trustee. Transfers were tripled by the experimenters. After making both transfer decisions, participants viewed pre-recorded videos of the trustees stating how much money they had decided to return to the trustor. As in the previous experiments in this chapter the 'strategy' method was used (Brandts & Charness, 2009): participants were informed that trustees had previously made a series of hypothetical back-transfer decisions, one for each of the possible transfers trustors could make. In reality trustee decisions were manipulated such that trust was either reciprocated (70% of tripled transfer returned) or betrayed (10% returned).

Immediately prior and subsequent to these games, participants performed a self-recognition task (Tajadura et al., 2012) with each of the trustees' faces, in order to measure participants' point of subjective equality (PSE) with each face. During the self-recognition task participants were presented with a series of images. For each image they indicated whether the depicted face looked more like their own face or more like the other person's face using a two-alternative forced choice (2AFC) method. Each image depicted a face with a varying degree of morphing between "self" and "other".

PSE was calculated to reflect the degree of morphing for which participants were equally likely to judge the morph as “self” or as “other”. PSE values obtained for both interleaved staircases (“self to other” and “other to self” directions) were averaged for each experimental condition(Watson & Clifford, 2003; Webster, Kaping, Mizokami, & Duhamel, 2004). This value is presented as the percentage of the “other” face contained in the PSE. For example, a PSE of 43% suggests that participants could not distinguish between self and other in the picture that contained 43% of the other-face and 57% of the self-face. Any increase in this value as a result of the social interaction would suggest an increase in the maximum percentage of the “other” face contained in the pictures judged as self.

The order of conditions and the identities of the models used as the trustworthy and untrustworthy trustees were fully counterbalanced across participants. Following the completion of the self-recognition task, participants completed the Inclusion of the Other in the Self scale (Schubert & Otten, 2002) with each trustee and were subsequently debriefed and dismissed with their earnings.

5.4.2.4. Participants

66 participants gave their informed consent to participate and were paid for their participation. The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London. 59 participants (mean age ± *SD*: 23.6 ± 5.2, 15 male) were included in the analysis (3 participants’ data was lost due to technical failure, 2 participants did not send any money to one of the trustees and so did not receive any information regarding that trustee’s trustworthiness and 2 had a PSE of either below 10 or above 90 indicating that they hadfailed to perform the self-face recognition task correctly).

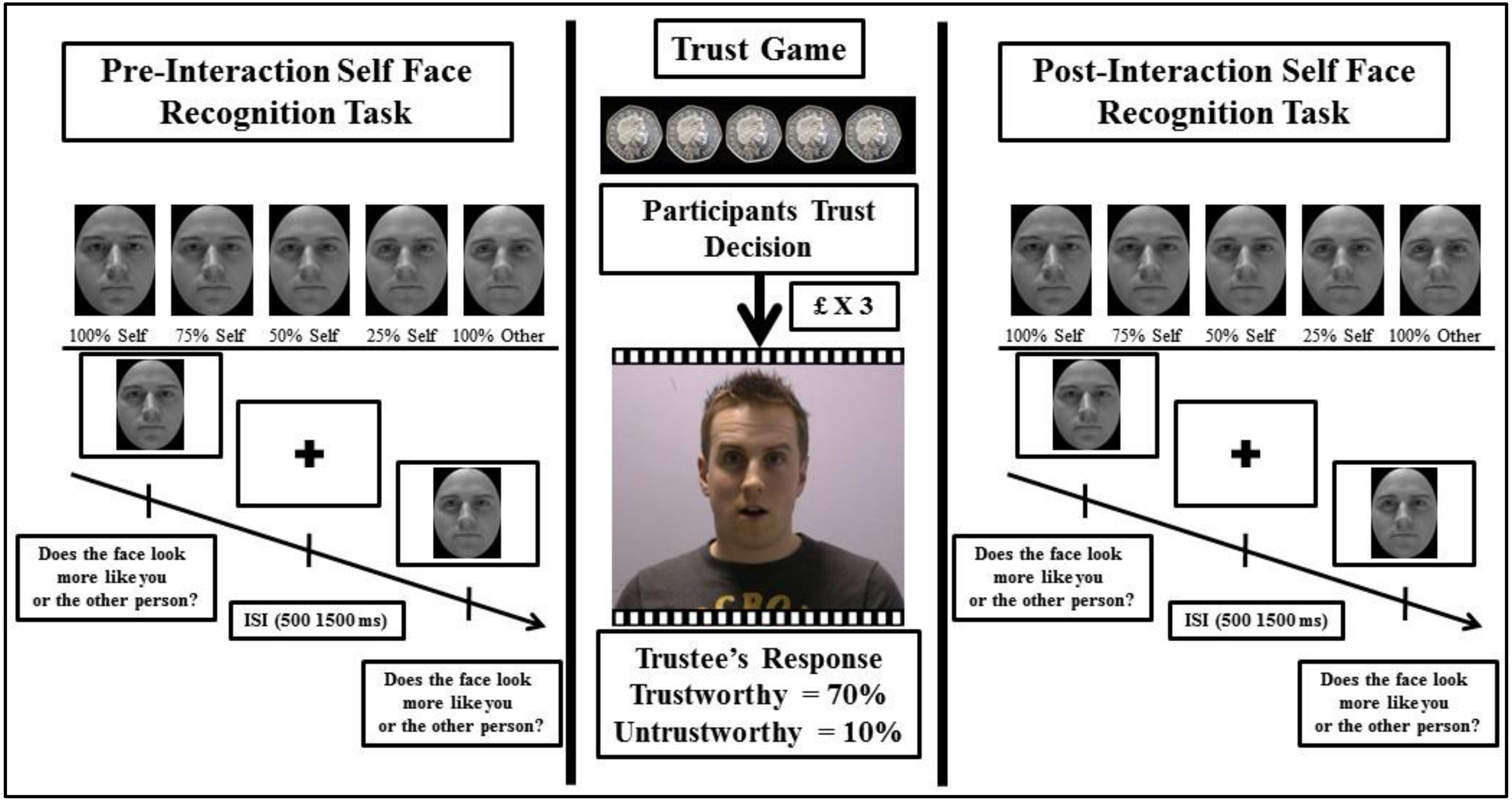

Figure 5-5. Experimental procedure for experiment 5.3.

5.4.3. Results

5.4.3.1. Perception of Facial Similarity Prior to Social Interaction

In order to ensure that there were no significant differences in participant's ratings of the two trustees prior to the trust game. Paired sample t-tests were carried out on the ratings given to the trustees faces in session one. These t-tests confirmed that there were no significant differences in ratings of attractiveness, $t(58) = .98, p > .05$, (trustworthy: $M = 3.91$, $SD = 1.21$, untrustworthy: $M = 3.76$, $SD = 1.37$), trustworthiness $t(58) = -.76, p > .05$, (trustworthy: $M = 4.1$, $SD = 1.27$, untrustworthy: $M = 4.25$, $SD = 1.12$) or similarity to own face $t(58) = 1.2, p > .05$, (trustworthy: $M = 3$, $SD = 1.54$, untrustworthy: $M = 2.71$, $SD = 1.45$). In addition a paired sample t-test was carried out on participants' PSEs from the pre-interaction self-face recognition task, which showed no significant difference between the two faces, $t(58) = -.71, p > .05$, (trustworthy: $M = 45.86$, $SD = 9.44$, untrustworthy: $M = 44.93$, $SD = 9.55$). There were also no significant differences in either the amount of money sent to the two faces in the trust game, $t(58) = -.33$, I > .05 (trustworthy: $M = 2.95$, $SD = 1.22$, untrustworthy: $M = 2.9$, $SD = 1.14$) or in the amount of money participants expected to receive back from the player $t(58) = -1.42, p > .05$, (trustworthy: $M = 2.03$, $SD = 1.22$, untrustworthy: $M = 2.25$, $SD = 1.13$).

5.4.3.2. Perception of Facial Similarity Following Social Interaction

In order to test whether, after accounting for perceived similarity before the interaction, participants would judge the face of the model who displayed trustworthy behaviour towards them as more similar to their own face than that of the one who displayed untrustworthy behaviour towards them a repeated measures analysis of covariance (as per Huck & Mclean, 1975; Tabachnick & Fidell, 1999), with post-game PSE as dependent variable, pre-game PSE as a covariate, and trustee trustworthiness as independent variable, revealed a significant difference between conditions, $F(2,57) = 6.31, p < .05$. This finding means that once the pre-interaction PSE was taken into account the post-interaction PSE was significantly higher in the trustworthy condition ($M = 48.42$, $SD = 11.41$) than in the untrustworthy condition ($M = 45.76$, $SD = 9.06$) (See Figure 5-6).

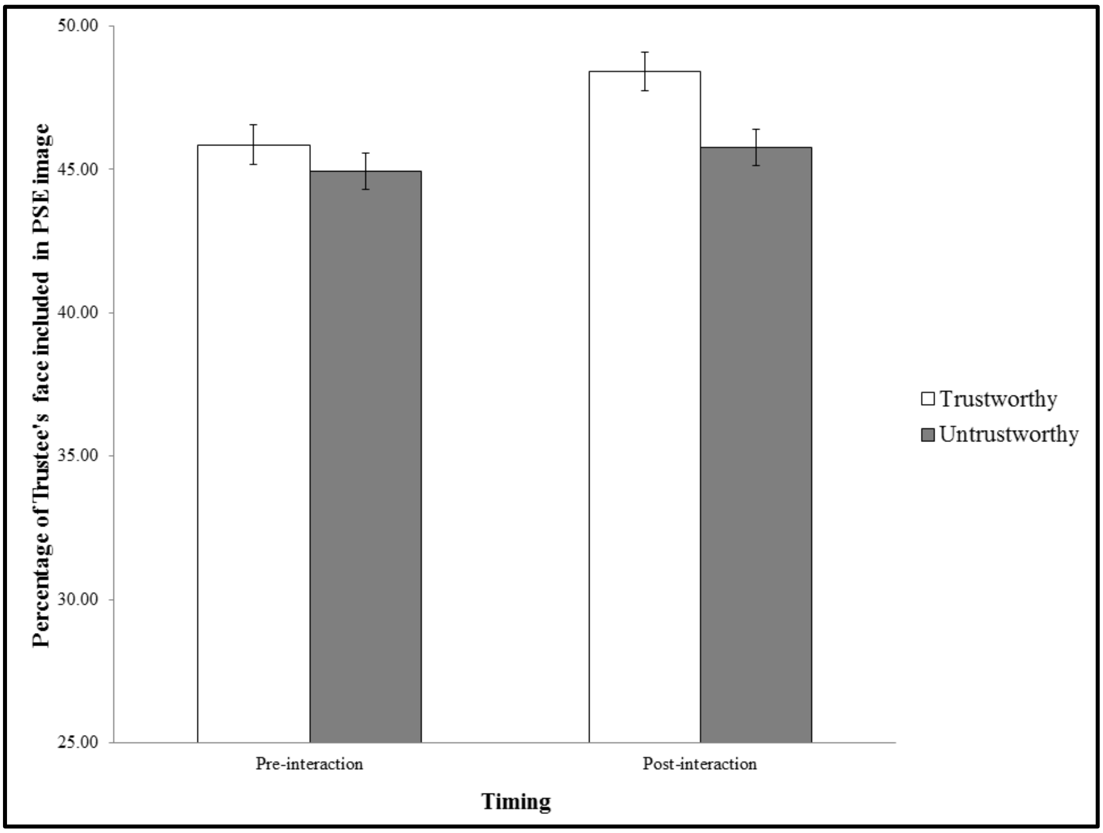

Figure 5-6. Percentage of other's face in the PSE image of pre- and post-trust game self-face recognition task for trustworthy and untrustworthy players. Higher values indicate greater perceived similarity between self and other. Errors bars represent SEM.

5.4.3.3. IOS scores Following Social Interaction

In order to show that the manipulation of the trust game had an effect on how participants viewed the two trustees a paired sample t-test was carried out on the responses to the IOS scale. A significant difference was found between the rating of closeness for the trustworthy and untrustworthy players, $t(58) = 6.8$, $p < .001$, with participants feeling closer to the trustworthy player ($M = 3.34$, $SD = 1.17$) than to the untrustworthy player ($M = 2.07$, $SD = 0.98$) (see Figure 5-7).

5.4.4. Discussion

The current experiment investigated whether participants' judgements of facial similarity between themselves and another person was affected by that person's prior behaviour towards them in a trust game. It was found that, accounting for pre-trust game performance, participants judged someone who had given them a generous amount of money as being more physically similar to them than someone who had returned only a very miserly amount of the money. This finding is consistent with those of Epley and Whitchurch (2008) and Verosky & Todorov (2010) in indicating that the tendency to see the self as positive can also be applied to judgements of physical appearance and is also consistent with the findings of Hassin and Trope (2000) and Paunonen (2006) that information about a person's personality can affect judgement about their facial appearance.

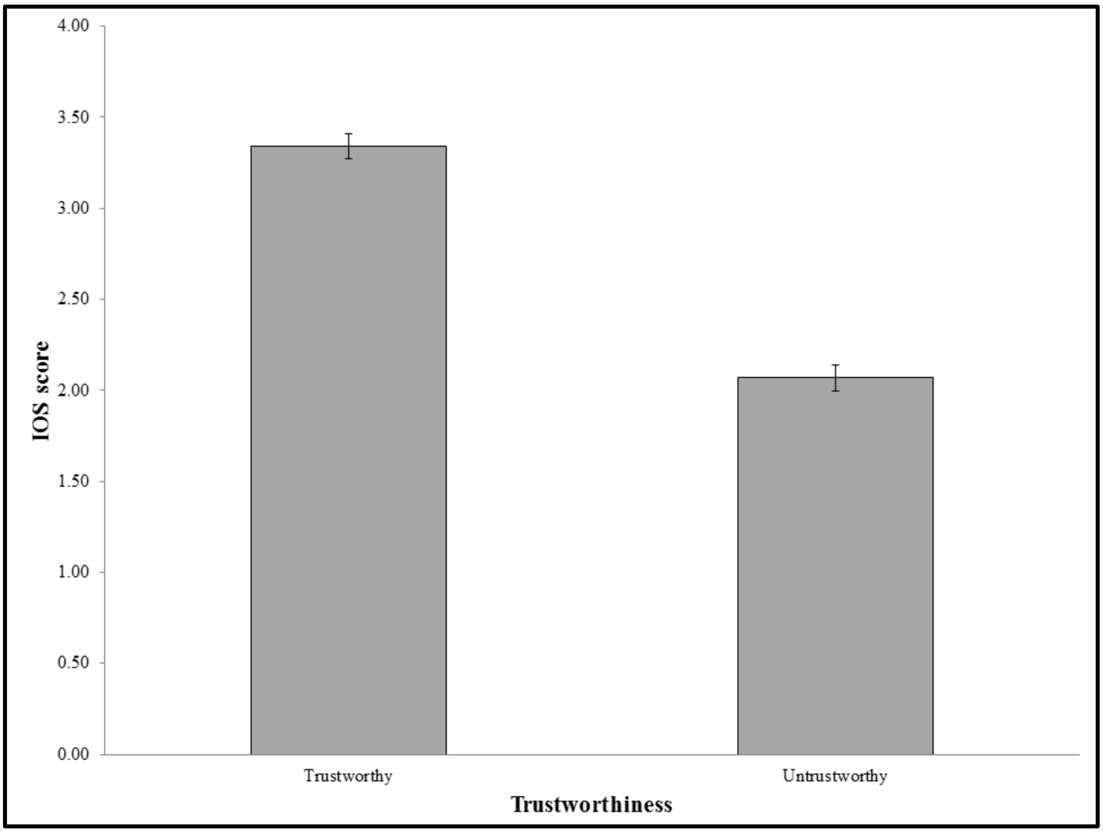

Figure 5-7. IOS scores for trustworthy and untrustworthy players. Errors bars represent SEM.

The current experiment is the first to show that behavioural interactions with another person can affect judgements about one's physical similarity to another. Several other studies (Bailenson et al., 2006, 2009; DeBruine, 2002, 2005; Krupp et al., 2008) have demonstrated that faces which are more physically similar to the self are attributed more positive personality traits than dissimilar faces. The current experiment indicates that the reverse is also true, that knowledge about someone's personality gained through social interaction can feed back to create a perception of greater physical similarity between their face and one's own.

By examining the relationship between the pre- and post-interaction scores on the self-face recognition task it can be seen that this effect was primarily driven by participants having a greater perception of similarity between themselves and the generous trustee after the interaction rather than by their perception of a greater sense of dissimilarity with the ungenerous trustee. In fact the PSE for both the generous and ungenerous trustee both increased slightly compared to the pre scores. Some of this change may be due to the fact that in the pre-interaction self-face recognition task our participants tended to underestimate the amount of their own face compared to the other's in each morphed photo. Given that participants had received more exposure to both faces in the post-interaction task some of the increase in the PSE may simply be due to the greater familiarity they had with both faces. None the less the significant difference found between trustworthy and untrustworthy faces still demonstrates that participants judged trustworthy individuals as being more similar to themselves than untrustworthy individuals over and above any effect of familiarity.

The fact that this change in self recognition was only found in the direction of the generous trustee also rules out one possible alternative explanation for our results which is that participants were consciously trying to disassociate themselves from the miserly trustee and associate themselves with the generous one. If this were the case then one would expect that, for the untrustworthy trustee, the PSE in the post-interaction test would be lower than in the pre-interaction. Indeed given that the untrustworthy trustee actually took money from the participants one might expect a stronger negative reaction against them rather than a positive change towards the trustworthy trustee. The fact that PSE actually rose (indicating greater similarity between self and other) for both trustees suggests that participants were not consciously trying to dissociate themselves from the miserly trustee and therefore also makes it likely that their PSE for the trustworthy trustee was not greatly affected by a conscious bias.

The result of the current experiment suggests that positive self-bias is transferable between different types of self-information. That is just as physical similarity between one's own face and that of another leads to the belief that the other has more positive personality traits so too the discovery that another person has more positive personality traits leads to the judgement that a morphed face containing more of the other person is actually more similar to one's own. This finding suggests an effect similar to the "perceptual accuracy hypothesis" (Silvia & Gendolla, 2001) which claims that any type of self-focussed attention will improve an individual's accuracy in judging both somatic and cognitive aspects of the self. Both the perceptual accuracy hypothesis and the results of experiment 5.3 suggest, in line with the prediction of embodied congition, that self-relevant information, whether based on the physical body or in more abstract cognitive representations of the self, are linked together such that changes in one source of self-relevant information can lead to similar changes in other forms of self-representation.

Similarity to the self can be viewed in evolutionary terms as providing an important cue to genetic relatedness (DeBruine, Jones, Little, & Perrett, 2008). It has been argued that the positive social effects of similarity are an indicator of our tendency to favour our close genetic relatives over strangers and, as previously mentioned, several studies (DeBruine, 2002; Krupp et al., 2008) have shown that people cooperate more with those who look similar to them. Based on these considerations it is arguable that the experience of facial similarity is the phenomenological component of a neurocomputational variable ('kinship index') that calibrates altruistic behaviours and regulates group cooperation (Krupp et al., 2008; D. Lieberman, Tooby, & Cosmides, 2007). On this interpretation, the results of the current experiment, which suggest that evidence of cooperative intent in others serves to structure the phenomenology of facial perception, indicate that evidence of cooperative intent in others serves as a contextual cue to genetic relatedness.

This reciprocal relationship between trustworthy behaviour and perceived facial similarity may have an adaptive value as a way to encourage long term cooperation between unrelated individuals. If cooperative behaviour can lead to greater perceived similarity and perceived similarity can likewise predispose us towards cooperative behaviour then it is conceivable these two processes could reinforce each other. This would lead to a virtuous circle in which initial cooperation leads to a sense of greater physical resemblance which in turn leads to the activation of cognitive processes adapted towards assisting one's kinship group creating a predisposition towards further cooperation. In such a way this phenomena of increased perceived similarity towards trustworthy others would act as a buffer against possible temptations to defect against or betray the other person and thus help to maintain mutually beneficial relationships.

The findings of the current experiment also corroborate the fluidity of perceived facial similarity. IMS experiments have demonstrated that synchronous VT stimulation of one's own and another person's face causes participants to perceive the other person as both more physically and psychologically similar to themselves (Paladino et al., 2010; Tsakiris, 2008). Notably the change in the percentage of other face included in the PSE image between pre and post manipulation self-face recognition tasks is of similar magnitudes in the current experiment as they were in previous studies that have used similar measures (Tajadura-Jiménez, Grehl, et al., 2012; Tsakiris, 2008). Thus the findings of the current experiment extend the results of previous IMS studies by demonstrating that a purely social, as opposed to bodily, intervention can lead to equivalent changes in perceived facial similarity.

While the current experiment is a purely behavioural one, the similarity between its results and those found in the fMRI study conducted by Verosky and Todorov (2010) does allow for some speculation on the possible neural mechanisms that underlie the observed findings. Verosky and Todorov found a number of brain areas that showed increasing activation as the untrustworthy faces became less similar to the self but far less activation as the trustworthy faces became less similar to the self, suggesting that they distinguished between untrustworthy faces and the self far more than they did trustworthy faces. Based on findings from other imaging studies (Morita et al., 2008; Uddin, Kaplan, Molnar-Szakacs, Zaidel, & Iacoboni, 2005) Verosky and Todorov suggested that these areas, in particular the right inferior frontal gyrus, may become more active when associating positive stimuli with the self and less active when distancing negative stimuli from the self. In the current experiment it is possible that the effect of the social interaction was to decrease the amount that these areas activated when observing morphs of the self-face with the untrustworthy face and to increase to amount they activated for morphs of the self-face with the trustworthy face. Further research is needed however to investigate exactly how the distinct neural areas involved in the judgement of facial similarity and in judgements of trustworthiness interact to produce the behavioural effects observed here.

