Multisensory and Gaze-Contingent Stimulation of the Own Face

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Alejandro J. Estudillo

University of Kent

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Abstract

When observers' own face is stroked in synchrony, but not in asynchrony with another face, they tend to perceive that face as more similar to their own and report that it *belongs* to them. This "enfacement effect" appears to be a compelling illusion and also modulates social cognitive processes. This thesis further examined the effect of such synchronous multisensory stimulation on physical and psychological aspects of the self. Chapter 2 explored whether multisensory facial stimulation can reduce racial prejudice. White observers' faces were stroked with a cotton bud while they watched a black face being stroked in synchrony. This was compared with a no-touch and an asynchronous stroking condition. Across three experiments, observers consistently reported an enfacement illusion after the synchronous condition. However, this effect did not produce concurrent changes in implicit or explicit racial prejudice.

Chapter 3 explored whether a similar enfacement effect can be elicited with a novel gaze-contingent mirror paradigm. In this paradigm, an onscreen face either mimicked observers' own eye-gaze behaviour (congruent condition), moved its eyes in different directions to observers' eyes (incongruent condition), or remains unresponsive to the observers' gaze (neutral condition). Observers experienced a consistent enfacement illusion after the congruent condition across two of three experiments. However, while the mimicry of the onscreen face affected observers' phenomenological experience, it did not alter their perceptual self-representations.

A final experiment, in Chapter 4, further investigated the cognitive locus of the enfacement effect by using ERPs. Observers were exposed to blocks of synchronous and asynchronous stimulation. ERPs were then recorded while observers were presented with images of (a) a synchronously stimulated face, (b) an asynchronously

stimulated face, (c) their own face, (d) one of two unfamiliar filler faces and (e) an unfamiliar target face. Observers consistently reported an enfacement illusion after the synchronous condition. However, this enfacement effect was not evident in ERP components reflecting early perceptual encoding of the face (i.e., N170) or subsequent identity- and affect-related markers, such as the N250 and the P300.

Altogether the results of this thesis show that it is possible to enface a face, even when it belongs to a different ethnic group to that of the observer. This effect is such that observers report that the enfaced face belongs to them. Interestingly, a similar phenomenological enfacement experience can be obtained with gaze-contingent mirror paradigm. However, this enfacement effect seems to be too short-lived to be reflected in ERP components.

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Declaration

I declare that this thesis is my own work carried out under the normal terms of supervision.

Alejandro José Estudillo

Publications

Chapters 2, 3 and 4 have been submitted for publication.

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To my beloved grandmother, Pepa. She will always be in my memory.

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Chapter 1:

General Introduction

1.1 Introduction

The own face is a distinctive physical feature that has a strong relationship with the own identity. This is such that some authors consider the own face as the emblem of the self (McNeill, 1998) and an 'identity boundary issue' (Ting-Toomey, 1994). The own face not only forms the main visual means by which other people recognise us, but also the main means by which we recognize ourselves in front of the mirror or in recorded footage. Interestingly, this ability to recognize the own face (i.e., self-face recognition) has been observed in humans, but also in non-human primates (Chang, Fang, Zhang, Poo, & Gong, 2015; Robert, 1986) and other mammals such as elephants (Plotnik, de Waal, & Reiss, 2006) and cetaceans (Reis & Marino, 2001).

Research has shown that, in terms of identity, the own face has a relevant status over other pieces of self-related information such as the name. The reason for this might be that the face is a unique and distinctive personal feature, unlike other personal information such as names, which could be shared by several individuals (see Devue & Brédar, 2011). This relevance of self-face information for the own identity is illustrated in some dramatic and unfortunate real scenarios. For example, Robert Antelme was a member of the French Resistance. In his book *La especie humana* (Antelme, 1947), Antelme gave an interesting testimony about the time he spent as a prisoner in a concentration camp, during the Second World War (see also Fanon, 1952). In these camps, Nazi soldiers tore apart the identity of the prisoners by confiscating their personal belongings and swapping their names for a number. After a long time without seeing his own face, an inmate gave Robert Antelme a small mirror in which he could see his face. Antelme reported that, during this mirror experience, he recovered his sense of identity (Antelme, 1947; Fanon, 1952).

Cognitive psychologists have tried to understand what is so relevant about the own face. Several lines of research have shown that the self-face is not only relevant compared with other pieces of self-information but also compared with others' faces (see Devue & Brédar, 2011 for review). This is striking as all faces have a very similar configuration — all of them have two eyes above a central nose and mouth. What is exclusive about the own face is not its configuration, but the access that it provides to two interrelated concepts of the self, namely *identity* and s*elf-consciousness*.

1.2 Identity and self-consciousness

The definition of identity and self-consciousness has been an important question for philosophers and psychologists. Philosophers from Classical Greece (i.e., Socrates, Plato, Aristotle) and occidental philosophers (i.e., Rene Descartes, John Lucke, Immanuel Kant, Ortega y Gasset) already tried to describe and understand the nature of identity and consciousness. More recently, with the advent of the experimental psychology, psychologists and neuroscientists have studied this topic in a more systematic way (see Gallagher, 2000 for review).

Identity and self-consciousness are related concepts. While identity consists of the personality traits, the features and the social relationships that define who one is (Oyserman, Elmore, Smith, 2012), self-consciousness makes reference to being aware of who one is or, in Morin's (2006) words, *the capacity to become the object of one´s own attention.* That is, identity can be considered as pre-requisite of self-consciousness. The process of self-consciousness involves focusing the attention to any feature related to the self, from our physical appearance to more abstract self-information such as thoughts, values, opinions and intentions. The fact that self-consciousness reflects different aspects of self-information shows that it is a multifaceted concept (see Ben-Artzi, Mikulincer, & Glaubman, 1995; Zeman, 2001).

Morin (2006) presents a model of self-consciousness that takes into account different types of self-information, which differ in nature and complexity. This model of self-awareness is presented in Figure 1 and distinguishes between conceptual or private and perceptual or public self-information (for a similar description, see Fenigstein, Scheier, & Buss, 1975). Conceptual self-information consists on the unobservable features and events related with the self, such as intentions, motives, values, goals, and emotions. On the contrary, perceptual self-information would be the observable aspects of the self, such as our behaviour and physical