Facial similarity has been established to have an effect on judgements of trustworthiness and on cooperative behaviour. Experiment 5.3 demonstrates that a reciprocal relationship also holds, participants viewed another person who had cooperated with them in a social interaction as being significantly more similar to them. This finding demonstrates that information about the social behaviour of another person towards the self can affect judgements of physical similarity between self-face and other person's face suggesting a two way link between representations of physical appearance and representation of personality traits.

5.5. General Discussion

Experiments 5.1, 5.2 and 5.3 all examined the relationship between the representation of one's own face and the face of another person and the perceived trustworthiness of that other person. Experiments 5.1 and 5.2 investigated the question of whether the application of tactile stimulation to one's own face while observing the synchronous tactile stimulation being applied to the face of another, a procedure that has previously been shown to lead to greater perceived similarity between one's own face and that of the other person, would lead to greater offers in the trust game than asynchronous VT stimulation did. Experiment 5.3 investigated whether the relationship between trust and perceived facial similarity held in the other direction, that is whether information about whether another person was trustworthy or untrustworthy would affect how similar that person's face was perceived to be to one's own face.

The results of the three experiments offer support for the idea that facial similarity and trust have a reciprocal relationship. Experiment 5.1 found a significant difference between the synchronous and asynchronous conditions in the ratings of the trustworthiness of the trustee. Synchronous IMS led to higher ratings of trustworthiness and attractiveness and also led to higher ratings of similarity between the participant’s face and the face of the trustee. Experiment 5.2 found a significant effect of synchrony on the amount given in the trust game with synchronous IMS leading to larger amounts of money being sent to the trustee than did asynchronous stimulation. Experiment 5.3 found that learning through a social interaction that another person was trustworthy, as opposed to untrustworthy, led to an increase in their perceived facial similarity to one’s own face.

As covered in the introduction to this chapter many studies have shown that facial features are automatically used in judgements of personality (Berry & McArthur, 1986; Hassin & Trope, 2000; Todorov et al., 2008) Several recent studies have also shown that IMS can change perceptions of social closeness and similarity in personality (Paladino et al., 2010; Tajadura-Jiménez, Longo, et al., 2012) as well as in physical appearance (Sforza et al., 2010; Tajadura-Jiménez, Grehl, et al., 2012; Tsakiris, 2008). Taken together the findings of these experiments add to the considerable amount of research showing strong bidirectional links between the perception of physical characteristics, in this case perceived facial similarity, and the attribution of personality traits. At present however it is still unclear what the precise mechanism behind this link and further research is necessary in order to identify the neural basis of these findings.

Another important issue in interpreting the results of the current chapter is the question of how far the offers and responses in the trust game can be considered to be truly indicative of trust. In the introduction to this chapter I reviewed a number of studies suggesting strong links between subjective judgements of trustworthiness and the trust game (Ashraf et al., 2006; Chaudhuri & Gangadharan, 2007; Gächter et al., 2004; Glaeser et al., 2000; Johansson-Stenman et al., 2013; Naef & Schupp, 2009). However, several researchers (Ashraf, Bohnet, & Piankov, 2003; Ermisch, Gambetta, Laurie, Siedler, & Noah Uhrig, 2007; Haile, Sadrieh, & Verbon, 2008; Holm & Nystedt, 2008) have failed to find any association between offers in the trust game and the response to commonly used survey measures of trust such as the General Social Survey (GSS) or the World Values Survey (WVS). This has led some authors (e.g. Hardin, 2003, 2006; Levi, 2003; Levitt & List, 2007; Nannestad, 2008) to argue that the trust game fails to be a good measure of trust. In particular Levi (2003) and Hardin (2003, 2006) have pointed to a specific problem of interpretation in connection with the trust game and have argued that the amount of money sent by the trustor is a measure not of trust but cooperation. Taking cooperation as a proxy for trust, as is routinely done in many trust experiments, is valid only if trust is from the outset defined as cooperation, or if it is assumed that trust is a necessary condition for the cooperation observed. This question raises the issue of whether any results of the experiments reported here can be interpreted as strictly being due to an increase in trust or whether they might instead reflect a more general effect of increased cooperation. It is important to note that while in the rest of this chapter the measures and manipulations used are referred to as being based around trust this does not necessarily mean that they are trust specific, it is also possible that they reflect a more generalised modulation of pro-sociality or cooperation.

A related question is whether the effects found in these studies are specific to trust or whether they are due to a more general sense of affiliation between self and other. In experiment 5.1 as well as leading to increased ratings of trustworthiness, synchronous IMS also led to increased ratings of affiliation. One possible explanation for the disparity in the findings between effect of synchronous stimulation on the ratings of trustworthiness and the lack of such an effect in the behavioural measure of trust is that participants did not actually feel greater trust for the trustee in the trustworthy condition. Instead they may have felt a sense of greater general affiliation with the trustee which they then expressed by giving higher rating of trustworthiness when this question was presented to them but which did not translate into greater trust when it came to decision making. While this is possible given the results of experiment 5.1 the finding of effect of synchrony on trust behaviour in experiment 5.2 suggests that, at the very least, synchrony can lead to enough positive affiliation towards another to affect behaviour in an economic game. It is also worth noting that in the principle component analysis conducted by Tajadura-Jiménez, Longo, et al. (2012), ratings of affiliation did not load on the same component as ratings of trust and attractiveness. This suggests that, in that study at least, multisensory stimulation affected judgements of trustworthiness and affiliation independently. It is also notable that in experiment 5.1 no effect of synchrony was found on the IOS scale measure, in contrast to the effect found by Paladino et al.

(2010), indicating that the effect of synchronous stimulation on affiliation in the current study varied depending on the measure used in a similar way to its effect on trust.

In experiment 5.3, the manipulation of the trustworthiness of the other person led to effects for both judgements of physical similarity, and for the rating of the others on the IOS scale. This is in line with the finding by Ashraf, Bohnet and Piankov (2006), that trustworthy behaviour is most strongly predicted by general benevolence and suggests that the effect of the manipulation of amount of money returned on perceived physical similarity may have been driven by a general feeling of the trustee being a kind and generous person, rather than being specifically tied to that person being trustworthy.

The question of what exactly drives the bidirectional relationship between trust and body representations observed here is fertile ground for future studies. One path of investigation would be to examine whether manipulating the other facets of trustworthiness described by Mayer et al. (1995), i.e. ability and integrity, also lead to increased perceived facial similarity. For example would discovering that a person was competent versus incompetent in advising the participant on how to complete a task such as judging the number of dots in an array (Paladino et al., 2010)or judging which of a series of gratings has a greater contrast than the others (Bahrami et al., 2010) lead to greater perceived similarity?

Alternatively one could investigate whether manipulations that are not based on trust but which are designed to increase feelings of interpersonal closeness such as similarity of interests, tastes or personality lead to increased perceived facial similarity. Given that similar personal tastes have been found to correlate with feelings of interpersonal liking (Bakagiannis & Tarrant, 2006; Lydon, Jamieson, & Zanna, 1988) a finding of a similar effect to the one found in experiment 5.3 after these manipulations would suggest that the effect found here is primarily based on feelings of similarity in personality between self and other rather than trust per se.

Finally further investigation is needed to identify the mechanism by which synchrony of IMS has an effect on participants' trust behaviour. One potential fruitful avenue would be to examine the mediating role of other known effects of IMS, such as increased perceived facial similarity or increased affiliation as measured in questionnaire items or the IOS. If the effects of synchrony on trust behaviour found in experiment 5.2 are driven by the power of IMS to increase physical similarity between self and other then one would expect the PSE of a post-stimulation self-face recognition task to mediate the amount of money offered. If on the other hand the effect of synchrony on trust is due to increased social affiliation between self and other then scores on the IOS scale and ratings of affiliation and trustworthiness would be expected to be mediating variables.

In conclusion the studies presented in this chapter show evidence for a bidirectional relationship between representations of physical similarity between self and other and both explicit and behavioural measures of the trustworthiness of the other person. In the following chapter the relationship between trust and body representations is again investigated but this time with a focus on shared neural representations of the actions of oneself and others.

Chapter 6. Trust in Action: Effect of Trustworthiness on Neural Systems for Action Observation.

"Behaviour is the mirror in which everyone shows their image"

Johann Wolfgang von Goeth, (1906, p. 36)

6.1. Introduction

The previous chapter of this thesis examined the relationship between trust and face perception. Experiment 5.2 revealed that synchronous IMS led to increased trust in others as measured by the amounts sent in a trust game while experiment 5.3 demonstrated that discovering that a person is trustworthy leads to an increase in perceived similarity between one's own face and that of the other person. Expanding upon the results of experiment 5.3, the experiment reported in this final experimental chapter used fMRI to examine the effects of perceived trustworthiness on a different measure of bodily overlap between self and other, namely the activation of the motor system when observing the actions of others.

As discussed in chapter 1 there is now a vast amount of evidence that the observation of the actions of another person leads to the activation of a network of neural regions involved in the execution of those actions (for recent reviews see: Bonini, Ferrari, & Fogassi, 2013; Fogassi, 2011; Molenberghs, Cunnington, & Mattingley, 2012; Rizzolatti & Sinigaglia, 2010). While mirror neurons were orgininally identified in the premotor cortex of the maccaque by G Rizzolatti et al. (1988; see also di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996), they have since been found in humans using single cell recordings (Mukamel et al., 2010). There have also been a large number of imaging studies that suggest the existence of a similar shared neural system of shared representations of action execution and observation in humans. Originally this network was believed to consist mainly of the inferior frontal gyrus (IFG), the inferior parietal lobe (IPL) and also the superior temporal sulcus (STS), which is activated by action observation but not action execution (Iacoboni & Dapretto, 2006). However further studies have revealed a number of other neural regions that have been found to exhibit shared representations of action observation and action execution, including the ventral premotor cortex (vPMC), the dorsal premotor cortex (dPMC), the intraparietal sulcus (IPS), the superior parietal lobe (SPL), the precuneus, the insula, the primary somatosensory cortex (SI), the cingulate suclus and the cerebellum (Cattaneo & Rizzolatti, 2009; Molenberghs et al., 2012).

The existence of these "mirror neuron" regions appear to offer a link between perceiving the actions of others and generating one's own motor actions and have been hypothesised to be involved in a number of social cognitive processes including imitation, empathy and mind reading (Bonini et al., 2013; Gallese, 2009; Hurley, 2008; Iacoboni, 2009; Oberman & Ramachandran, 2007). It has become clear that mirror mechanisms also exist in areas involved in somatosensory (Avenanti et al., 2005; Bufalari et al., 2007; Keysers & Gazzola, 2009; Keysers et al., 2004; Keysers, Kaas, & Gazzola, 2010; Thomas et al., 2006) and emotional (Bastiaansen et al., 2009; Jabbi et al., 2008; Wicker et al., 2003) processing. Given the diversity of areas that show mirror properties and the varying accounts of what brain areas make up the classic motor "mirror neuron system", for the sake of clarity I will henceforth refer to the network of specifically motor neural regions that are activated by the observation of actions under investigation in this chapter as the action observation network (AON).

The claims made about the importance of mirror neurons for social cognition in general raise the question of how far the AON network is modulated by social factors. Several studies have sought to examine the effect of various social factors on the AON using a number of different neuroimaging methodologies. One commonly used methodology for the investigation of the mirror neuron system has been to examine the electrophysiological signals produced by action observation. Of particular interest is the mu suppression (8-13Hz) bandrange (Gastaut & Bert, 1954) which has been linked to motor simulation due to the fact that mu suppression to observation of movements is similar to that during execution of movements (Cochin, Barthelemy, Lejeune, Roux, & Martineau, 1998; Lepage & Théoret, 2007; Muthukumaraswamy & Johnson, 2004).

Mu suppression has been shown to be modulated by a number of social factors. Indeed Gastaut and Bert (1954), in the first study to identify mu suppression, noted that suppression seemed particularly strong when a participant identified themselves with a person on the screen. The first study to systematically investigate the social modulation of mu suppression by social relevance (Kilner, Marchant, & Frith, 2006) found that mu suppression over the parietal cortex was stronger when observing the actions of another person face to face than when the same actions were observed with the person's back facing the participant. Oberman, Pineda and Ramachandran (2007) demonstrated that mu suppression increased with the amount of social interaction observed, and a second study by the same researchers found greater mu-suppression when observing human actions than when observing actions carried out by a robotic arm (Oberman, McCleery, Ramachandran, & Pineda, 2007).

Two other studies that investigated the effect of social interaction on mu suppression did so by measuring EEG signals during social interaction. Kourtis, Sebanz and Knoblich (Kourtis, Sebanz, & Knoblich, 2010) focused on the amplitude of the contingent negative variation (CNV) (Walter, Cooper, Aldridge, McCallum, & Winter, 1964), the late part of which is considered a marker of motor preparation and predominantly reflects SMA and MI activity (for a review, see Leuthold, Sommer, & Ulrich, 2004), and also measured activity in the beta bandrange. They found that when observing the actions of a partner in an interaction, both signals showed greater activation of the late CNV and greater suppression of beta signals compared to when the same actions were performed by a 'loner' who did not interact with the participant. A similar paradigm was used by Meyer, Hunnius, van Elk, van Ede and Bekkering (2011) who showed greater mu suppression in 3 year olds when observing the actions of an adult when they were playing a game with them compared to when they were not interacting with that adult. Perry, Stein and Bentin (2011) also showed a greater effect of mu suppression when participants view a person acting during a social interaction compared to outside of a social interaction. However in this case the interaction was competitive rather than cooperative.

Finally Gutsell and Inzlicht (2010) examined the relationship between mu suppression in EEG and ingroup/outgroup racial groups, and found greater mu suppression for a racial ingroup compared to a racial outgroup during the observation of simple actions. In addition the authors note that this mu suppression for the out group was negatively correlated with racial prejudice, with less mu suppression for negatively judged racial outgroups than for positively judged outgroups. Further studies (Gutsell & Inzlicht, 2013) showed that this ingroup bias in mu suppression could be modulated by creating a greater sense of closeness between one's self and the outgroup. Furthermore ingroup bias was present when participants watched a friendly action by either ingroup or outgroup, but when they observed a hostile action the bias disappeared. This finding indicates that the AON is sensitive to contextual factors such as the valance of an action as well as the identity of the observed actor.

As well as EEG studies, TMS induced measures of corticospinal (CS) excitability have also indicated that the AON is sensitive to the ingroup/outgroup status of an observed actor. Molnar-Szakacs, Wu, Robles and Iacoboni (2007) found that that CS excitability was modulated by both the ethnicity of an actor and the meaning of the gestures being made, with American participants showing higher CS excitability towards an American actor making American cultural gestures and higher CS excitability towards a Nicaraguan actor making Nicaraguan cultural gestures than vice versa. In contrast however Désy and Théoret (2007) found increased corticospinal activation when participants observed a hand of a different skin colour performing an action compared to a hand of their own colour. This discrepancy may be due to the different nature of the hand actions observed in the two studies; Molnar-Szakacs et al. used communicative gestures while Désy and Théoret used simple finger movements. Despite the differences, both studies point to the sensitivity of the AON to the ethnic identity of an actor.

Additional TMS evidence for the social modulation of the AON comes from two studies. Möttönen, Farmer and Watkins (2010) used signs from British Sign Language to show that the AON is sensitive to the communicative value of gestures, with greater CS excitability in the left hemisphere once participants are informed that the actions they are observing have a communicative meaning. Hogeveen and Obhi,

(2012) split participants into 4 groups, each of which either took part in social interaction then observed human actions, took part in social interaction then observed robot actions, only observed human actions or only observed robot actions. The study found that prior social interaction led to increased MEPs when watching human actions but not when watching robot actions. Additionally those who were involved in social interactions were split between mimickers and non-mimickers, and it was found that mimickers had higher MEPs than non-mimickers when watching human actions but not when watching robot actions.

The final methodology to reveal evidence of social modulations of the AON is a series of fMRI studies (Liew, Han, & Aziz-Zadeh, 2011; Molenberghs, Halász, Mattingley, Vanman, & Cunnington, 2013; Sobhani, Fox, Kaplan, & Aziz-Zadeh, 2012). Liew, Han and Aziz-Zadeh had Chinese participants watch either Chinese or Caucasian actors performing familiar and unfamiliar gestures. The study found that watching actors of the same race led to greater BOLD activation in the IPL, a key part of the AON, but also, surprisingly given the results of Molnar-Szakacs et al. (2007), greater activation of the IPL when watching unfamiliar as opposed to familiar gestures. The other two studies that investigated this issue both sought to study the effect of purely social (as opposed to racial) differences between observed action. Molenberghs et al. divided participants into two teams and asked them to observe members of their own team and the other team making hand gestures in a competitive setting. They found that participant's judged hand actions of their own team members as relatively faster than those of member of the other team and found using fMRI that observation of one's own team led to a preferential activation of the IPL.

The final fMRI study to investigate the effect of social modulation was carried out by Sobhani et al. (2012) and bares the most similarity to the study reported in this section. In this study Jewish participants observed the actions of actors who belong to either a dislikable group (neo-Nazis) or a likable group (tolerant people). Apart from being labelled as a member of one or other groups all actors were of a white ethnic background and performed the same actions. An MVPA analysis found that a classifier trained on brain activation patterns successfully discriminated between the likable and dislikable action observation conditions within the right ventral premotor cortex. These two studies indicate that the AON is sensitive to the membership of a social ingroup/outgroup per se rather than only being affected by the physical similarity or dissimilarity of an observed actor.

However, despite the fact that there was no physical difference between the actors in the two groups used by Molenberghs et al. (2012) and Sobhani et al. (2012), in both studies the actors were made to be socially closer or more distant to the participant based either on the decision of the experimenter as to how to split people into groups (Molenberghs et al., 2012) or via a verbal cue (Sobhani et al., 2012). As yet there have been no studies that have examined how judgements about an individual, based on prior experience of that individual's behaviour, affects the AON. Investigating the question of whether the AON is sensitive to such interpersonal, as opposed to intergroup factors, is important as, more often than not, we interact with individuals from the same social milieu (e.g. at work, school and socially) and therefore simple ingroup/outrgoup distinctions may not capture the full range of variability of our social life. Thus it is important to investigate how specific others, rather than an unspecified unknown "other group", are represented in the AON. The current study therefore addressed this lacuna by investigating whether manipulating the perceived trustworthiness of an actor leads to a greater activation of the AON, indicating a greater overlap between self and other, for a trustworthy actor than for an untrustworthy actor.

As well as examining the general effect of trustworthiness the current study was also interested in determining whether the AON would be active during the actual social interaction between the participant and each of the actors. Therefore a novel, multi-round economic game was developed to be played within the scanner, in which the actions of each of the observed actors also served to indicate the choice they had made in the game. The possibility that the AON may be differentially activated by actions with different reward value has been suggested by several recent studies. The first by Caggiano, Fogassi, Rizzolatti, Casile and Giese (2012) measured the activations of single neurons in the monkey brain and found a set of neurons in F5 that fire during both the observation and execution of the grasping of an object and are modulated by the value the monkey associates with the grasped object. The majority of the neurons measured (61%) fired specifically when the grasping or observing the grasping of food while a small minority (7%) showed a preferential response to non-food objects.

A number of studies have also found evidence that the AON in humans shows a preferential activation when observing rewarding actions (E. C. Brown, Wiersema, Pourtois, & Brüne, 2013; Cheng, Meltzoff, & Decety, 2007). Cheng et al. found that participants who had not eaten showed greater activation in the IFG and posterior parietal cortex when observing another person grasping food than did those who had eaten recently. In addition a recent study by Brown et al. showed that mu suppression was delayed when participants watched actions that were financially punishing compared to when they watched actions that were financially rewarding, indicating that the AON is also modulated by the processing of more abstractly rewarding stimuli.

Given that AON responds to observed actions and is modulated by social factors, the current study investigated whether observing an actor's actions that indicate a fair (i.e. monetarily positive choice) response towards the participant during an economic game will result in greater/higher AON responses as opposed to the observation of an actor's actions that indicate an unfair (i.e. a monetarily negative) choice. Participants made a series of decisions whether or not to accept or reject the offers of their interaction partner, during which they observed recorded videos of actors who could be either acting in a trustworthy or untrustworthy manner. One actor was consistently making positive choices, and thus building a positive/trust reputation, while the other actor was consistently making negative choices, thus building a negative reputation. Importantly however, the participant's only means to ascertain whether a particular action was likely to be positive or negative was the identity of the actor making the action, thus allowing the study to focus on the effects of prior reputation on the AON.

6.2. Methods

6.2.1. Design

In this study, participants viewed the actions of two people (henceforth referred to as interaction partners) during multiple rounds of an economic game. To investigate activity that occurred when participants were monitoring other's actions, activity time-locked to the onset of videos of each interaction partner's actions was examined. Participants were told that the videos were recordings of each of the interaction partner's decisions on how to split a pot of money, which could be either a fair or unfair split. This created a 2x2 factorial design. The first factor called "trustworthiness" was whether the interaction partner made fair or unfair splits of a £10 pot on the majority of trials. The second factor called "indicator" was whether the interaction partner indicated their choice of how to split the money by grasping one of the lamps or by using a hidden remote control to turn on one of the lamps (see table 6.1).

Table 6.1. Design of experiment 6.1.

Condition	Trustworthiness	Indicator
1	Trustworthy	Grasping
2	Trustworthy	Light
3	Untrustworthy	Grasping
4	Untrustworthy	Light

Following the videos, participants were presented with a screen where they could either reject or accept an offer from the person seen in the video (before they knew the offer). To allow the investigation of activity while participants were deciding whether to accept or reject the offers made by their interaction partner, activity time locked to the presentation of the participants decision screen was examined. A one factor design was used for this analysis. The factor was whether participants decided to reject or accept the split made by the interaction partner. In addition, to ensure that the manipulation affected participants' judgements of the trustworthiness of their interaction partners and to ensure that there was no significant difference between pre-interaction judgements of trustworthiness for the trustworthy and untrustworthy interaction partners, pre and post-interaction ratings of trustworthiness and attractiveness were gained from the participants. Missed trials were not included in this analysis.

6.2.2. Apparatus

The behavioural and fMRI data for this study was collected using the same experimental setup and apparatus (see fig.6.1 for a schematic). Participants were scanned using the 3tesla Siemens Trio scanner housed at Royal Holloway, University of London. During data collection, participants lay supine in the scanner with the fingers of the right hand positioned on a MRI-compatible 4-button response box. Stimuli were projected onto a screen behind the participant and viewed in a mirror positioned over the participant's head. Presentation software (Neurobehavioral Systems, Inc.) was used for the presentation of stimulus and the collection of participants' responses. A custom-built parallel port interface connected to the PC running Presentation received transistor-transistor logic (TTL) pulse inputs from the response keypad and also received TTL pulses from the MRI scanner at the onset of each volume acquisition, allowing events in the experiment to become precisely synchronized with the onset of each volume acquisition. Behavioural data analysis was performed offline, and event timings were prepared for subsequent general linear model (GLM) analyses of fMRI data. Analyses of fMRI data were conducted in SPM8.

6.2.3. Procedure

6.2.3.1. Experimental Task

The main experimental task used in this study involved making a series of economic decisions using a modified version of the Ultimatum Game (Bolton & Zwick, 1995;

Güth, Schimittberger, & Schwarze, 1982; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003; Thaler, 1988). In the standard Ultimatum Game, two players are given the opportunity to split a sum of money. One player is deemed the proposer and the other, the responder. The proposer makes an offer as to how this money should be split between the two. The second player (the responder) can either accept or reject this offer. If it is accepted, the money is split as proposed, but if the responder rejects the offer, then neither player receives anything. According to rational choice theory, responders should accept all non-zero offers. In reality, responders typically reject offers in which the proposer's share exceeds 80% of the total, preferring to gain nothing rather than accept an inferior share of the winnings (Bolton & Zwick, 1995; Güth et al., 1982).

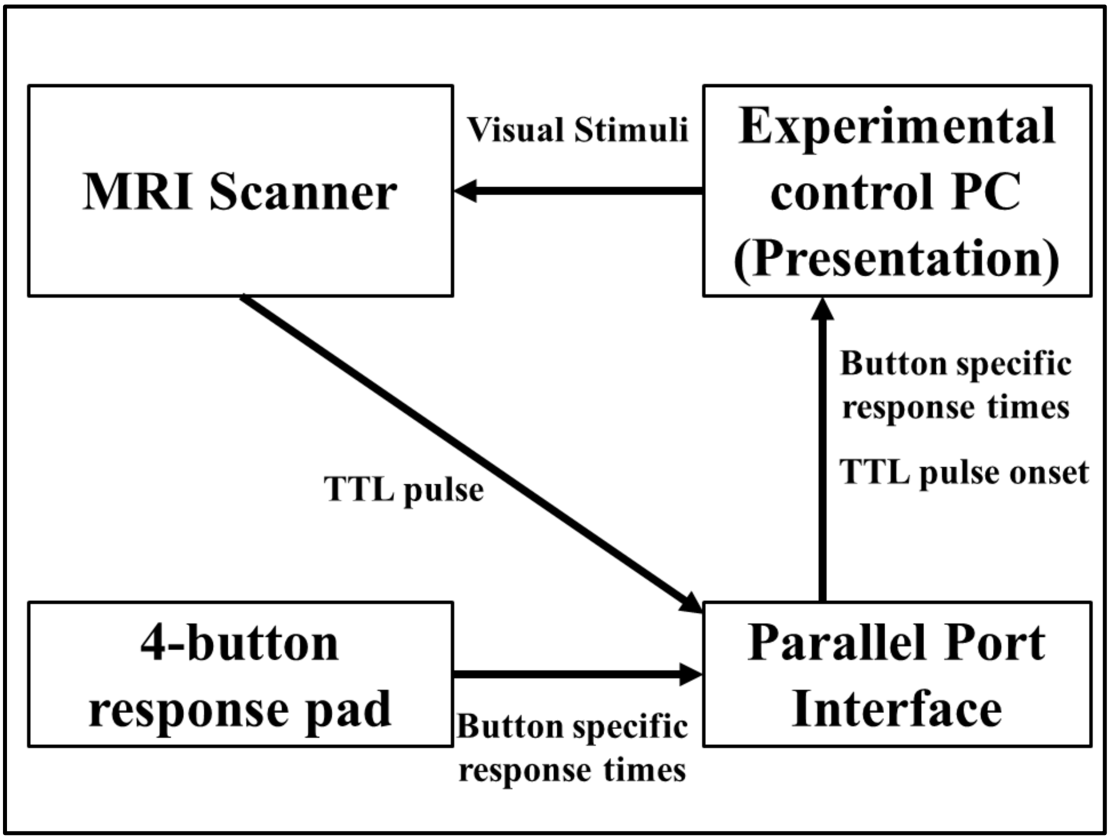

Figure 6-1 Apparatus used in scanning session

The task used in the current study had the same basic setup as the ultimatum game, with the participant taking the role of responder and their interaction partner that of proposer. In the current task participants were told that they would be interacting with two different proposers and would take part in multiple interactions with each.

However a number of alterations were made to the game in order to allow it to take place in the scanner and to ensure that a number of key aspects of the central hypothesis of the study were maintained. The greatest change to the game was that, rather than participants first receiving a proposal and then making a decision whether to accept or reject that offer, in the current study participants first had to decide whether to accept or reject the offer and only subsequently discovered what it was. This modification, which in effect made the current study's task a hybrid of the ultimatum game and the trust game, was made to ensure that participant's based their decision on whether to accept or reject each amount only on their past experience of how each proposer had decided to split the money rather than basing their decision on the way the money was split in each particular trial. This allowed for the examination of the reputational effects on AON responses.

A second change was that participants were informed that they would not be taking part in a live interaction with the proposers but that instead the two proposers had each made multiple choices on how to split the pot, based on a forced choice between two possible ways to split the pot offered by the experimenter. Participants were informed that although the proposers had already made their decisions, both the participant and the proposer would each be paid based on the decisions made by both the participant and proposer in one of the trials in which they interacted. This change was made so that, despite the use of video stimuli of the proposers' actions, participants still believed that their decisions would have an effect on both their own payment for the study and also on the payment that the proposers themselves received.

A third change to the standard ultimatum game was that before making the decision to accept or reject the offer participants viewed a video of the proposer. In each video the proposer was seated at a table with two lamps on each side of them and with their right hand placed in the centre of the table and their left hand hidden. Participants were informed that while these videos were being filmed the experimenter had been standing behind the camera with two options of how to split the money they had been given for the pot, one on the left side of the proposer and the other on the right. Participants were told that in some trials the proposers had been told to indicate the choice of which proposal they wished to make by reaching and grasping the lamp on one side or the other and in other trials the proposer had indicated which of the proposals they wished to make by using a hidden remote to turn on one or other of the lights.

In fact the proposers were confederates who had not actually made any decisions during these videos. The decisions attributed to them were in fact manipulated by the experimenter to ensure that one of the proposers usually made a fair division, offering either 40%, 50% or 60% of the pot to the participant, while the other proposer always made an unfair division, offering either 5%, 10% or 15% of the pot to the participant. However, in the scanning session there were also seven “catch trials” in which the proposer made offers of the opposite trustworthiness from the offer they usually made. This ensured that participants did not become too habituated to the correspondence between the fair and unfair splits and the identity of the two proposers, so that they treated their decision on each trial as being of equal importance. To ensure that participants had a chance to learn the correspondence between the trustworthiness of the split and the identity of the proposer, the catch trials only appeared after the first ten trials, five with each of the proposers.

A final alteration from the standard ultimatum game was the means by which participants indicated whether they were willing to accept or reject the offer being proposed. In order to ensure that participants focused on the grasping action in the grasping condition, participants were told to press either a left or right button to indicate whether they wished to accept or reject the offer. Which button meant accept and which meant reject varied according to which of the lamps was reached for/lit up by the proposer and was indicated in the following decision screen. In half of the trials, to accept the offer participants were told to press the button corresponding to the side of the screen that the proposer had indicated and in the other half, to accept the offer participants were told to press the button corresponding to the opposite side of the screen that the proposer had indicated. In all trials participants were told to respond using an egocentric reference frame rather than the reference frame of the proposer, so that when the proposer reached to the left side of the screen from the participant’s perspective, and the following decision screen said to press the same side, they would press the left button, Importantly, participants only discovered whether each trial required them to use the same or opposite button to indicate accept after they had finished observing the video for that trial, thus ensuring that any activation in the motor cortex observed during the duration of the video was not due to motor preparation but must instead have been due to action observation.

These modifications allowed the current study to investigate the effect on the AON on observing the action of someone known to be trustworthy compared to the action of someone known to be untrustworthy, and also allowed the contrast between a visually observed action (the grasping condition) and a non-action based indicator (the light condition). The fact that, apart from the identity of the proposer, the setup looked identical at the onset of all videos ensured that participants could not determine whether each video would be a light or action video. The fact that in each video the proposer indicated their choice with reference to the position of the lamps ensured that all videos were equivalent in terms of their demands on spatial attention, meaning that any difference in the motor system between the grasping and light conditions had to be due to a differential effect of processing the observed action.

As a result of these changes to the ultimatum game, each trial of the task in the current study was divided into four different periods (see Figure 6-2). In the first period participants observed a 2 second “indicator” video in which the proposer indicated their decision on how to split the pot as described above. In the second period participants had to decide whether they wanted to accept or reject the division of the pot that the other person had made in the indicator video, using one of the two direction buttons as detailed above. In this period of the trial participants saw a screen with either the word “same” or “different” on it, which indicated whether they had to press the button corresponding to the same side of the screen the proposer had indicated or to the opposite side. This “decision” screen was always present for 3 seconds. In the third period participants saw an “outcome” screen which was made up of a picture of the face of the proposer and information about how they had decided to split the pot of money between themselves and the participant. The “outcome” screen was also present for 3 seconds and ensured that participants had a chance to learn the difference between the trustworthy and untrustworthy proposer in terms of how they split the pot of money. Finally, in the fourth period participants received feedback on what their decision had been. This was in the form of either the word accepted or rejected or, in cases where participants failed to press either button before the end of the "decision" screen, the word missed. This "feedback" period was displayed for 500 ms. The purpose of the "feedback" period was to ensure that participants understood how to use the buttons to correctly express their decisions and also to provide them with an additional prompt to make sure they responded to the "decision" period within the 3 seconds.

6.2.3.2 Training Session

In order to ensure that participants were able to understand and complete the task correctly all participants attended a training session no more than 14 days before they took part in the MRI scanning session. During this training session participants first saw images of the faces of the two people they would interact with during the scanning session, along with 8 gender matched faces and an additional 10 faces of the opposite gender. They were first asked to rate the faces for attractiveness and then again for trustworthiness. The faces were presented in a random order. Each face was presented for 2 seconds and participants then had to rate the face using a small marker on a horizontal scale which could be moved along the scale using the keyboard. In all the scale had 30 possible positions. After rating all 20 faces for attractiveness the faces were presented again in a random order and participants rated each face for trustworthiness.

Following the face rating, participants were given the instructions for the main experimental task that they would undertake during both the training phase and in the scanner. They were then given a shorter version of the main experimental task consisting of 60 trials, which were equally distributed between the four experimental conditions (15 trustworthy grasping, 15 untrustworthy grasping, 15 trustworthy light and 15 untrustworthy light). The training version of the experimental task used videos where both proposers were from the opposite gender to the participant and participants were informed that the pot of money being split in each trial was £5. In addition, due to the lower number of trials in the training session there were no "catch" trials in this session.

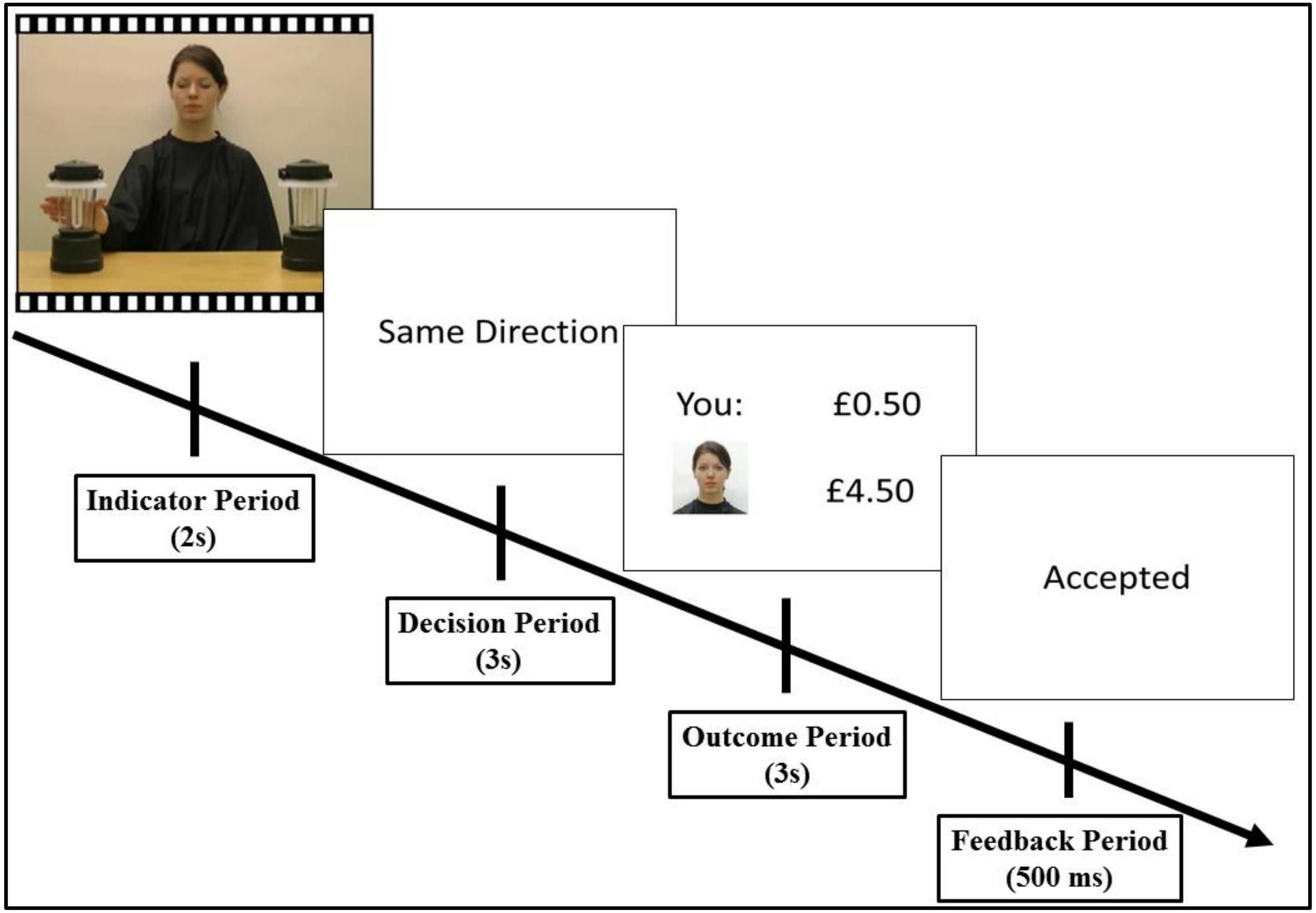

Figure 6-2 Outline of the time line of experimental trials during the main task.

In total 41 participants took part in the training session. However, the current study was concerned with producing an affective reaction towards the two proposers. Therefore it was important to ensure that only those participants showing an affective response to the untrustworthy person, by rejecting more of their offers than they accepted, were invited to take part in the scanning session. This screening procedure was used for two reasons. First it ensured that all participants for the scanning session were able to learn the correspondence between the identity of the proposer and the trustworthiness of the offers. Second it removed those participants who employed the optimal strategy according to rational choice theory and accepted all offers made by either proposer. This was necessary because those who accepted all or almost all offers did not have to pay any attention to the identity of the proposer and so might not be expected to have a strong affective reaction to either proposer. Although removing participants from the study based on their failure to perform as desired in the behavioural task does reduce the generalizability of the current study's results, the expense of scanning participants in an MRI study meant that this screening process was necessary in order to ensure that the participant's tested did experience the two proposers as trustworthy and untrustworthy. Out of the 41 participant's tested in the training session 28 showed the desired pattern of responses and of those, 21 were subsequently scanned and 18 were included in the final analysis (for more details see section 6.2.4).

6.2.3.3 Scanning Session

In the scanning session participants first had the experimental task explained to them again and were then told that in this version of the task the amount of money being split by each proposer was £10. Participants were then positioned in the scanner and first carried out a practice block of ten trials of the main task described in section 6.2.3.1. The practice session had two purposes. First it allowed participants to become familiar with the screen and button box setup used in the scanner and second it allowed participants to learn the relationship between the two proposers and their likely responses, meaning that during the main scanning session they were already aware of the trustworthiness of their proposers. During this practice session a high resolution T1-weighted structural image was acquired. These anatomical images were used for the purposes of normalization (see below) and displaying results.

Following the completion of the practice block and anatomical scan participants then began the main experimental task. The task consisted of 140 trials, which were equally distributed between the four experimental conditions (35 trustworthy grasping, 35 untrustworthy grasping, 35 trustworthy light and 35 untrustworthy light). Events in each trial took place across five TRs (0–15 s; TR=3s). The interval between scan onset and "indicator" period onset was varied over the first TR from trial-to-trial. To optimally sample the decision a randomly varying interval between the scan onset and these cues was introduced over the second and third TRs. This achieved an effective temporal sampling resolution much finer than one TR for the conditions of interest. These intervals were uniformly distributed for each condition, ensuring that Evoked Haemodynamic responses (EHRs) time-locked to the events were sampled evenly across the time period following each "indicator" or "decision" period.

Subsequent participants carried out the face rating task which they had performed at the beginning of the training session, again rating each face for attractiveness and trustworthiness. While participants rated the faces phase and magnitude, maps were collected using a GRE field map sequence.

Following the completion of the face rating task participants were removed from the scanner and were debriefed as to the true nature of the study. Participants were informed that they would not be paid based on their responses as had previously been claimed but instead would be paid £15 plus whatever money they had earned in the training session. The field maps were used to unwarp the images post-hoc in order to minimize artefactual effects.

6.2.4. Participants

In total twenty one participants were scanned. All gave their informed consent to participate and were paid for their participation. All participants were healthy and right-handed and were screened for neurological disorders. Three participants were excluded from the analyses, two due to a high level of movement artefacts and one due to a technical problem that led to a loss of their data. This left a total of eighteen participants (mean age ± *SD*: 21.1 ± 2.4, 4 male) The study was approved by the Departmental Ethics Committee, Royal Holloway, University of London.

6.2.5. Functional imaging and analysis

6.2.5.1 Data Acquisition

720 EPI scans were acquired from each participant. In each scan 38 slices were acquired in an ascending manner, at an oblique angle (≈15˚) to the AC-PC line in order to decrease the impact of susceptibility artefacts in the orbitofrontal cortex (Deichmann et al., 2003). A voxel size of 3×3×3 mm (20% slice gap, 0.6 mm) was used; TR=3 s, TE=32, flip angle=85°. The functional sequence lasted 36 minutes. Prior to the functional sequence high resolution T1-weighted structural images were acquired at a resolution of 1×1×1 mm using an MPRAGE sequence. Immediately following the functional sequence, phase and magnitude maps were collected using a GRE field map sequence (TE_1 = 5.19ms, TE_2 = 7.65ms).

6.2.5.2. Image Preprocessing

Scans were pre-processed using SPM8 (www.fil.ion.ucl.ac.uk/spm). The EPI images from each participant were corrected for distortions caused by susceptibility-induced field inhomogeneities using the FieldMap toolbox (Andersson, Hutton, Ashburner, Turner, & Friston, 2001). This approach corrects for both static distortions and changes in these distortions attributable to head motion (Hutton, Kyme, Lau, Skerrett, & Fulton, 2002). The *B*0 field map acquired after the EPI sequence was used to calculate static distortion and the EPI images were then realigned, and coregistered to the participant's own anatomical image. The structural image was processed using a unified segmentation procedure combining segmentation, bias correction, and spatial normalization to the MNI template(Ashburner & Friston, 2005). The same normalization parameters were then used to normalize the EPI images. Finally, the images were spatially smoothed in order to conform to the assumptions of the GLM implemented in SPM8 by applying a Gaussian kernel of 8 mm FWHM.

6.2.5.3. First-level Analysis

Two first-level GLMs were created for factorial analyses. In the first GLM there were five event types. Each event-type was used to construct a regressor by convolving the "indicator" video durations with the canonical HRF. Each of the four conditions specified in the design was modelled as a separate regressor. In addition, one regressor modelled the activity during the "decision" period (regardless of the condition the period was in). The residual effects of head motion were modelled as covariates of no interest in the analysis by including the six head motion parameters estimated during realignment.

In the second GLM there were two event types, corresponding to decision trials in which participants had accepted an offer from the proposer and decision trials in which they had rejected an offer from the proposer. Each event-type was used to construct regressor by convolving the timing of the decision period onset with the canonical HRF. Trials in which the participant failed to respond within 3s of the onset of the "decision" period were excluded from the model. The residual effects of head motion were modelled as covariates of no interest in the analysis by including the six head motion parameters estimated during realignment.

6.2.5.4 Second-level Analysis

For each of the two GLMs, random effects analyses (Full-Factorial ANOVAs) were applied to determine voxels significantly different at the group level. SPM{t} contrast images from all participants at the first-level were input into second-level full factorial design matrices. *t*-contrasts were conducted in the second-level random-effects analyses for each of the main effects in the first GLM and for the main effect of the second GLM. An *F*-contrast was conducted in the second-level random-effects analyses for the interaction of the first GLM. Whole-brain analyses are reported using significance level of $p > 0.001$ whole-brain uncorrected, with a spatial threshold of 10 voxel cluster size, an approach similar to that used in previous studies (Eisenberger et al., 2010; Kuhl, Shah, DuBrow, & Wagner, 2010; P. A. Lewis, Rezaie, Brown, Roberts, & Dunbar, 2011; Masten, Morelli, & Eisenberger, 2011; Slavich, Way, Eisenberger, & Taylor, 2010; Wittmann et al., 2005; Younger, Aron, Parke, Chatterjee, & Mackey, 2010). This approach provides a reasonable balance with respect to type I and type II error concerns, consistent with the false discovery rate in typical behavioural science research, as outlined by Lieberman and Cunningham (2009).

6.3. Results

6.3.1. Behavioural Results

6.3.1.1. Ratings of Proposers' Faces Before Manipulation

In order to ensure that there were no significant differences in participants' ratings of the two proposers prior to the scanning task, paired sample t-tests were carried out on the ratings given to the proposers faces in the training session. These t-tests confirmed that there were no significant differences in ratings of attractiveness ($t(17) = -.62$, p = .55) or trustworthiness ($t(17) = -.69$, $p = .50$).

6.3.1.2. Ratings of Proposers' Faces After Manipulation

To examine whether the experimental manipulation of trustworthiness had been successful, two analyses of covariance were carried out. In the first ANCOVA, the dependent variable was participants' ratings of attractiveness for the proposers' faces after the scanning session, the independent variable was the trustworthiness of the proposer and the covariate was participants' ratings of attractiveness for the proposers' faces during the training session. This analysis found no significant effect of the experimental manipulation on ratings of attractiveness, $F(1, 20.29) = 0.9$, $p > .05$. In the second ANCOVA, the dependent variable was participant's ratings of trustworthiness for the proposers' faces after the scanning session, the independent variable was the trustworthiness of the proposer and the covariate was participant's ratings of trustworthiness for the proposers' faces during the training session. This analysis found a significant effect of the experimental manipulation on ratings of trustworthiness, $F(1, 16.4) = 5.183$, $p < .05$, because, taking into account their pre interaction rating, after social interaction participants judged the trustworthy proposer as being more trustworthy (*M* = 4.83, *SD* = 4.79) than the untrustworthy proposer (*M* = 1.5, *SD* = 5.94).

6.3.1.3. Acceptance of Offers During Scanning Task

In order to investigate whether participants had indeed learnt to associate the two proposers with the correct offers, the total number of offers accepted and rejected in the scanning task for each of the four experimental conditions was calculated for each participant. These values were then used as the dependent variables in a 2 x 2 x 2 analysis of variance, with response (accepted/rejected), indicator (grasping/light) and trustworthiness (trustworthy/untrustworthy) as the independent variables. No main effects were found but a significant interaction between response and trust was found $F(1, 17) = 104.5$, $p < .001$ (see figure 6-3). Planned comparisons revealed that this interaction was driven by the fact that for the trustworthy proposer participants accepted (*M* = 61.94, *SD* = 8.91) more offers than they rejected (*M* = 7.28, *SD* = 8.92). By contrast, for the untrustworthy proposer participants rejected (*M* = 54.11, *SD* = 16.16) more offers than they accepted (*M* = 54.11, *SD* = 15.26).

6.3.1.4. Reaction Times for Decisions During Scanning Task

In order to investigate whether participants showed differential reaction times during the decision period for the different conditions, a 2 x 2 x 2 repeated measures ANOVA was conducted, with reaction time as the dependent variable and trustworthiness (trustworthy, untrustworthy), indicator (grasping, light) and response (accept, reject) as the independent variables (see Figure 6-3). Three participants were excluded from the analysis as they did not make any responses in one of the eight conditions. A main effect of trustworthiness was found as participants took longer to respond to the untrustworthy proposer (*M* = 1130.38, *SD* = 375.41) compared to a trustworthy proposer (*M* = 1060.55, *SD* = 525.35). A main effect was also found for response with participants taking longer to reject offers (*M* = 1288.83, *SD* = 291.33) than to accept offers (*M* = 1098.24, *SD* = 511.35) (see Figure 6-3).

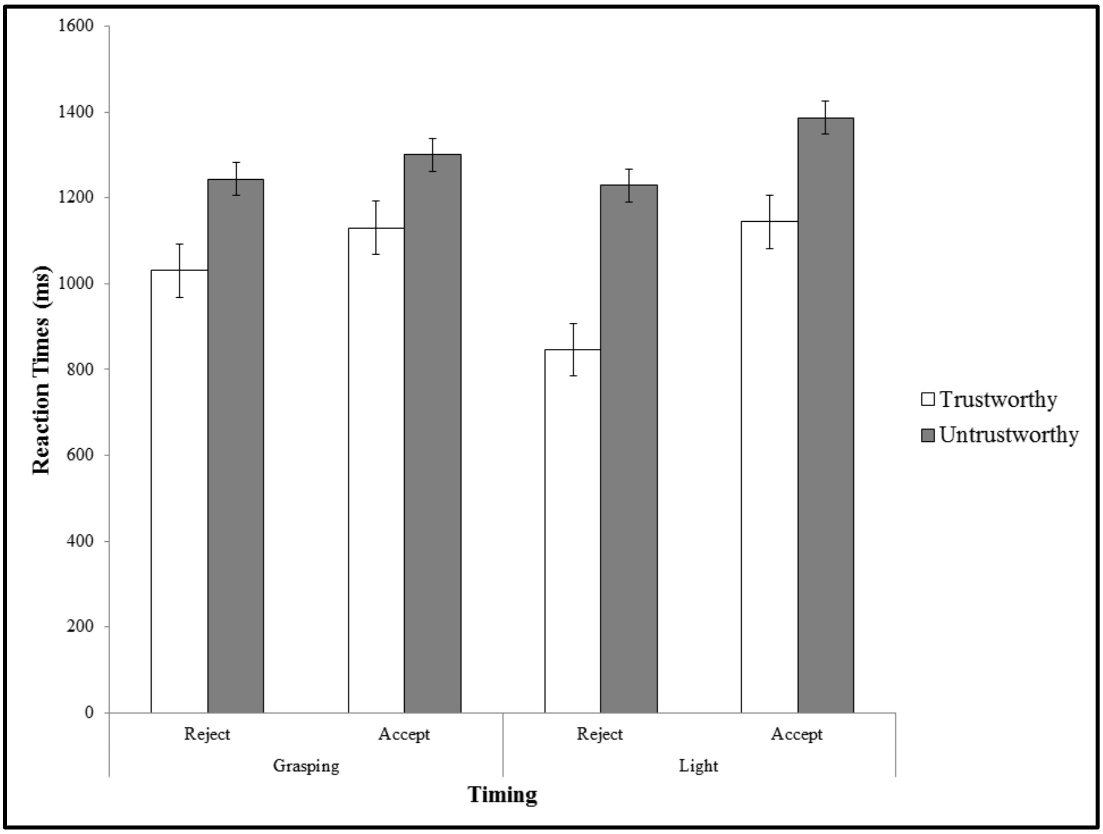

Figure 6-3. Reaction Times for offers in each of the different conditions. Error bars represent SEM.

6.3.2. Functional Imaging Results

6.3.2.1. Main effect of Indicator

Figure 6-4. and Table 6-2. show the results of the contrast Grasping > Light. As can be seen this contrast revealed that observing grasping actions compared to lights turning on led to greater activation in bilateral occipital and temporal regions extending across the middle temporal gyrus and middle occipital gyrus and encompassing the left STS. It also led to the activation of a cluster consisting of bilateral frontal polar regions and the left superior frontal gyrus and a cluster in the left middle frontal gyrus.

Figure 6-4. and Table 6-3. show the results of the contrast Light > Grasping. As can be seen this contrast revealed that observing lights turning on compared to grasping actions led to an increase in activation in the left superior frontal gyrus and the right inferior frontal gyrus.

Table 6.2 Grasping > Light. Peak voxel coordinates in MNI space and z-values for the fMRI contrast revealing areas more activated by observation of grasping than by observation of light turning on. Different colours indicate regions in the same cluster, * indicates a cluster that survived family wise error correction.

Region (BA)	Hemisphere	X	Y	Z	Z-Score	Cluster Size
Middle Temporal Gyrus* (19/V5)	R	48	-60	0	5.44	1597
Lateral Occipital Sulcus	R	38	-80	6	4.47	
Middle Occipital Gyrus	R	30	-82	0	4.47	
Middle Occipital Gyrus*	L	-50	-78	4	5.4	1445
Superior Temporal Sulcus	L	-46	-60	10	4.88	
Frontalpolar Gyrus	L	-12	66	10	3.89	124
Superior Frontal Gyrus	L	-10	62	0	3.49	
Frontalpolar Gyrus	R	6	56	24	3.47	
Superior Frontal Gyrus	L	-18	32	44	3.54	10

Table 6.3 Light > Grasping. Peak voxel coordinates in MNI space and z-values for the fMRI contrast revealing areas more activated by observation of light turning on than by observation of grasping. Different colours indicate regions in the same cluster.

Region (BA)	Hemisphere	X	Y	Z	Z-Score	Cluster Size
Superior Frontal Gyrus (6)	L	-10	10	46	4.60	40
Inferior Frontal Gyrus, Pars Opercularis (6/44)	R	54	6	40	4.07	20

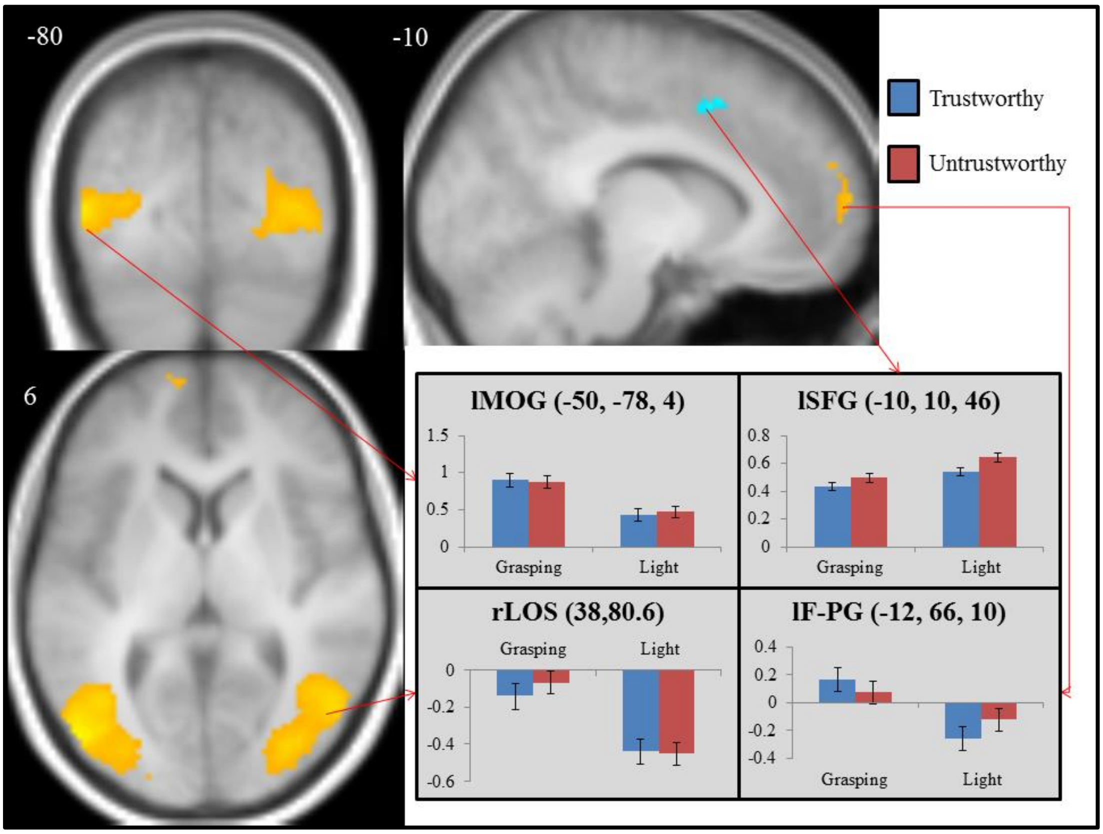

Figure 6-4. Brain areas showing greater activation for the observation of grasping (orange) or light (blue) and parameter estimates for peak voxels. Blue indicates estimates for the trustworthy proposer and red for the untrustworthy proposer. Coordinates are in MNI space. lMOG = left middle occipital gyrus; lSFG = left superior frontal gyrus; rLOS = right lateral occipital sulcus; lF-PG = left frontalpolar gyrus. Error bars represent SEM.

6.3.2.4. Main effect of Trustworthiness

No brain areas were significantly more active when observing a trustworthy proposer compared to an untrustworthy proposer.

Figure 6-5. and Table 6-4. show the results of the contrast Untrsutworthy > Trustworthy. As can be seen this contrast revealed that observing untrustworthy proposer compared to observing untrustworthy proposer led to an increase in activation in the left superior frontal gyrus and the left superior temporal sulcus.

Table 6.4. Untrustworthy > Trustworthy. Peak voxel coordinates in MNI space and z-values for the fMRI contrast revealing areas more activated by observation of an untrustworthy proposer than by observation of a trustworthy proposer. Different colours indicate regions in the same cluster.

Region (BA)	Hemisphere	X	Y	Z	Z-Score	Cluster Size
Superior Frontal Gyrus (6)	L	-26	-4	66	4.65	133
Inferior Parietal Lobe (7)	R	30	-48	52	3.77	17
Precuneus (7)	L	-8	-62	54	3.64	27
Superior Temporal Sulcus	L	-42	-46	12	3.54	24
Precuneus (7)	R	12	-58	52	3.44	22
Superior Frontal Gyrus (6)	R	30	-4	58	3.27	12

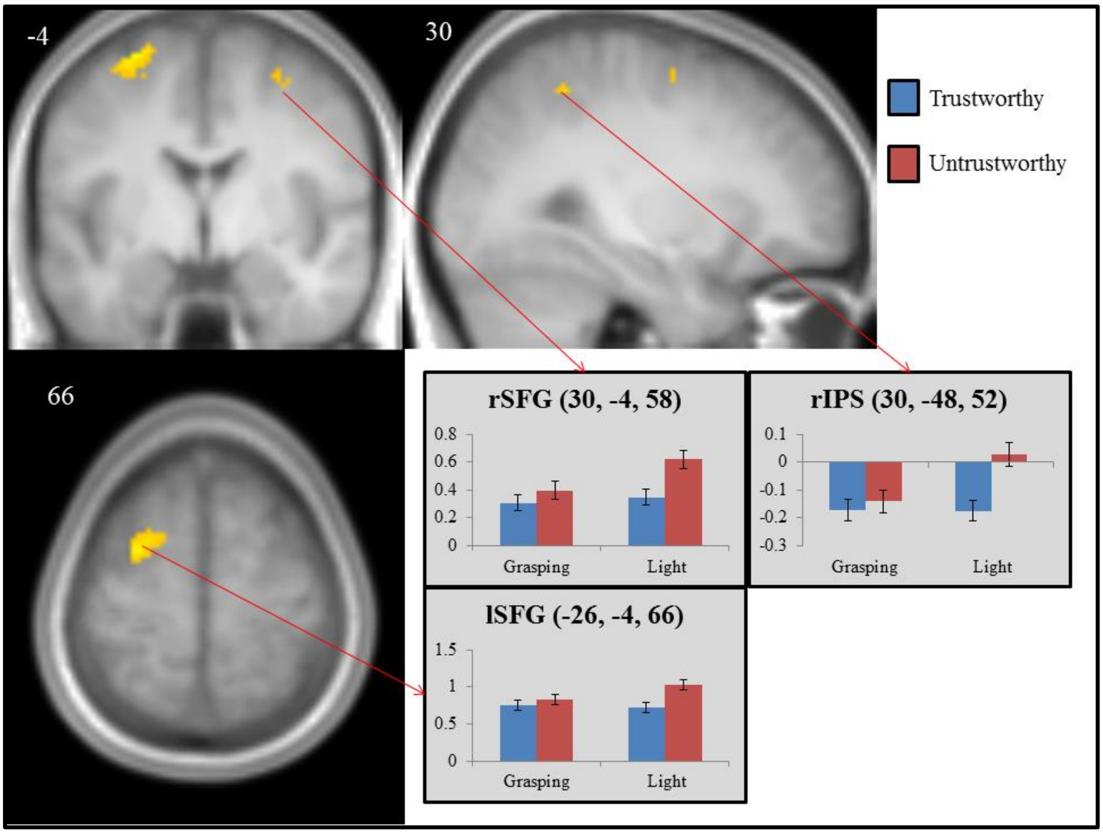

Figure 6-4. Brain areas showing greater activation for the observation of untrustworthy proposers and parameter estimates for peak voxels. Blue indicates estimates for the trustworthy proposer and red for the untrustworthy proposer. Coordinates are in MNI space. rSFG = right superior frontal gyrus; rIPS = right interparietal sulcus lSFG = left superior frontal gyrus . Error bars represent SEM.

6.3.2.5. Areas Showing an Interaction between Indicator and Trustworthiness

Figure 6-5. and Table 6-5. show the results of the interaction analysis between indicator and trustworthiness. This contrast revealed interaction effects in a number of bilateral occipital-temporal regions the right precuneus, the right orbital gyrus, the left middle frontal gyrus (corresponding to the dPMC), the right inferior precentral sulcus expanding into Brodmann area 44, and the left STS. Inspection of parameter estimates revealed that almost all areas activated showed greater activation when participants observed a trustworthy proposer performing an action than when a trustworthy proposer turned on a light and greater activation when an untrustworthy person turned on a light than when they performed a grasping action. The one exception to this was activation in the left STS which showed the opposite pattern of activation.

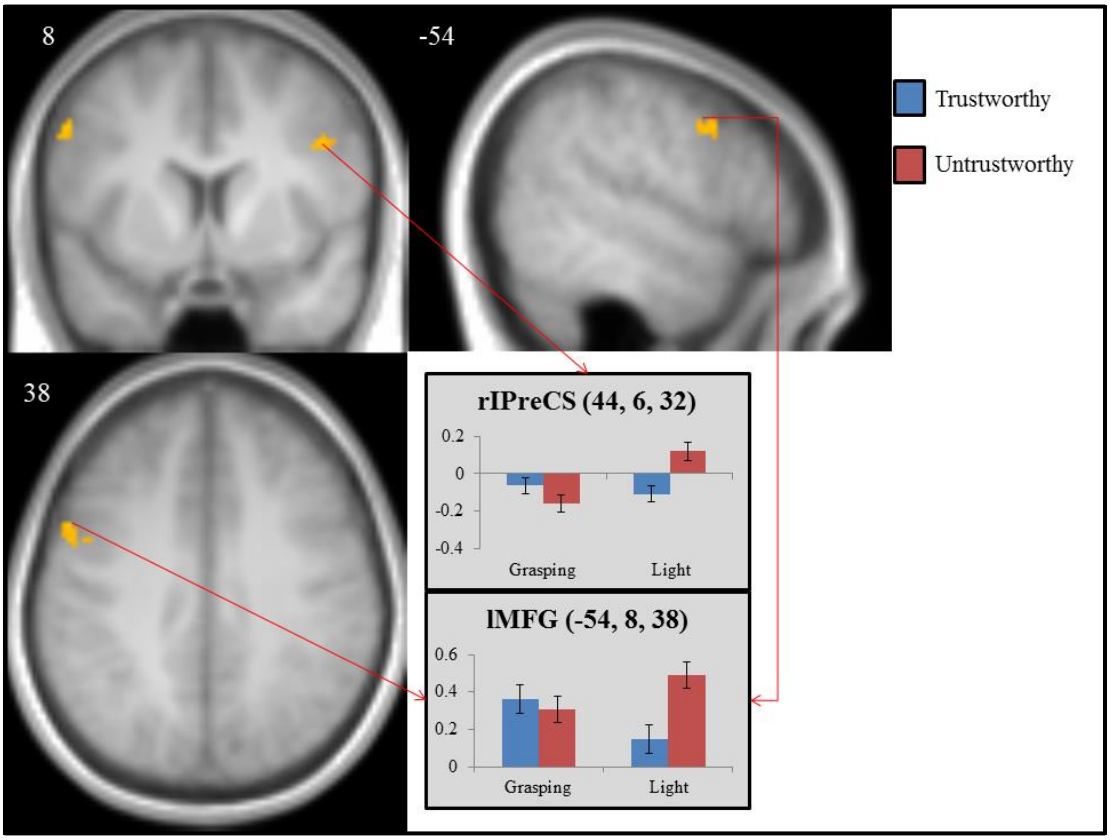

Figure 6-5. Brain areas showing an interaction between indicator and trustworthiness as well as parameter estimates for peak voxels. Blue indicates estimates for the trustworthy proposer and red for the untrustworthy proposer. Coordinates are in MNI space. rIPreCS = right inferior precentral sulcus; lMFG = left medial frontal gyrus. Error bars represent SEM.

Table 6.5 Interaction between Indicator and Trustworthiness. Peak voxel coordinates in MNI space and z-values for the fMRI contrast revealing areas that show an interaction effect between the trustworthiness of the proposer and the type of indicator observed. Different colours indicate regions in the same cluster.

Region (BA)	Hemisphere	X	Y	Z	Z-Score	Cluster Size
Trustworthy Grasp, Untrustworthy Light > Untrustworthy Grasp, Trustworthy Light						
Inferior Occipital Gyrus (19/V3)	L	-18	-92	-10	4.43	153
Lingual Gyrus (19/V4)	L	-24	-90	-18	3.60	
Precuneus (7)	R	6	-62	46	4.14	47
Middle Temporal Gyrus	R	34	-54	10	3.92	69
Middle Occiptal Gyrus	R	28	-50	20	3.22	
Inferior Temporal Gyrus	L	-40	-12	-24	3.91	11
Inferior Occipital Gyrus (19/V3)	R	30	-86	-20	3.85	43
Medial Orbital Gyrus	R	18	36	-14	3.79	12
Middle Frontal Gyrus (6)	L	-54	8	38	3.76	43
Inferior Precentral Sulcus (44)	R	44	6	32	3.66	19
Inferior Temporal Gyrus	R	56	-14	-30	3.57	12
Untrustworthy Grasp, Trustworthy Light > Trustworthy Grasp, Untrustworthy Light						
Superior Temporal Sulcus	L	-32	-56	12	3.56	10

6.3.2.5. Areas activated During Deciding Whether to Accept or Reject an Offer

A further analysis focused on brain areas activated that were differentially activated while participants made a decision to accept or reject the proposers offer, in order to discover whether the brain regions activated during the observation of rewarding or unrewarding actions by another overlapped with those involved in decisions about whether to accept or reject the reward associated with those actions. Figure 6-5.and Table 6-6. show the results of the contrast accept > reject for the second GLM. As can be seen this contrast revealed that when participants decided to accept offers, there was increased activation across a range of brain regions including bilateral precuneus activation, a cluster of activation centred on the right orbitofrontal cortex but extending into the cingulate sulcus and into the left orbitofrontal cortex, activation in the left middle and superior frontal gyri, activation in the left middle temporal gyrus and angular gyrus and activation in the right parahippocamal gyrus and into a cluster of activation centred on the right angular gyrus but extending into the middle occipital gyrus and the STS.

Table 6.6 Accept > Reject. Peak voxel coordinates in MNI space and z-values for the fMRI contrast revealing areas more activated when participants decided to accept the offer from the proposer than when they decided to reject the offer. Different colours indicate regions in the same cluster, * indicates a cluster that survived family wise error correction.

Region (BA)	Hemisphere	X	Y	Z	Z-Score	Cluster Size
Precuneus (7)*	L	-8	-52	16	4.88	1465
Precuneus (7)	R	8	-52	24	4.56	
Medial Orbital Gyrus*	R	4	32	-10	4.48	2078
Cingulate Sulcus	R	12	54	10	4.45	
Middle Temporal Gyrus*	L	-58	-12	-18	4.37	158
Posterior Orbital Gyrus	R	36	36	-10	3.97	39
Middle Frontal Gyrus*	L	-20	30	40	3.94	227
Superior Frontal Gyrus	L	-22	42	40	3.72	
Angular Gyrus (39)*	L	-38	-78	38	3.91	142
ParaHippocampal Gyrus	R	30	-32	-14	3.75	37
Angular Gyrus (39)	R	50	-62	28	3.62	144
Middle Occipital Gyrus	R	50	-72	26	3.28	
Superior Temporal Sulcus	R	46	-62	16	3.28	

Figure 6-6. and Table 6-7. show the results of the contrast reject > accept for the second GLM. As can be seen this contrast revealed that for offers participants decided to reject there was increased activation across a range of brain regions including activation in the left dPMC, a cluster of activation centred on the left precentral gyrus (posterior M1) and extending into the post central gyrus. There was also activation in the right hemisphere occipital regions, the right precuneus, the left inferior parietal gyrus and lateral interparietal sulcus.

Table 6.7. Reject > Accept. Peak voxel coordinates in MNI space and z-values for the fMRI contrast revealing areas more activated when participants decided to reject the offer from the proposer than when they decided to accept the offer. Different colours indicate regions in the same cluster, * indicates a cluster that survived family wise error correction.

Region (BA)	Hemisphere	X	Y	Z	Z-Score	Cluster Size
Middle Frontal Gyrus (6)*	L	-26	-2	38	4.66	153
Middle Frontal Gyrus (6)*	R	28	-10	40	4.31	190
Postcentral Gyrus*	L	-30	-32	40	4.11	63
Calcarine Gyrus (17)*	L	-4	-92	0	3.98	312
Lingual Gyrus (18)	L	-12	-84	-6	3.89	
Fusiform Gyrus (19/V4)*	R	32	-78	-16	3.85	111
Lingual Gyrus (18)*	R	18	-72	-2	3.80	79
Middle Occipital Gyrus*	R	32	-72	30	3.77	73
Inferior Parietal Gyrus (40/Pf)	L	-56	-44	36	3.53	22
Interparietal Sulcus	L	-22	-66	38	3.48	27
Interparietal Sulcus (40/Pf)	L	-48	-44	56	3.48	16
Precuneus (7)	R	16	-54	42	3.44	11

6.4. Discussion

The aim of the current experiment was to investigate whether the AON observation network is modulated by the perceived trustworthiness of an actor. Based on previous studies showing that liking (A. H. Fischer et al., 2012; Mcintosh, 2006) and percieved social closeness to another (Bourgeois & Hess, 2008; Liebert et al., 1972; Neely et al., 1973; van der Schalk et al., 2011; Weisbuch & Ambady, 2008; Yabar et al., 2006) can modulate imitation and studies showing a close link between areas involved in imitation and action observation (Buccino et al., 2004; Grèzes, Armony, Rowe, & Passingham, 2003; Heiser, Iacoboni, Maeda, Marcus, & Mazziotta, 2003; Iacoboni et al., 2001; Koski, Iacoboni, Dubeau, Woods, & Mazziotta, 2003; Leslie, Johnson-Frey, & Grafton, 2004; Molenberghs, Brander, Mattingley, & Cunnington, 2010; Molenberghs et al., 2012) it was hypothesised that observing the actions of a trustworthy person compared to the actions of an untrustworthy person would lead to greater activation of the AON. Due to the focus of the current study on regions in the AON, in this discussion I will focus on activations found in the areas that have previously been implicated as being activated by the observation of action. These areas include the IFG; the IPL, the STS; the vPMC; the dPMC; the IPS; the SPL,the precuneus, the insula, the primary somatosensory cortex (SI), the cingulate gyrus and the cerebellum.

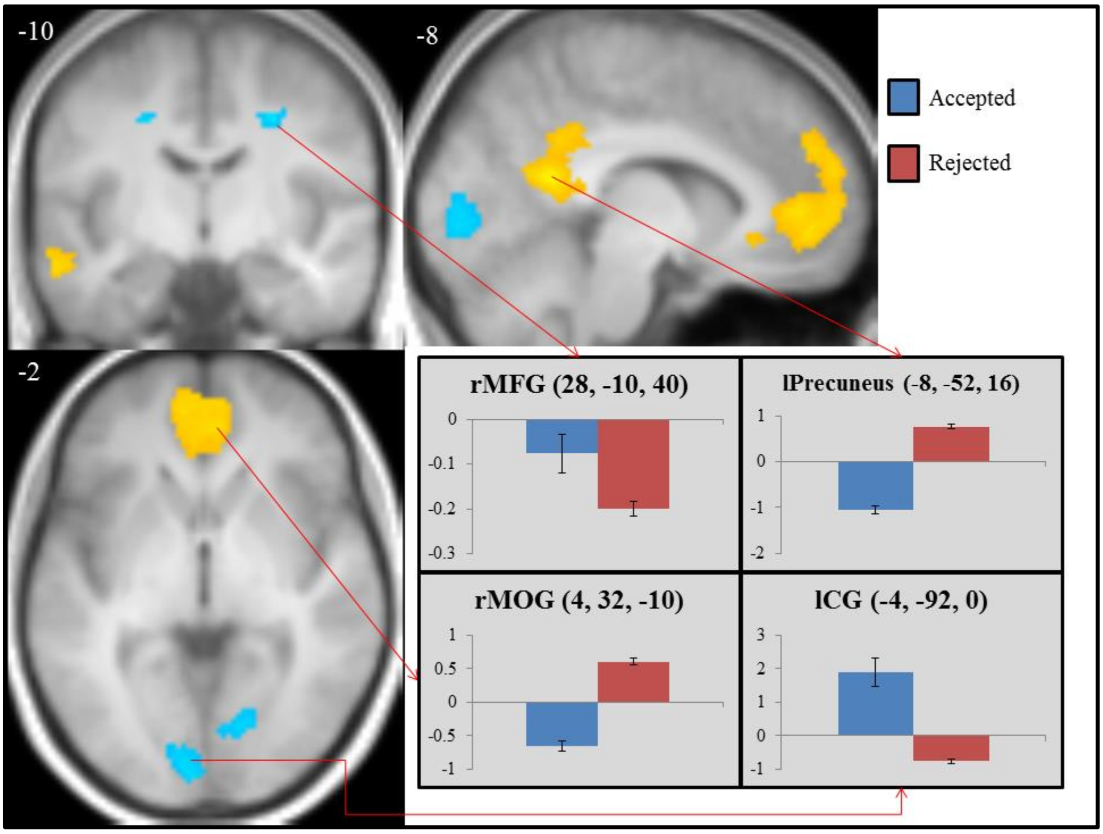

Figure 6-6. Brain areas showing greater activation for the decision to accept (orange) or reject (blue) offers from the proposer, as well as parameter estimates for peak voxels. Blue indicates estimates for the accept condition and red for the reject condition. Coordinates are in MNI space. rMFG =right middle frontal gyrus; lPrecuneus = left precuneus gyrus; rMOG = right medial orbital gyrus; lCG = left calcerine gyrus. Error bars represent SEM.

<u>6.4.1 Areas Activated in the Contrasts between Indicators</u>

Contrasts between the two indicator conditions (grasping and light) revealed that observing a grasping action led to increased activation in a network of bilateral occiptial-temporal regions which in the right hemisphere centred on area V5 and in left hemisphere extended into the STS. The greater activation of these areas during the observation of hand actions is consistent with findings reported by several studies that indicate that these regions are selectively activated by the observation of motion in genral (Beckers & Zeki, 1995; Lechak & Leber, 2011; Zeki & Stutters, 2013) and by hand and body actions in particular (Grèzes, Costes, & Decety, 1998; Grossman et al., 2000; Jastorff, Clavagnier, Gergely, & Orban, 2011; Kable & Chatterjee, 2006; Kable, Kan, Wilson, Thompson-Schill, & Chatterjee, 2005; Wiggett & Downing, 2011).

Increased activation during the observation of action was also observed in the frontal poles. This region has been demonstrated to play an important role in inhibiting behaviour. Of particular interest to the results of the current study, damage to the frontal pole has been associated with the emergence of an imitation behavioural syndrome (Brass, Derrfuss, Matthes-von Cramon, & von Cramon, 2003; De Renzi, Cavalleri, & Facchini, 1996; Lhermitte, Pillon, & Serdaru, 1986) which has been linked to the failure of inhibitory processes and suggests a link between the frontal pole and the inhibition of action. This link between the frontal pole and imitation inhibition has been supported by the results of several fMRI studies in healthy participants (Brass, Derrfuss, & von Cramon, 2005; Brass, Zysset, & von Cramon, 2001; Ruby & Decety, 2001, 2003) which have shown increased activation in frontopolar areas in tasks that involve inhibiting one's own perspective while attending to the perspective of another. The assumption of an inhibitory role of the frontopolar region is also in accordance with the finding that inhibitory neurons (GABA neurons) in the anterior cingulate and frontopolar cortex are lacking in the brains of patients who are susceptible to confusing self and other (Glantz & Lewis, 2000; Selemon & Goldman-Rakic, 1999).

The other area to show greater activation for observing grasping rather than light-switching was the superior frontal gyrus. Activation in this region has been associated with both response inhibition (Beauregard, Lévesque, & Bourgouin, 2001; Booth et al., 2003; Kelly et al., 2004; Tamm, Menon, & Reiss, 2002) and working memory (du Boisgueheneuc et al., 2006). This link between frontal pole and superior frontal gyrus activity and imitation inhibition suggests that the frontal pole activation observed in the current experiment related to the need for participants to inhibit their own possible motor responses while having to attend to and memorise the spatiality of the proposer's grasping movement.

The failure to find any activation in the AON in the contrast between grasping and light indicators was suprising. More suprising however was that the contrast to identify areas that showed greater activation for the light indicator than the grasping indicator revealed two clusters, one located in the left SMA and the other in the pars opercularis of the right inferior frontal gyrus. Both of these areas are part of the AON and so might be expected to show a greater activation to the observation of an action than to the observation of a light turning on. A possible explanation for this finding may lie in the details of the instructions participants were given about the two videos. Before the task, participants were told that in the light condition the proposers were activating the light during the video using a remote control that was hidden from view below the table. This was necessary in order to make participants believe that they were observing the proposers making their decision in both versions of the video.

The fact that participants had been informed that the proposer was making an occluded action during the light videos may explain the activation of areas of the AON seen during those videos. Several researchers (Csibra, 2008; Friston, Mattout, & Kilner, 2011; Kilner, Friston, & Frith, 2007a; Neal & Kilner, 2012; Schubotz, 2007) have suggested that the AON can be usefully understoood as involved in implementing a Bayes-optimal predictive coding mechanism in order to predict the future states of an observed action and thus understand the goal of that action. If this is view is correct then it seems likely that the AON would simulate actions that are occuring, even if those actions are occluded or only detectable by their sensory consequences.

In support of this view is evidence from single cell recordings that mirror neurons in monkeys will fire when observing an occluded action (Umiltà et al., 2001). Behavioural studies have shown that participnats are remakably accurate at judging the appropriateness of an action even after a long period of occlusion or when the action is distorted (Parkinson, Springer, & Prinz, 2011, 2012; Sparenberg, Springer, & Prinz, 2012). It has also been found that these judgments can be affected by motor execution (Springer et al., 2011) and by TMS induced disruption of the premotor cortex (Stadler et al., 2012). Of particular interest, given the finding of left SMA activation in the current study, is the finding that judging occluded actions involves the recruitment of left SMA and dPMC areas (Stadler et al., 2011). Furthermore, a number of imaging studies have demonstrated that parts of the AON are active prior to the observation of a predicted movement (Aglioti, Cesari, Romani, & Urgesi, 2008; Kilner, Vargas, Duval, Blakemore, & Sirigu, 2004)and during the observation of still images of actions (Urgesi, Moro, Candidi, & Aglioti, 2006). Taken together this suggests that the AON is employed in the simulation of action even when the action is not directly observed.

Further evidence for the fact that the AON is not only activated when visually observing actions comes from single cell recording in monkeys indicating the existence of a population of mirror neurons that activate when hearing the auditory consequences of an action (e.g. paper ripping, dropping a stick) as well as when seeing the same action (Keysers et al., 2003; Kohler et al., 2002). Behavioural and TMS and fMRI studies also indicate that the human AON has a similar ability to activate to the sensory consquences of an action even when the action itself is not observed (Aziz-Zadeh, Iacoboni, Zaidel, Wilson, & Mazziotta, 2004; Bangert et al., 2006; Fadiga, Craighero, Buccino, & Rizzolatti, 2002; Gazzola, Aziz-Zadeh, & Keysers, 2006; Pizzamiglio et al., 2005).

Considering the evidence that the AON is tuned to both hidden actions and to the sensory consequences of unseen actions, it is perhaps less surprising that the light indicator condition in our study led to activation of areas of the AON. However this does not explain why these areas were more active in the light condition than in the grasping condition. There are two possible reasons why this should be the case. The first is that the increase activation seen in the light condition reflects the fact that, in the absence of visual information about an action, greater activation of the motor system is required to simulate that action. This is because the cognitive burden for the prediction of that action falls solely on the motor simulation of the action rather than on the integration of incoming sensory signals from the STS and other areas involved in the visual recognition of action and the motor system.

An alternative explantion for the results is that, while both the grasping and light conditions could have allowed for motor simulation, in the grasping condition this motor simulation was inhibited. Given the links reviewed above between the preforntal cortex and motor inhibition (Brass et al., 2005, 2001; Ruby & Decety, 2001, 2003) this explanation would account for the greater prefrontal activations during the observation of grasping actions reported above. Greater inhibition during the grasping condition would be due to the fact that the observed actions of the proposer could potentially conflict with the response to the offer the participant wished to make, while in the light conditions no directly observed action was present to require inhibition. Unfortunately the design of the current study does not enable these two accounts to be decisively evaluated. However the results here do provide further evidence that the AON is involved in simulating actions, even when those actions are not directly perceivable .

6.4.2 Areas Activated in the Contrasts between Trustworthiness

In terms of brain regions that showed a general effect of the trustworthiness of the proposer regardless of the indicator used, no areas in the brain were found that showed a greater activation for the perception of the trustworthy proposer than perception of the untrustworthy proposer. However, contrary to findings of Sobhani et al. (2012) that increased positive affiliation leads to increased activation of the AON, in the current study observation of the untrustworthy proposer led to increased activation in a number of areas implicated in the AON, including bilateral dPMC, the left STS, the right IPG and bilateral precuneus activations.

The dPMC has been found to be particularly involved in the prediction of occluded actions (Stadler et al., 2011), in specifying the desired end state of an action (Majdandzic, Bekkering, van Schie, & Toni, 2009), in detecting errors in the actions of others (Desmet, Deschrijver, & Brass, In Press) and in predicting the sensory consequences of an action (Kilner, 2011). This suggests that the activation seen in dPMC in the current study might reflect a greater attempt by participants to predict the consequences of another's actions in the case of the untrustworthy proposer. This increased activation when observing an untrustworthy proposer is likely to be due to loss aversion (McGraw, Larsen, Kahneman, & Schkade, 2010; Yao & Li, 2013), a phenomenon in decision making in which a loss has more influence on choices than a gain of the same magnitude. Given that our participants tended to reject offers from the untrustworthy proposer, making all untrustworthy trials effectively represent a loss of potential income, participants may have been more motivated to try to interpret the actions of the untrustworthy proposer than they were for the actions of the trustworthy proposer.

There is some evidence that the AON can be modulated by the valence of particular actions and shows a bias towards interpreting actions with a threatening or negative outcome. Lotze et al. (2006) found that activation in the right STS was positively correlated with the negative valence of observed expressive valence, while Gutsell and Inzlicht (Gutsell & Inzlicht, 2013) showed that reduced mu-suppression for the observation of out-group actions was abolished when those actions had a threatening component. Additionally Sinke, Sorger, Goebel and de Gelder (2010) also found evidence for greater activation when observing another person making threatening gestures to a third party compared to when they were making teasing gestures. The finding of increased activation of the AON here adds to the literature showing that areas involved in action observation are sensitive to the social context of the actor.

Activation in the precuneus is also interesting, as this region has been implicated in processing the mental states of self and others (Atique, Erb, Gharabaghi, Grodd, & Anders, 2011; Lombardo et al., 2010; Muscatell et al., 2012; Schnell, Bluschke, Konradt, & Walter, 2011; Van Overwalle & Baetens, 2009). Increased activity in the precuneus and other areas in the mentalising network (dorsal medial prefrontal cortex) has been shown to underlie greater accuracy in identifying the feelings of others (Zaki, Weber, Bolger, & Ochsner, 2009). Thus in the current study it was found that observing an untrustworthy proposer who was about to make a decision on how much money to offer the participant led to greater activation of regions involved in both more low level interpretation of actions and in high level mentalising.

6.4.3 Areas Activated by an Interaction between Indicator and Trustworthiness

The key aim of the current study was to investigate whether the observation of actions was modulated by the trustworthiness of the observer. To that end the key analysis to carry out was an interaction analysis between the factors of indicator and trustworthiness. The F-contrast carried out revealed activation across a number of areas including a bilateral group of occipital temporal areas. These areas, which have been implicated in the visual recognition of bodies (Schwarzlose, Baker, & Kanwisher, 2005; J. C. Taylor, Wiggett, & Downing, 2007; Vocks et al., 2010) and faces (Kanwisher & Yovel, 2006; Schwarzlose et al., 2005), as well as in the recognition of actions (Pelphrey, Morris, Michelich, Allison, & McCarthy, 2005) and of emotional facial expressions (Jehna et al., 2011), showed a differential response with greater activation for the trustworthy proposer in the grasping condition and the untrustworthy proposer in the light condition than vice versa. It is likely that the differential response seen in these areas is due to a combination of the difference in visual scene between the grasping and light conditions (in particular the change in illumination in the light condition) and the face of the proposer in the trustworthy/untrustworthy conditions.

A number of regions in the AON including the precuneus and bilateral dPMC areas also showed the same pattern of response. This pattern of activation may reflect the decreased inhibition of observed gestures compared to unobserved gestures for the trustworthy proposer when compared to the untrustworthy proposer, suggesting that the systems involved in action observation are indeed sensitive not only to the nature of the action being observed (overt vs covert) and the trustworthiness of the actor being observed but also to the contextual combination of the two. It is possible that the interaction in these areas is due to the fact that there was greater inhibition of overt actions made by the untrustworthy proposer than of overt actions made by the trustworthy person. This interpretation would be in line with the original hypothesis that participants' AON would show greater overlap between self and other when observing the actions of trustworthy others compared to untrustworthy others.

Alternatively the fact that these areas showed greater activation for the untrustworthy light condition compared to the untrustworthy grasping condition may reflect the greater need for motor simulation in interpreting the actions of the untrustworthy participant in the light condition compared to the grasping condition, given that the light condition contained even fewer overt cues as to the proposer's intentions than did the grasping condition.

Also noteworthy is the activation of the right orbital gyrus, an area that has been implicated in the processing of rewarding stimuli (Berridge & Kringelbach, 2013; Grabenhorst, Rolls, Parris, & D'Souza, 2010; Klein-Flügge, Barron, Brodersen, Dolan, & Behrens, 2013; Kringelbach, 2005; O'Doherty, Kringelbach, Rolls, Hornak, & Andrews, 2001; Rushworth, Noonan, Boorman, Walton, & Behrens, 2011; Simmons et al., In Press; Wallis & Miller, 2003), suggesting that participants perceived the observing the actions of the trustworthy proposer as more rewarding than observing the actions of the untrustworthy proposer. The final brain area activated, the left STS, showed the reverse pattern from all other areas, with increased activation for the observations of the untrustworthy proposers grasping action compared to that of the trustworthy proposer and vice versa in the light condition.

6.4.4 Areas Activated by the Decision to Accept or Reject an Offer

Areas that demonstrated greater activation for accepted as opposed to rejected offers fell largely into two regions that have previously been found to be involved in social decision making. One of these regions was made up of activation in temporal-parietal regions including bilateral activation in the precuneus and angular gyrus and activation in the right STS. As mentioned above these regions have been linked to the processing of one's own and other's mental states (Apperly, Samson, Chiavarino, & Humphreys, 2004; Carter & Huettel, 2013). In addition they are also involved in the processing of decision making in the presence of uncertainty (Paulus et al., 2001)and in decision making during economic games (Delgado, Locke, Stenger, & Fiez, 2003; Halko, Hlushchuk, Hari, & Schürmann, 2009; Kenning & Plassmann, 2005; Kirk, Downar, & Montague, 2011; Knutson & Bossaerts, 2007; Ko et al., 2009; Rilling, Sanfey, Aronson, Nystrom, & Cohen, 2004; W. van den Bos, van Dijk, Westenberg, Rombouts, & Crone, 2009). In the current context this parieto-temporal activation may reflect a greater use of the mentalising system when processing the decision that the other person was likely to make and the risk of accepting a low offer.

Also showing greater activation for accepted compared to rejected decisions were two areas in the prefrontal cortex: the right orbitofrontal cortex and the left dorsolateral prefrontal cortex (DLPFC). As well as being strongly linked to the processing of reward (see above) the orbitofrontal cortex has also been strongly implicated in the processing of reward and social decision making (Nestor et al., 2013; Zaki, López, & Mitchell, In Press), suggesting that activation in this area was due to the anticipation of a rewarding offer from the proposer.

Several studies have implicated the left DLPFC in self-control. Figner et al. (2010) used TMS to disrupt the left DLPFC during decision making, leading to more impulsive behaviour as indicated by increased choices of immediate rewards over larger delayed rewards, while valuation judgments of the same rewards remained stable. Steinbeis, Bernhardt and Singer (2012) found that the left DLPFC mediated age-related and age-independent individual differences in strategic social behaviour. In addition the left DLPFC has been found to be activated during decision making in economic games. Single cell recording studies carried out in monkeys who had been trained to play economic games found that neurons in the DLPFC were involved in encoding strategic choices (Barraclough, Conroy, & Lee, 2004; Seo & Lee, 2007). Neuroimaging studies in humans have also implicated the left DLPC as being involved in the processing of fairness in the ultimatum game (Guo et al., In Press; Güroğlu, van den Bos, Rombouts, & Crone, 2010; F. Krueger, Grafman, & McCabe, 2008; Sanfey et al., 2003; Yoshida, Seymour, Friston, & Dolan, 2010).

Interestingly however, in most previous studies activation in the left DLPFC has shown a greater activation when being presented with unfair offers. The reverse activation seen in the current study may reflect the fact that in the game used in the experiment, participants had to infer whether the offer was fair or unfair only from the identity of the proposer. It is possible therefore that the increased activation in the

DLPFC seen in this study reflects greater processing of the potential reward of rejecting or accepting an offer when presented with a high probability of that offer being fair compared to unfair.

The final region to show an increased response to accepted as opposed to rejected offers is the parahippocampal gyrus. The parahippocampal gyrus has been implicated in processing spatial memory (Aminoff, Kveraga, & Bar, 2013; Bohbot et al., 1998; Ploner et al., 2000). Thus it seems likely that the increased activation seen for accepted offers reflects participant's greater motivation to recall the direction that the participants moved in so as to ensure that they did not accidently reject an offer from a trustworthy participant, a mistake that had a higher cost to the participant than accidently accepting an offer from an untrustworthy participant.

The final contrast, examining areas that were more activated when participants decided to reject rather than accept an offer, found widespread bilateral activation within the AON including the premotor cortex, the post central gyrus, and the left inferior parietal gyrus and sulci, along with bilateral activation in occipital regions including the right fusiform face area. Considering the role of the premotor cortex in motor planning (Liuzzi et al., 2010; Pastor-Bernier, Tremblay, & Cisek, 2012; Sugawara et al., In Press; Weinrich, Wise, & Mauritz, 1984) and the finding that participants took significantly longer to respond when making a decision to reject rather than accept an offer, this increased activation in the AON might be due to participant's taking longer to prepare their motor response in the reject condition. Another possibility however is that the greater activation in the AON is due to the fact that participants' greater focus on the actions of the proposer in the untrustworthy condition during watching the video continued even after the video ended and represents greater use of motor simulation when trying to interpret whether or not the the proposer was likely to be sending a fair or unfair offer. Activation in the right fusiform gyrus and related occipital areas known to be involved in the interpretation of facial expressions (Fu et al., 2004; Pessoa, Kastner, & Ungerleider, 2002; Schupp et al., 2004; Thielscher & Pessoa, 2007) also suggests that participants' exerted more effort in trying to interpret the actions and facial expressions of the proposer before rejecting a decision than before accepting it.

The final area showing greater activation for decisions to reject an offer was found in the right precuneus in a more posterior and lateral position than that which showed greater activation when accepting an offer. Margulies et al. (2009) used resting-state fMRI to identify functional distinctions between areas of the precuneus and demonstrated 3 subdivisions, with the anterior precuneus being functionally connected with the superior parietal cortex, paracentral lobule, and motor cortex, suggesting a role in sensorimotor, the central precuneus being functionally connected to the prefrontal and inferior parietal cortexes, suggesting a cognitive/associative region and the posterior precuneus being functionally connected to adjacent visual cortical regions. Thus the posterior precuneus activation seen here is likely connected to the increased activity in the right occipital cortex and reflects further visual processing of the face and action of the proposer when an offer is rejected compared to accepted.

6.4.6. Conclusion

In conclusion the current experiment sought to investigate the ability of trust to modulate activity in the human AON. Contrary to predictions, greater activation was found in the AON during the observation of choices being indicated by turning on a light than by grasping a light. This was likely due to the inhibition of the AON during the observation of grasping actions to prevent those actions from interfering with the participant's response. Moreover, again contrary to predictions, the observation of the actions of an untrustworthy person compared to a trustworthy person led to the activation of regions in the left dPMC. There was also however a significant interaction between the observation of actions and the trustworthiness of a proposer, with greater activation in the left PMC when participants observed the trustworthy proposer making an action compared to the untrustworthy person making an action and vice versa for the light condition. These findings offer evidence that the AON is sensitive to the interaction with other and in particular to the other's reputation as a trustworthy interaction partner.

It should be noted however that some the results presented here, particularly that of greater activation of the AON when observing an untrustworthy other regardless of the indicator used, contrast with the findings of previous studies that examined the AONs. The studies by Molenberghs et al. (2012) and Sobhani et al. (2012) found greater activation for liked others as opposed to disliked others. The discrepancy between the results of the current study and these previous studies could be due the relationship between the participant and the observed actions. In the previous two studies, participants observed the actions of others but those actions had no bearing on the participants themselves, in the current study by contrast the actions of the other people directly affected the amount of money participants thought they would receive from this study. It is possible therefore that while passively observing the actions of a disliked other leads to reduced mirror neuron activation, observing the actions of a disliked or untrustworthy other that have a direct impact on the participant leads to greater AON activation, as the participant has a greater need to process and predict potentially threatening actions. A second possible explanation for this discrepancy is the different ways that feelings of likableness or closeness to the participant were modulated in the different experiments. While the current study investigated responses to a specific interpersonal other whose likability to the participant was based on their reputation as trustworthy or untrustworthy towards the participant, in Molenberghs et al. and Sobhani et al. likeability was modulated by an in-group or out-group distinction.

To conclude, the results of this study provides important evidence for the power of social cognition to modulate. Further research is in this area is needed however, in order to determine the exact functional role of AON modulation when observing actions conducted by positively or negatively evaluated others.

Chapter 7. Discussing the Body, the Self and Social Cognition

"The human body is the best picture of the human soul.

Ludwig Wittgenstien, (1953, p. 178e)

7.1. Summary

The studies presented in this thesis examined the relationship between the phenomenal self, constituted by the integration of representations of the body in different modalities, and the social self which is, in part, defined by representations of closeness to and similarity with others. Following the embodied cognition approach, it was postulated that these representations of the social self's relationship to others would be closely linked to perceptions of physical closeness being both affected by and in turn affecting representations of bodily similarity. Therefore, the experiments presented in the previous chapters all sought to manipulate the perception of bodily similarity between self and other(s) and then to investigate the effects of this manipulation on some fundamental aspects of social cognition, such as implicit biases (Chapters 2 and 3), stereotype activation (Chapter 4) and trust (Chapters 5 and 6).

As highlighted in the introduction the studies considered in this thesis can be broadly split into two strands. The first examined the relationship between the representations of one's own body and different social groups and comprised of the studies reported in chapters 2, 3 and 4. The second strand examined the relationship between body representations and interpersonal interactions, modelled using economic games. A brief summary of the findings of the studies in this thesis are presented below.

7.1.1. Chapter 2 – Skin Colour and Body Ownership

The experiments covered in chapter 2 investigated the effect of skin colour on body ownership. Both experiments found that participants could indeed experience body ownership over a rubber hand with the skin colour of a racial out-group. Experiment 2.1 showed that, while subjective reports of ownership were significantly lower for a hand with the skin colour of a racial out-group compared to a hand of a similar skin colour to the participant, the change in feelings of ownership due to VT-stimulation was of the same magnitude for hands of both skin colours. In addition, no significant effects of skin colour were found for the more objective measures of body ownership, proprioceptive drift and SCR to threatening stimuli. Experiment 2.1 also found limited support for the power of body ownership to affect participants' implicit attitudes towards members of a racial out-group. It was found that a linear regression which included both participants' ratings of ownership over the rubber hand with the skin colour of a racial in-group and their ratings of ownership over the rubber hand with the skin colour of a racial out-group as predictors significantly predicted post VT-stimulation implicit racial bias, with greater ownership leading to lower bias. However, the within participants nature of experiment 2.1's design meant that it was not possible to determine whether this effect was due to a generalised effect of body ownership or whether it was specifically due to ownership over the out-group rubber hand. Experiment 2.2 further investigated the effect of feeling ownership of the out-group rubber hand on SCR to threatening stimuli and also introduced a new control condition, that of synchronous stimulation delivered to a hand seen from a third person perspective. The results of this experiment replicated those found for experiment 2.1 showing main effects of skin colour on feelings of ownership but not for SCR responses. It also extended the findings by showing that the increased SCRs found after synchronous stimulation were only present when the hand was seen from a first person perspective and also that only those participants who experienced a feeling of body ownership over the out-group hand showed a subsequent increase in SCR when that hand was threatened.

7.1.2. Chapter 3 – Body Ownership and Implicit Bias

The experiments reported in chapter 3 sought to expand on experiment 2.1's finding of an effect of experiencing body ownership over a hand from a racial out-group by investigating whether experiencing ownership over the hand of a racial out-group would lead to more positive attitudes towards that out-group as measured by implicit racial bias (experiment 3.1) and sensorimotor empathy for pain (experiment 3.2). Experiment 3.1, used a between participant design and found evidence that synchronous multisensory stimulation over a hand with the skin colour of a racial out-group led to more positive implicit attitudes towards that racial out-group while experiencing asynchronous stimulation over the hand led to a more negative implicit attitudes. Although no direct effect of ownership was found in this study there was a strong relationship between synchrony of multisensory stimulation and ownership of the rubber hand. Experiment 3.2 used single-pulse TMS to measure somatosensory evoked potentials to painful and tactile stimuli being applied to in-group and out-group hands both prior and subsequent to the delivery of synchronous or asynchronous VT-stimulation. The experiment found that after synchronous multisensory stimulation participants showed reduced z-scored MEP size when watching tactile or painful stimuli applied to a black hand. In contrast after asynchronous stimulation participants showed an increase in z-scored MEP size in response to painful and tactile stimuli, further suggesting that asynchronous stimulation, as well as synchronous stimulation, leads to an alteration in racial bias.

7.1.3. Chapter 4 – Age, Body Ownership and Motor Imagery

The experiments in chapter 4 moved from investigating the effect of body ownership of a hand of a different skin colour to examining the effect of body ownership on a hand of a different age to that of the participant. Specifically the studies in this chapter sought to investigate whether feeling body ownership over an elderly hand would lead to activation of the elderly stereotype and thus cause participants to imagine their movements as being slower on a motor imagery task. Experiment 4.1 used a between subjects design and found that it was possible, using synchronous VT-stimulation, to induce ownership over the elderly hand. However the attempt to find an effect of ownership of the old hand on speed of motor imagery was confounded by a significant difference in participants' pre VT-stimulation motor imagery times. Experiment 2.2 sought to avoid this issue by using a within participant design. No significant effect of synchrony of VT-stimulation was found. It was however found that when participants' movement time in the pre VT-stimulation period was taken into account participants who experienced higher levels of ownership in the synchronous condition imagined their movements as being slower. This finding suggests that experiencing ownership over a hand belonging to an elderly person does indeed lead to the activation of stereotypes related to the elderly.

7.1.4. Chapter 5 – Trust and Face Representation

The experiments in chapter 5 moved from investigating the relationship between body ownership and different social groups to investigating the relationship between body representations and interpersonal social relationships. Experiments 5.1 and 5.2 both investigated whether synchronous IMS would lead to increased trust as measured by the amount of money sent to the other person in a trust game. The results of these two studies found mixed evidence for the power of IMS to affect trust. Experiment 5.1, which used a between participants design found that synchronous IMS led to higher ratings of trust than did asynchronous stimulation but not higher amounts sent in the trust game. Experiment 5.2 used a within participants design with a larger number of trials per participants and small increments of money that could be sent to the trustee. It found a significant effect of IMS, with synchronous stimulation leading to higher amounts being offered in the trust game. Experiment 5.3 investigated the reverse relationship between trust and representations of facial similarity and found that participants perceived the face of a trustee as being significantly more similar to their own after the trustee had shown themself to be trustworthy compared to when the trustee had shown themself to be untrustworthy.

7.1.5. Chapter 6 – Trust and the Action Observation Network

The final study of the thesis, experiment 6.1, employed fMRI to investigate whether the trustworthiness of an observed actor led to a differential activation of the AON. Based on the findings of previous studies it was hypothesised that observing a trustworthy actor would lead to a greater activation of the AON than would observing an untrustworthy actor. In fact the results of experiment 6.1 showed the opposite pattern with greater activation in the AON for actions made by an untrustworthy actor. In addition, it was found that covert unobserved actions led to a greater activation of the AON than did overtly observed actions. This finding suggests an evolutionarily important role for the AON with a focus on the simulation of potentially threatening actions.

7.2. Methodological Issues

Before discussing the key theoretical implications of the experiments reported in this thesis I will briefly discuss two methodological issues that the studies in this thesis highlight, the use of multiple measures and the calculation of sample size.

7.2.1. The Use of Multiple Measures

Several of the studies reported in this thesis involve the use of multiple dependent variables in order to probe the same underlying phenomena. Notably experiment 2.1 used introspective reports, proprioceptive drift and SCR to threatening stimuli in order to examine the effects of VT-stimulation on embodiment of a rubber hand while experiment 2.2 used introspective reports and SCR to threatening stimuli to examine the same issue. In addition experiment 5.1 measured trustworthiness using both participants' ratings of trust and their behaviour and expectations in the trust game. The use of multiple measures in order to examine a particular phenomenon of interest does however raise the question of which measures should be considered an appropriate test of that phenomenon and whether such measures are measuring the same or difference phenomena.

The problems with the use of multiple measures are particularly acute in the case of the experiments mentioned above because in all three cases the different measures used did not show identical effects. The results of experiments 2.1 and 2.2 demonstrated a distinction between participants' introspective reports of their feelings of body ownership and the behavioural (proprioceptive drift) and physiological (SCR) measures of ownership in regards to skin colour. Although participants' introspective reports suggested that they felt less ownership over the black hand than they did for the white hand no effect of skin colour was found for the more objective measures of proprioceptive drift and SCR. In a similar way participants' in experiment 5.1 rated the face of another person as significantly more trustworthy after synchronous IMS than after asynchronous IMS but showed no effect of synchrony of IMS in the amounts of money they were willing to give .

The distinctions between the results of different measures in these three experiments allow for an examination of a number of questions including: Which measures are most appropriate for examining a particular issue?; Whether combining different measures can provide a more complete view on a subject?; and which measure should be given greatest priority if the results of two measures disagree? In the case of all of these questions it is important to be aware of the phenomena which one's research is designed to investigate. To demonstrate this I will first consider each question in regard to the investigation of the sense of body ownership carried out in chapter 2 and then move to consider them in the context of the investigation of trust carried out in experiment 5.1.

When considering the experiments investigating body ownership reported in chapter 1 it is important to be clear on exactly what the central meaning of the concepts of body ownership and embodiment in general are. As Longo, Schüür, et al. (2008) point out the concepts of embodiment and body ownership are essentially experiential. Such a view is also echoed by Tsakiris (2010) who defines body ownership as the experience of a body as being mine. The experiential nature of embodiment has presented a challenge to its scientific study due to a methodological distrust of introspective reports as opposed to the behavioural correlates of an experience. This distrust of relying purely on introspective reports has motivated researchers to find behavioural (Tsakiris & Haggard, 2005b), physiological (Armel & Ramachandran, 2003) and neurological (Ehrsson et al., 2004; Kanayama, Sato, & Ohira, 2009) correlates of the experience of body ownership. Such measures are often seen as more reliable than merely relying on participants' reports of their experience. However, as Longo et al. and Lewis and Lloyd (2010) point out, solely concentrating on these objective measures of the illusion runs the risk of ignoring the phenomenological core of body ownership. This risk is especially great as some recent studies have shown that the phenomenal and objective measures of embodiment can be come apart. For example several studies (Holle et al., 2011; Holmes et al., 2006; Rohde et al., 2011) have demonstrated that it is possible for subjects to display proprioceptive drift without the accompanying experience of body ownership. These findings raise the issue of whether researchers studying embodiment should favour subjective reports or objective measures in cases where the two forms of measure come into conflict.

In the current thesis this problem is highlighted by the findings of experiments 2.1 and experiments 2.2 that, while participants reported experiencing a stronger feeling of body ownership when the observed hand was white as opposed to black, there was no effect of skin colour on either proprioceptive drift or SCR. This raises the question of whether to ignore participants' introspective reports and concentrate on the objective measures. Likert scales and other self-report measures do have a number of problems, such as being open to social desirability, cognitive biases, and the lack of a clear idea of whether all participants assign the same value to a particular point on the scale Schwartz (N. Schwartz, 1999). Indeed, this last problem can be seen in the current thesis by the fact that in the within subject studies in chapter 2 participants reported significantly higher ownership over the white hand but in experiment 3.1 which used a between subjects design no such difference was found.

Despite the weaknesses in the use of such measures however, it is also clear that we lack a reliable objective correlate of body ownership. While measures such as proprioceptive drift and SCR normally seem to go along with the experience of body ownership both can come apart from it as in studies 2.1 and 2.2. In such cases it is important to remain focussed on the ultimate goal of the research. If one is most closely interested in how proprioception is influenced by vision and touch then it might be justified to ignore the participant's reports in favour of the proprioceptive drift measure. When however the purpose of the experiment was to discover how body ownership itself is modulated by a property of the rubber hand, e.g. skin colour, then to dismiss participant's reports of their own experience simply because they clash with a behavioural measure appears to be an incorrect approach which risks fetishizing the appearance of scientific objectivity over gaining a fuller understanding of the phenomena under investigation.

The importance of remembering the research question being asked in a study is also illustrated by the case of experiment 5.1. In this study the focus of the study was on whether synchronous IMS led to greater amounts of trust, as measured by the amount sent in a trust game and by ratings of trustworthiness, towards another than did asynchronous stimulation. The results of experiment 5.1 found that while IMS increased ratings of trustworthiness it appeared to have no effect on trusting behaviour which raises the question of which measure is more relevant when deciding the effect of IMS on trust.

As discussed in the introduction to chapter 5 trust has generally been thought of as a behavioural phenomenon. We determine the amount of trust a person has for another not on their words but on their actions. For example if I say that I trust you but then refuse to lend you money because I don't think you will pay me back the most obvious interpretation is that my claim to trust you was false. Thus in the case of experiment 5.1 the discrepancy between people rating of trustworthiness and their actual behaviour in the trust game seem to suggest that the higher ratings of trustworthiness were not really measures of trust but rather tapped into a more general, but weaker, form of prosociality such as general affiliation or closeness rather than a real willingness on the part of participant to place their trust in the trustee.

In conclusion the difference between the choice of which type of measure, introspective report or behaviour, to give priority to in the experiments discussed in this section highlights to importance of keeping clear exactly what the focus of an experiment is and exactly what each form of measure is actually measuring when using a multiple measures approach. However, provided this is done the multiple measure approach can be helpful in revealing different aspects of the phenomenon under investigation.

7.2.2 Sample Size

One potential limitation with the studies described in this thesis is the fact that the samples used in experiments that found significant effects varied from a low of 12 participants providing two data points in the data set each, leading to 24 data points in experiment 4.2, to a high of 59 participants each providing data for two conditions, leading to 118 data points in experiment 5.3. It is worth noting here that although the difference in sample sizes between these studies is large it is to some extent justified due to the varying nature of the question under investigation. In the case of experiment 4.2 the key dependent measure was time taken in a motor imagery task, a measure that generally has little variation between participants. By contrast in experiment 5.3 the key dependent variable was performance in a self-face recognition task which was far more likely to be affected by individual differences such as the objective physical similarity between the face of the participant and that of the trustee.

Despite these differences in experimental design the high variance in sample size between the different experiments in this thesis does raise the question of the correct methodology to be used when determining sample size. The failure to use the correct sample size in an experiment can lead to misleading interpretations of the results of that research in two ways. First and more obviously the failure to recruit a large enough sample of participants can lead to a study being underpowered therefore increasing the risk of a Type II error in which the null hypothesis is accepted despite the fact that a significant difference exists between the two experimental conditions. While the possibility of making a Type II to error due to an underpowered study is well known, the second potential source of misinterpretation due to not calculating a correct sample size is that with a large enough sample size any chance difference between groups can become statistically significant, leading to a situation which the null hypothesis is rejected even though there is no substantial difference between conditions.

This second source of misinterpretation due to lack of sample size calculation is based in the use of null-hypothesis significance testing (NHST) as the key statistical measure in psychology. Despite the near ubiquitous use of NHST in psychological and neuropsychological research both psychologists (e.g. Killeen, 2006; J. Krueger, 2001; Nickerson, 2000) and statisticians (Krantz, 1999; Wilkinson & Task Force on Statistical Inference, 1999) have long been aware of the potential problems with using NHST as a measure of the importance of an effect. At the heart of the problem is that fact that NHST tests for the null-hypothesis i.e. that there is absolutely no difference between two conditions. However, there is always likely to be some difference between any two conditions, even if that difference is just due to chance variations. As increasing the sample size of a study will lead to an increase in statistical power it is possible to find a significant difference between two conditions in almost any sample simply by increasing the statistical power of the study via increasing the sample size. This flaw in NHST can lead to researchers simply continuing to add data to a study in order to reach significance despite the fact that the real amount of difference between two conditions is minute and thus risks making the entire exercise of determining significance becoming trivial.

Several possible solutions have been suggested in order to deal with the problems associated with calculating sample size. The most radical solution is to replace NHST with a different methodology such as Bayesian (Killeen, 2006) or model fitting (Anderson, Burnham, & Thompson, 2000) data analysis. While these methodologies do have a number of merits, they also have several draw backs. In the case of model fitting Nickerson (2000) notes that many of the procedures for assessing the goodness of fit of a model themselves involve a form NHST which seems to only move the problems with NHST back a step in the statistical analysis. Likewise Frick (1996) raises several problems with Bayesian hypothesis testing. First the determination of the prior probabilities of competing hypotheses is inherently subjective. The second problem is that the subjectivity inherent in determining priors means that it is possible to construct prior probabilities to ensure that the conclusion of the analysis matches that expected by the researcher making Bayesian analyses particularly prone to confirmation bias. The third problem is that the prior probabilities for any result would also change over time meaning that any Bayesian analysis would only apply for a short period and would need to be repeated with new priors in order to ensure that its conclusion was still warranted. In the end both Fick (1996) and Nickerson (2000) conclude that despite its ability to be misunderstood or misused provided good judgement is used the use of NHST can be justified.

The suggestions proposed above act as a control for the aforementioned issue of trivially significant results however in order to also protect against the risk of having insufficient power to detect a real difference between two means it is necessary to carry out a calculation of sample size prior to conducting an experiment. There are two general methods for conducting sample size, the first of these is to use a fixed sample size calculation. On this method a researcher should perform a sample size calculation prior to carrying out the study which will determine the optimal size of the sample to be used. A sample of that size is then collected and statistical tests are performed once on that sample with the results of those tests being considered final. In order to calculate the sample size it is necessary to consider a number of factors (Kirby, Gebski, & Keech, 2002).

First it is necessary to set an acceptable level of significance in order to guard against Type I errors, this is conventionally set at 0.05 (i.e. a 5% chance of making a Type I error). Second it is necessary to determine the power of the study in order to ensure that Type II errors are not made, conventionally this is set at a higher value than the significance level with a power of 0.80 (i.e. a 20% chance of a Type II error) being the standard. Third it is necessary to estimate the size of the effect under examination with a larger effect size requiring a smaller sample size to be detected and finally it is necessary to estimate the standard deviation of the population to be examined. Neither the expected effect size nor the standard deviation of the population can be set by convention and so both must be estimated by examining previous studies.

While fixed sample size calculations have the advantage of setting a clear and determinate sample size they also have several disadvantages. Frick (1998) identifies several weaknesses with such procedures including the fact that they may lead to collecting an inefficiently large number of participants if a significant effect is either assured or very unlikely after testing a much smaller number of participants than had originally been planned, that it seems unreasonable to abandon a study if the *p* value is small but significant and that in the case of exploratory studies in an area that has not previously received much investigation, such as those reported in this thesis, it may well be very unclear exactly what the effect size should be. In place of carrying out a fixed sample size calculation Frick recommends instead using a sequential stopping rule in which a statistical test can be carried out at any point during data collection and if the outcome of that test is that $p < .01$ the researcher is justified in rejecting the null hypothesis while if the outcome of the test is $p > .36$ the researcher stops testing without rejecting the null hypothesis. For *p* values between .36 and .01 further subjects are added to the pool. Using Monte Carlo simulations Frick demonstrates that using this COAST method leads to results having an effective α of 5%. Therefore the sequential stopping rule

While the calculation of sample size does serve an important role in experimental design such calculation were not conducted for the studies in this thesis due to the exploratory nature of the studies and the lack of previous research on the relationship between body representation and social cognition. However, another alternative to the problem of trivial but significant findings is to report a measure of effect size alongside *p* values in order to allow the magnitude of the significant effect to be observed (Wilkinson & Task Force on Statistical Inference, 1999). Although this approach does not control for the risk of type II errors it does allow readers to judge the size of the effect and to decide for themselves whether or not the effects being reported are truly meaningful or not. There are a number of different ways to report effect size but the most commonly used methods either report the magnitude of the difference between two groups and variable, e.g. are Cohen's *d* or estimate the shared variance between variables or between an interaction term such as Pearson's *r* or Eta squared statistics (Ferguson, 2009; Vacha-Haase & Thompson, 2004). While reporting such measures of effects has not been done in the current thesis, the mean and standard deviation of all groups with significant differences has been reported, allowing for the reader to calculate Cohen's *d* for all reported findings if they so wish.

7.3. Implications for the Relationship Between Bodily and Social Selves

7.3.1. The Relationship Between Body Representation and Social Groups

A key hypothesis underlying the studies carried out in this thesis was that the phenomenal experience of selfhood, which is dependent on the multisensory integration of body-related information, is closely related to, and provides the foundations of more conceptual and socially constructed representations of selfhood. One key aspect of these social representations of the self is what McAdams (2013) has termed the self as actor, the concept of the self as being situated within, and constituted by, a network of complex social relationships and identities. In investigating the relationship between body representation and social identity the studies reported in this thesis sought to explore three distinct questions. First, do surface features of the body indicative of different social groups have an effect on the experience of body ownership? Second, do participants' pre-existing social attitudes have an effect on their experience of body ownership? Third, does an updated representation of a participant's bodily self lead to changes in the way in which they perceive and relate to other(s)?

7.3.1.1. Is the Experience of Body Ownership Affected by Social Features?

Previous research on the RHI has shown that the visual form of the stimulated object (Haans et al., 2008; Tsakiris et al., 2010; Tsakiris & Haggard, 2005b) and the posture of the object compared to the participant's own hand (Lloyd, 2007; Makin et al., 2008; Preston, 2013; Tsakiris & Haggard, 2005b) both play an important role in determining whether participants experience the feeling of body ownership over the stimulated object. There is less evidence however that the surface features of a hand shaped object can modulate body ownership. In the current thesis, experiments 2.1, 2.2 and 3.1 are the first studies that have systematically compared the experience of body ownership over a hand with the same skin colour to that of the participant with the experience of body ownership over a hand with a different skin colour. In addition experiments 3.2, 4.1 and 4.2 all sought to induce feelings of body ownership over a hand that differed from those of the participants' own hands either with respect to skin colour (experiment 3.2) or age (experiments 4.1 and 4.2), although, in these studies no direct comparison was made between feelings of ownership for hands with similar and dissimilar surface features.

The findings of these experiments suggest that differences between the surface features of a stimulated hand and the participant's own hand do not play a major role in modulating the experience of body ownership. Synchronous VT-stimulation successfully induced a feeling of ownership over a hand that is different in its surface features from the hand of the participant in at least 50% of participants in all of the experiments in this thesis. There is however an apparent discrepancy between the findings of experiments 2.1 and 2.2 and the results of experiment 3.1. The experiments in chapter 2 found significantly lower feelings of ownership over a dissimilar (black) hand as opposed to a similar (white) hand while experiment 3.1 found no such effect. This discrepancy between the three studies is likely to be due to the fact that, while the experiments in chapter 2 utilised a within participant design in which participants experienced VT-stimulation over both hands, experiment 3.1 used a between participants design where participants were unable to directly compare their experience of ownership for the similar and dissimilar hands. This suggests that there may be an effect of the similarity of surface features on participants' experience of body ownership but that this effect is only observable when participants are able to compare for themselves the difference in ownership over the two hands. In support of this interpretation is the fact that Maister, Sebanz, et al. (2013) which used a between participants design found no significant effect of skin colour on ratings of ownership while Haans et al. (2008) who used a within subjects design did find an effect of the texture of the rubber hand on ratings of ownership. It is also worth noting however, that even when a within subjects design was used there was no difference in behavioural (proprioceptive drift) and physiological (SCR to painful stimuli) measures of ownership. This raises the possibility that participants did in fact experience roughly comparable *feelings* of body ownership in both conditions but that the obvious dissimilarity between their own hand and the black hand biased their introspective *judgements* of ownership (for an application of the distinction between feelings and judgements to the issue of agency see Haggard & Tsakiris, 2009).

From a functional perspective the decreased importance of surface features of an object for the experience of body ownership compared to factors like the anatomical form or posture makes sense. For, while it is very unlikely that a hand will experience large changes in its basic shape or postural relationship with the rest of the body, changes to the surface features of our hands happen all the time. We gain experience of our hands changing their surface features every time we put on gloves or, to give an example that is more valid for our evolutionary history, get mud or other substances on them. Therefore it would be maladaptive for the experience of body ownership to change along with changes in our hands' surface features. Furthermore knowledge of the current state of the surface features of the body is more reliant on direct visual inspection than either the general form or the posture, both of which are partially specified by proprioceptive information. Since in the RHI setup visual information about the current state of the body is absent the system determining body ownership will have less contradictory information regarding surface features than it does for posture and visual form.

7.3.1.2. Is the Experience of Body Ownership Affected by Social Attitudes?

The second question, of whether participants' own social attitudes affected their feelings of ownership over the rubber hand is relevant due to the considerable evidence from previous research that has indicated that the activation of shared bodily representations for action (Désy & Théoret, 2007; Gutsell & Inzlicht, 2010; Liew et al., 2011; Molnar-Szakacs et al., 2007), pain (Avenanti et al., 2010; Azevedo et al., 2013; Hein, Silani, Preuschoff, Batson, & Singer, 2010; Xu et al., 2009) and emotion (Gutsell & Inzlicht, 2012) are modulated by whether or not the person being observed is a member of an in-group or an out-group. These findings suggest that group membership, and more specifically the attitudes of the observer towards the group that the observed person is a member of (Avenanti et al., 2010; Gutsell & Inzlicht, 2010), is capable of exerting a top-down influence on some forms of shared body representation. There is also evidence that some types of individual difference in cognitive processing can affect the strength of body ownership. For example Asai et al. (2011) found that people high in empathic concern and positive schizotypal traits were more susceptible to the RHI while MacLachlan, Desmond and Horgan (2003) found that experiencing those who scored highly in psychometric measures of body plasticity, somatic preoccupation, and creative imagination were significantly more likely to experience the RHI and other forms of body illusion. In light of this evidence experiments 2.1, 3.1 and 3.2 all examined the relationship between participants pre-existing attitudes towards black people and their experience of ownership over a black rubber hand.

Interestingly, given the above literature, the studies in this thesis consistently found that pre-existing attitudes towards black people did not influence how likely people were to experience ownership over a black rubber hand. This finding was consistent across all three studies whether the attitude being assessed was participants' bias against black people relative to white people (experiments 2.1 and 3.2) or their attitudes to black people alone (experiment 3.1). It is also consistent with the findings of a similar experiment using the rubber hand conducted by Maister, Sebanz, et al. (2013) and a study by Peck et al. that employed virtual reality to give participants ownership over a black avatar. (Peck et al., 2013; M. Slater, personal communication, 24th Sepetember, 2013). The discrepancy between the findings of top-down effects of social group on bodily representations involved in the mirroring of action, pain and emotion and the lack of any top-down effects of social group on perception of body ownership found in the studies included in this thesis may be due to the fact that, in the case of body ownership, participants experienced a direct matching between the sensory stimuli they were receiving and the sensory stimuli being delivered to the body of the other. These sensory cues for ownership of the observed body part may be so strong that they simply override any modulating influence that social attitudes might exert on the perception of an observed object as being part of one's body. In the case of shared neural representations of self and other described above however no direct sensorimotor cues suggesting that the observed object is part of one's own body are present and thus the power of top-down influences such as social attitudes to modulate the activation of these representations may be correspondingly greater.

<u>7.3.1.3. Does the Experience of Body Ownership Alter the Perception of Social Groups?</u>

The second key question that the studies in the chapters 2, 3 and 4 aimed to investigate was the extent to which changing participants' representations of their own bodies by using synchronous VT-stimulation to make them feel ownership of a hand belong to a different social group would lead to a change in their social cognition towards that group. For experiments 2.1 and 3.1 this was investigated by examining whether experiencing a hand with the skin colour of a racial out-group led to changes in attitudes towards that group. In experiment 3.2 this was investigated by examining whether changes to body ownership led to a change in sensory motor empathy as measured by MEPs in response to painful stimuli and in the two studies in chapter 4 it was investigated by examining whether experiencing ownership over an elderly hand led to the activation of the elderly stereotype and consequently slower performance in a motor imagery task.

The results from these studies were largely supportive of the hypothesis that experiencing ownership over a body part that belongs to a different social group can lead to an increased association between the self and that group. Experiment 2.1 made a first step in this process by showing that participants' ratings of ownership over the black rubber hand significantly predicted their post VT-stimulation implicit racial bias as measured by the IAT with those who experienced greater ownership of the hand showing less racial bias. This finding was followed up in experiment 3.1 which found a significant effect of VT-stimulation on racial bias with synchronous stimulation of the black hand leading to more positive attitudes towards black people while asynchronous VT-stimulation led to more negative attitudes. When the robust relationship between synchrony of VT-stimulation and the experience of body ownership is taken into account these findings support a link between the bodily representations of the self and implicit attitudes towards social groups.

The results of experiment 3.2 also found some support for the hypothesis that multisensory stimulation over a hand belonging to a different racial group can lead to a change in responses towards that group. In this experiment the measure of interest was sensorimotor empathy to pain, as measured by MEP response to painful stimuli. The study found that after synchronous multisensory stimulation participants showed a reduction in z-scored MEP size after watching a black hand in pain, indicating increased sensorimotor empathy. Interestingly this affect was also found for tactile stimulation. In contrast after asynchronous stimulation participants showed an increase in z-scored MEP size in response to painful and tactile stimuli, further suggesting that asynchronous stimulation, as well as synchronous stimulation, leads to an alteration in racial bias.

The results of experiment 4.2 also support the hypothesis of strong links between body representation and the perception of social groups. In this experiment, rather than directly affecting participants' implicit attitudes towards the elderly, experiencing body ownership over an elderly hand led participants to imagine moving more slowly in a motor imagery task. This finding of slower motor imagery speeds after experiencing ownership of the hand fits into to a wider literature showing that being primed with stimuli associated with the elderly led participants to move more slowly due to the associations between old age and slowness (Bargh et al., 1996). Interestingly in experiment 4.2 this effect was only found when people felt ownership over the elderly hand despite the fact that in all conditions participants were exposed to the visual stimuli of the elderly hand. Therefore it seems that for elderly stimuli to affect motor imagery performance it was necessary for participants to associate this stimulus with their own body. This finding mirrors Wyer et al.'s (2011) finding that slower walking speeds following the priming of elderly stimuli were mediated by the association of the elderly stereotype with the self-concept. In the case of experiment 4.2 it seems likely that greater association between the elderly hand and the bodily self would have led to a greater integration of the elderly stereotype in participants' self-concept and that this integration led to the change in motor imagery.

The link between representations of one's own body and representations of social group found in the studies described above is in line with the embodied approaches to cognition in which off line representations of the body are thought to play an important role in scaffolding more cognitively abstract forms of representation (Barsalou, 1999, 2010; Lakoff, 2012). In particular these studies highlight the possibility that representations of the self as situated in a social context with an identity defined by being the member of particular social group may be modulated by and even dependent on representations of the self which are based on the integration of sensory information about the current state of the body. Considering the failure to find any significant effect of social attitudes on the experience of body ownership it appears that the relationship between these forms of self representation is largely a bottom up one. Thus while changes to the experience of the bodily self are capable of changing social attitudes and activating social stereotypes the reverse relationship in which attitudes towards a social group lead to a modulation in experience of ownership over a body part that appears to belong to those social groups does not appear to hold.

Another important point to highlight here is the fact that the social salience of the stimuli used in the experiments was relatively limited. In all these experiments participants experienced VT-stimulation over their own hand and a hand with some characteristic from the other social group but these hands contained relatively little information about the group that they had come from apart from direct visual cues of skin colour and age. This limited amount of social salience can be contrasted with the much greater amount of social information that can be gained from the face of another (Schmidt & Cohn, 2001). The fact that even feeling ownership over a hand from a different social group was enough to affect social attitudes towards that group or activate behavioural stereotypes associated with them speaks both to the strength of modulation that can be exerted by changes in perception of the bodily self and to the ubiquity of perceptual social cues of group membership.

7.3.2. The Relationship Between Body Representation and Interpersonal Interactions

As well as investigating how changes in bodily self-representation can alter peoples' perception of other social groups this thesis also sought to investigate the relationship between body representation and interpersonal interactions. This was an important second strand of the thesis due to the fact that in real life we are often interacting with specific people who we consider members of a social in-group. Therefore a large part of our social interaction with others is concerned more with the specific personalities of those people than generalisations based on social group. The experiments investigating this relationship used economic games, specifically variants of the trust game, as a proxy form of social interaction. Such games provide a useful tool for research as they allow the investigation of particular forms of social interaction within the controlled environment of the lab. As with the investigation of the relationship between body representation and social groups the investigations into the relationship between body and interpersonal trust sought to address this question from both angles. First, does changing the representation of the bodily self exert a bottom-up effect on judgments about the trustworthiness of the other? Second, does learning about the trustworthiness of the other person through your interaction with them change how we represent the similarity between their body and our own?

7.3.2.1. Is Interpersonal Trust Affected by the Experience of Body Ownership?

Experiments 5.1 and 5.2 both sought to investigate the effects of IMS on interpersonal trust. The studies both found evidence that interpersonal trust could be modulated by IMS. Experiment 5.1 replicated the finding of Tajadura-Jimenez, Longo, et al. (2012) that synchronous IMS applied to the face of one's self and another lead participants to give higher ratings of trust towards that other than did asynchronous VT-stimulation, and experiment 5.2 went further and showed an effect of synchronous IMS on the amount of money participants were willing to offer in a trust game. At present this behavioural effect must however be treated with some caution due to the failure to find such an effect in experiment 5.1 and the possibility that the effect seen in experiment 5.2 was due to demand effects. A third study investigating this questions is currently being conducted using the same basic setup as experiment 5.2 but with a between subjects, rather than within subjects design to avoid any possibility of demand effect.

Assuming that the effect of synchronous IMS on behavioural measures of trust is indeed genuine, it is important to recognise that there are a number of possible mechanisms through which this effect could be caused. The first is that IMS's effects on trust are mediated by its established effects on face perception. As covered in chapter 5 a number of studies (Sforza et al., 2010; Tsakiris, 2008) have demonstrated, using variants of the face self-recognition task, that IMS changes perceptions of similarity between one's own face and that of the other. There is also a large literature showing that faces that are more physically similar to one's own are perceived as more trustworthy although whether this fact is due to a specific evolutionary adaptation for prosocial behaviour towards kin, a more domain general effect of self positivity or a combination of the two is unclear. On this account the effect of multisensory stimulation on trust behaviour would be mediated by its effect of self-recognition. An alternative possibility is raised by the fact that shared experiences have been shown to lead to an increase in interpersonal trust and closeness (Fraley & Aron, 2004; Strikwerda & May, 1992). It may be that the increased trust generated by IMS derives simply from the fact that participants undergo a shared experience with the other person without any intervening modulation of judgements of facial similarity. One possible way to dissociate these two hypotheses would be to measure the perception of self other overlap in physical appearance after interpersonal multisensory integration using the self-face recognition task (Kircher et al., 2001) and to investigate how strongly that correlates with the amount of money sent in trust games.

7.3.2.2. Does Interpersonal Trust Affect Representations of Bodily Similarity?

Experiment 5.3 and experiment 6.1 both investigated the relationship between knowledge of the trustworthiness of an interaction partner on the overlap between self and other. However, the two experiments investigated the effect on trust on very different forms of body representation. Experiment 5.3 showed that the effect of altered face representation on trust behaviour shown in experiment 5.2 was bi-directional. Not only do interventions that make the other's face seem more physically similar to one's own also have an effect on one's social behaviour towards the other but receiving behavioural evidence of another person's trustworthiness led to that person's face being perceived as more similar to one's own and also to them judging the other person as being socially closer to them. This finding further indicates the strong relationship between perceptions of social closeness and perceptions of physical similarity.

In contrast experiment 6.1 investigated the effect of observing actions being made by a trustworthy person compared to an untrustworthy person on the activation of brain areas that form the AON. In this case however there was little evidence that increased trust towards the other person led to greater overlap between bodily representations of self and other. In fact overall there was greater activation of the AON when watching the untrustworthy person compared to the trustworthy person.

This difference between the two studies may be based on the distinct functional roles occupied by the different forms of body representation under investigation. While perception of facial similarity appears to be adapted for the detection of kin (Krupp, DeBruine, Jones, & Lalumière, 2012) the activation of motor areas of the cortex during the observation of action has been interpreted as involving the predictions of another's motor actions whether on the level of the goal of the action (e.g. Gallese, 2009) or on the precise kinematic of the action (Neal & Kilner, 2012). In an evolutionary context, while it may have been beneficial to see those who were known to be trustworthy as more similar to one's self, in order to benefit from adaptations for the favouring of kin, it is also very important to be able to understand and predict the actions of a person who intends to betray you. Thus if the AON is indeed involved in determining the goal of an action rather than simply being the result of neural connections formed by associative learning (Heyes, 2013), it is not so surprising that it is activated more by the actions of an untrustworthy person than by a trustworthy one.

7.4. Body Representation and Social Cognition

7.4.1. Body Ownership and Social Synchrony

I will now briefly draw two wider implications of the work presented in this thesis. The first of these relates to the relationship between interpersonal synchrony and social cognition. Although the findings in this thesis on the power of changes in body representation to alter intergroup and interpersonal social behaviours and attitudes all employed passive VT-stimulation their results neatly mirror those from studies that have shown that synchronous movement can also lead to increased pro-social behaviour in economic games (R. Fischer et al., 2013; Wiltermuth & Heath, 2009) and that non-conscious mimicry can alter both interpersonal and group based perceptions of others (Chartrand & Lakin, 2013). The results of the current thesis suggest that these effects of synchronous and similar movements on social cognition may ultimately be derived from the effect that such synchrony has on the perception of self and other. This insight is captured well by McNeill, a military historian, in his description of the similarity between his experience of carrying out military drill during his time in the army and the experience of participants during communal dancing:

"Boundary loss" is the individual and "feeling they are one" is the collective way of looking at the same thing: a blurring of self-awareness and the heightening of fellow-feeling with all who share in the dance. It matches my own recollection of what close-order drill felt like…" (McNeill, 1995, p. 8).

The studies in this thesis demonstrate that multisensory stimulation has the power to alter the social relationship between self and other as well as the physical relationship but this lesson appears to have been appreciated by cultures and institutions across the world since the dawn of humanity. Religions, armies and political movements have used the power of synchronous movements to create a sense of closeness and unity amongst their members while cultures across the world use dance as a way to create feelings of bonding and closeness. While these synchronous movements usually do not evoke the feeling of body ownership shown in the studies here they may create enough of a match between the representation of one's own body and the body of others to promote feelings of self-identification and communality with the other. Indeed it is interesting to note that the increased recent interest in the importance of bodily synchrony is already prompting the development of new interventions to aid in the development of emotional and cognitive forms of empathy (Behrends, Müller, & Dziobek, 2012).

7.4.2. A Model of the Bodily Self and Social Cognition.

The second implication of the current research relates to the basic embodied cognition hypothesis of a strong link between sensorimotor processes and higher level cognition, in particular how sensorimotor representations of the bodily self can modulate social cognition processes. In the introduction to this thesis I highlighted a number of different ways that the state of the body has been tied to concepts within social cognition. The experiments in the previous chapters have sought to investigate the way that the bodily representations underlying one of the most basic and fundamental form of self representation can also influence, and be influenced by, the more abstract and cognitive representations of the self involved in social cognition. The findings from this thesis offer support for the hypothesis that changes in bodily self-representations do indeed modulate social cognition and also that some aspects of social cognition, namely perception of another's trustworthiness, can modulate bodily representations of self and other. What is less clear however is the exact mechanisms by which these modulations occur. Here I will briefly outline a possible model of the relationship between bodily selfhood and social cognition that might explain the results found in this thesis along with other findings in the literature.

The model (see figure 7-1) suggests that, during social interaction, sensorimotor signals from both self (path a) and other (path b) serve as the input to a comparator process that computes the similarity of signals from self and other. The error signal of that comparator process is then fed forward to the processes underlying bodily self-representation in the manner outlined by Tsakiris (2010) (path c). These changes in the representation of the bodily self can then lead to changes in the activation of shared sensorimotor representations of others (experiment 3.2) and to a top-down modulation of future predictions regarding the match between sensorimotor signals from self and other (path d, e.g. VRT; Cardini, Tajadura-Jiménez, Serino, & Tsakiris, 2013). In addition the changes in bodily self-representation modulate various social cognitive processes (path e). These process including: stereotype activation (experiment 4.2), implicit attitudes (experiments 2.1 and 3.1), and interpersonal appraisal, e.g. trustworthiness (experiments 5.1 and 5.2). Finally these social cognitive processes can themselves serve to inform the comparisons between self and other (path f). In this way the model can explain the evidence that stereotype activation can lead to changes in motor acts, e.g. slower movement speeds (Bargh et al., 1996); that interpersonal interaction can affect representations of the bodily self (experiment 5.3); and that attitudes towards an out-group (Avenanti et al., 2010; Gutsell & Inzlicht, 2010; Serino et al., 2009) and interpersonal appraisal (experiment 6.1, Mcintosh, 2006; Sobhani et al., 2012) can both modulate shared body representations between self and other. Finally the sensorimotor signals of other's can lead to the direct activation of the processes involved in social cognition (path g; e.g. Zaki, 2013).

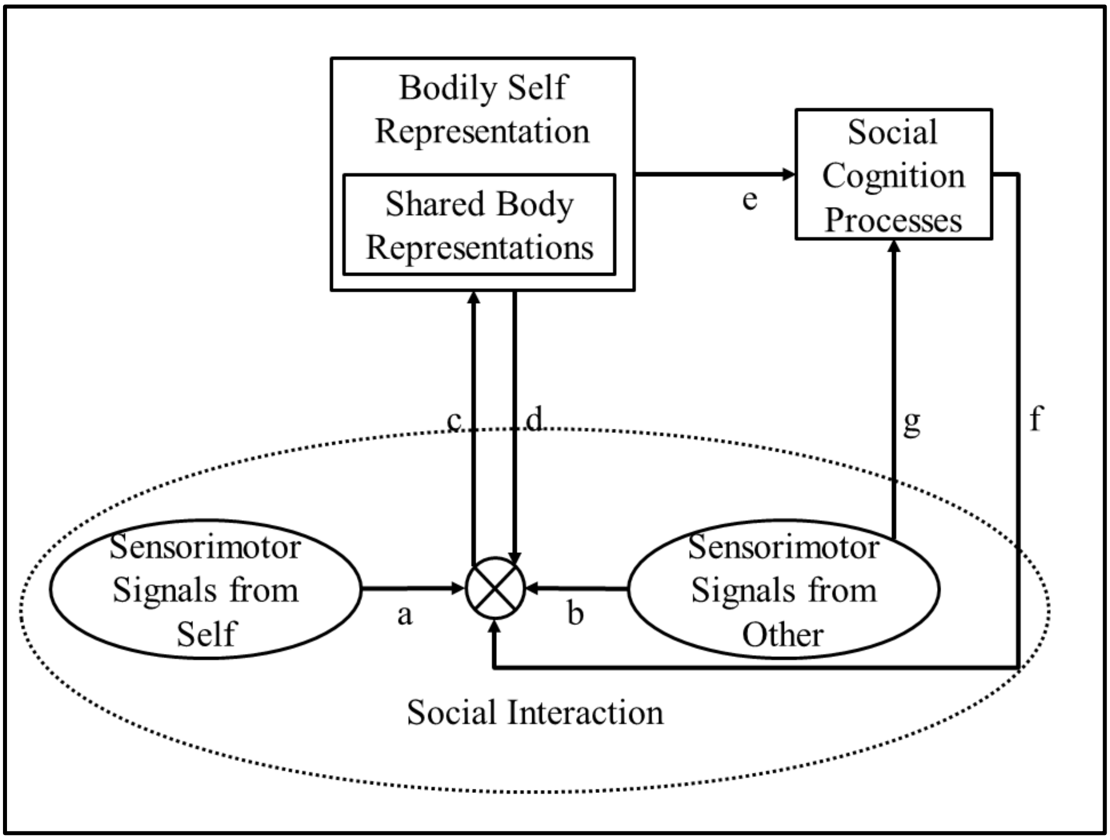

Figure 7-1: A model of the relationship between bodily representations of the self and social cognitive processes. Ovals represent incoming sensorimotor signals. Rectangles represent cognitive processes. Crossed circle indicates a comparator.

This model sees the relationship between social cognitive processes and bodily self-representation reported here as being direct, with changes in the bodily self separately affecting the different social processes that have been examined in this thesis. There is however an alternative possible model of this relationship in which changes to the bodily self are directly related only to changes to a more abstract social form self-representation. On this account the effects of changes to the bodily self on social cognition would be mediated by the extent to which those changes affected this social form of self-representation.

It is important to note that despite the fact that each of the modules in this model is presented as being a unitary block this is merely for conceptual convenience and is not intended to represent a claim that the processes within each module are necessarily unitary or modular. It is clear for example that there are a variety of different forms of body representations in different areas of the brain (see e.g. Berlucchi & Aglioti, 2010) and that many of these areas display shared representations of self and other (Keysers & Gazzola, 2009). In a similar way the processes involved in social cognition are likely to be implemented in a number of different neural networks. For example it seems likely that the cognitive processes involved in interpersonal appraisal and stereotype activation will be largely distinct from one another (Sugiura, 2013). In addition the comparison process itself is not intended to be a unitary phenomena. Instead the comparator in the current model represents a number of different comparison processes including the physical similarity between self and other and the temporal and spatial synchrony of sensory signals from self and other. Despite such limitations however, the model given above does provide some motivations for potential future directions of research in this area, three of which I will briefly outline in the next section.

7.5. Future Directions

Given the relatively unexplored nature of the topic of this thesis it should come as no surprise that the findings reported within it raise more questions than they answer. Much further research is needed to establish the exact scope and nature of the relationship between bodily self-representation and social cognition and at this point many of the mechanisms which underlie this relationship remain unclear. On the basis of the research reported in this thesis however, it is possible to highlight three areas of future research in this area which could shed light on some of these questions.

7.5.1. Bodily and Cognitive Self-Representations

The first of these areas is the question of whether the bidirectional relationship between bodily self-representation and social cognitive processes revealed by the studies in this thesis operates in a direct manner, as in the model in figure 7-1, or whether it is mediated by changes to some cognitive form of self-representation such as the self-concept (Epstein, 1973). There are few current studies that have directly investigated the role of cognitive self-representation in changing states of the body or mediating changes in social cognition. What studies that have been conducted however, support the view that cognitive forms of self-representation may play a mediating between changes in social cognition and changes in bodily states. For example, Wryer et al. (2011) demonstrated that the effects of stereotype activation on behaviour were modulated by the extent to which participants associated the primed stereotype with the self, while Banakou et al. (2013) demonstrated that embodying the body of a child led to greater implicit associations between the self and children.

Two further studies recent studies investigated the relationship between the self-concept and participants' awareness of their interoceptive states. Maister and Tsakiris (2014) examined differences in interoceptive awareness between Western and East Asian participants and found that while observing one's own face during the interoceptive awareness task led to increased accuracy in the Western group the same effect was not found for East Asian participants. The authors attributed this finding to the known cultural differences in self construal between Western and East Asian people, with Westerners generally showing a more independent construal of the self and Asians generally showing a more interdependent construal (Heine, 2001). They hypothesised that while for their Western participants observation of their own face activated bodily self-awareness which led to enhanced processing of interoceptive signals, for East Asian participants viewing the external appearance of the self led to greater activation of higher-level, social aspects of self-identity. The second study by Ainley and colleagues, including the author of the current thesis, (Ainley, Maister, Brokfeld, Farmer, & Tsakiris, 2013) demonstrated that the observation of self-relevant words e.g. the school they most recently attended or the name of the most important person in their life led to the same increase in interoceptive awareness as viewing one's own face suggesting that more cognitive and social self-related stimuli is as effective as viewing one's own body in increasing the perception of signals from one's own body.

The initial studies reviewed above speak in support of higher level self-representation having a reciprocal relationship to bodily self-representation. Further research could use tools such as priming different forms of self-construal (Gardner, Gabriel, & Lee, 1999), investigating associations between the self and a particular social group (Banakou et al., 2013; Wyer et al., 2011), or individual differences in factors related to social self-processing such as peoples' amount of self-monitoring (Snyder, 1974) or body objectification (Tiggemann & Kuring, 2004) to investigate how these more higher level forms of self-representation mediate the relationship between social cognition and the bodily self found in this thesis.

7.5.2. A Neurocognitive Account

The second key area for future research suggested by the findings in this thesis relates to the neural mechanisms that underlie the effects reported in this thesis. Speculating on the neural mechanisms behind these effects is somewhat difficult due to the confusing and somewhat contradictory findings in the current literature on the neural basis of self-representation. Indeed two recent reviews of the relevant literature concluded that the current literature on the neural basis of self-representation is inadequate. Gillihan and Farah (2005) noted that neuroimaging studies had failed to demonstrate any brain areas that specifically processed self-related stimuli, while Legrand and Ruby (2009) concluded that "standard ways to tackle the self by considering self-evaluation do not target the self in its specificity". Despite these pessimistic diagnoses of the present state of the neuroscience of self-related processes I do wish to make some tentative suggestions as to possible models of how the bodily self and social cognitive processes might affect each other on the neural level.

In making these suggestions I will draw on two recent models of how higher level social cognitive processes interact with bodily states. The first of these is the STORM model of how social factors modulate imitation proposed by Wang and Hamilton (2012). In this model of imitation, imitation is directly implemented by the classic mirror neuron areas of the IFG, IPL and STS. However, areas of the brain involved in social cognition are considered to have reciprocal connections with the classic mirror neuron system and are able to exert a top down effect on imitation and well as having their own activity modulated by imitation thus explaining the social effect of and modulations on imitation reviewed in the introduction to this thesis (see also Chartrand & Lakin, 2013). Wang and Hamilton particularly highlight the medial prefrontal cortex (mPFC) as playing a role in modulating activation within the mirror system. The mPFC has been shown to respond to social cues such as eye gaze and social status (Kampe, Frith, & Frith, 2003; Singer, Kiebel, Winston, Dolan, & Frith, 2004; Zink et al., 2008) and to have key role in monitoring other social processes (Teufel, Fletcher, & Davis, 2010).

Wang Ramsey and Hamilton (2011) tested this model by using dynamic causal modelling (Friston, Harrison, & Penny, 2003) to investigate how activation in the mPFC modulated the activation of the mirror system during an imitation task in which another person either directed their gaze to or averted their gaze from the target to be imitated. They demonstrated that there was strong intrinsic connectivity between the mPFC and both the STS and the IFG, suggesting that the mPFC constantly exerts top-down control on the mirror neuron system. Further they showed that having the gaze of another focused on the imitation target led to increased connections between the mPFC and the STS suggesting that the mPFC did indeed modulate activation in the mirror neuron system involved in imitation. Given the close overlap between brain areas implicated in alterations to body representation and those that make up the mirror neuron system (Apps, Tajadura-Jiménez, Sereno, Blanke, & Tsakiris, In Press; Ehrsson et al., 2005, 2004; Petkova et al., 2011) it seems likely that the same areas that are involved in the STORM model could also be involved in changes in social cognition caused by changes to bodily self-representation.

The second model I will briefly highlight is that presented by Sugiura (2013) who proposes a hierarchical layer structure model of the self with three distinct forms of self-processing realised in different networks of brain areas. While the scope of this model is too great to go into detail here it does possess a number of aspects which may be of use in identifying how the interactions between bodily self-representations and more cognitive self-representations can interact to produce the effect reported in this thesis. Firstly Sugiura divides self-representations in the brain into three strands. The first of these is physical self, approximately the same as the bodily self discussed in this thesis, which is supposed to be supported by the sensory and motor association cortices particularly those in the right hemisphere. The second is the interpersonal self, representing the attention or intentions of others directed at the self, which is supposed to be supported by several amodal association cortices in the dorsomedial frontal and lateral posterior cortices. Finally the social self, which represents the self as a collection of context-dependent social-values, is supported by the ventral aspect of the medial prefrontal cortex and the posterior cingulate cortex.

Of particular interest to the findings of the current thesis is Sugiura's division between the interpersonal self and the social self. This division roughly maps on to the division between the two strands of research reported in the current thesis. The studies in chapters 2, 3 and 4 of this thesis, which focused on the relationship between the bodily self and different social groups would in Sugiura's terminology be investigating the between the physical self and the social self. By contrast the studies in chapters 5 and 6 of the current thesis would be investigating the relationship between the physical self and the interpersonal self. This division between different forms of social self-representation is useful in two ways. First it helps shed light on the differences in the directionality of the relationship between the bodily self and social cognition found in the current study. As mentioned above, while evidence for a reciprocal relationship between bodily self-representation and interpersonal interaction was found in experiments 5.3 and 6.1 no such relationship was found for the studies on social groups reported in chapters 2, 3 and 4. Using Sugiura's framework one could consider this evidence that while reciprocal connection exists between physical and interpersonal self-representations no such relationship exists between the physical and social self-representations. The second is that due to the predictive coding nature of the model it offers the promise of situating the relationship between social representations and the bodily self within the growing number of predictive coding accounts of the bodily self (Apps & Tsakiris, In Press; Limanowski & Blankenburg, 2013)

7.5.3. The Affective Self

The final promising area for future research I wish to highlight is the question of how bodily selfhood might interact with more emotional aspects of social cognition. While the studies in this thesis were concerned largely with the relationship between the bodily self and cognitive aspects of social cognition involved in self representation, the role of emotion in social cognition is undeniable and the way we act towards others is often coloured by an affective aspect be that affection, love or hate. To date only two studies have touched on the question of the relationship between body ownership and emotion. Both of these studies investigated the relationship between perceiving another's emotion and the IMS induced overlap between self and other. Maister, Tsiakkas, et al. (2013) demonstrated that the enfacement illusion also facilitates emotion recognition, specifically fearful facial expressions while Beck et al. (2012) found that the effect of synchrony was abolished if the other person displayed a fearful facial expression. However, to date the relationship between one's own emotions and different forms of body representation has not been explored.

The link between alterations in the perception of the bodily self and emotion is particularly salient currently due to the resurgence in popularity of somatic theories of emotion. These theories posit that emotions are constituted by the perception of bodily states and have been strengthened by recent findings of a convergence between brain areas utilised in processing emotions and those which play a key role in the perception of and regulation of the body (Damasio, 2003; Zaki, Davis, & Ochsner, 2012) and between interoceptive sensitivity and emotional arousal (Barrett, Quigley, Bliss-Moreau, & Aronson, 2004; Dunn et al., 2010). In investigating the relationship between bodily self-representation and emotional aspects of social cognition it therefore seems natural to move away from exteroceptive representations of the bodily self and instead focus on interoceptive modalities of bodily information. The relationship between interoception and emotions may be particularly salient in the case of the so called self-conscious moral emotions (e.g. shame, guilt and pride) given the close relationship between these emotions and self-focus (Sheikh & Janoff-Bulman, 2010). Of these shame is a particularly important emotion to investigate in future research given its close links to a wide variety of mental disorders (Rizvi, 2009).

7.6 Conclusion

This thesis investigated the relationship between the bodily self and social cognition. The experiments conducted during this investigation used a variety of different methodologies to demonstrate that strong reciprocal links exist between perceptions of the bodily self and the perceptions of other's whether in the context of social groups or interpersonal interactions. The findings of this thesis thus offer support to views of the self as being grounded in bodily perceptions and the importance of a low level bodily self, underlied by the integration of sensory and motor signals from the body, in the formation of more abstract and socially focused forms of self representation. In this way the current thesis' findings add support to the claim that incorporating the other into our own body representations plays an important role in structuring social cognition.

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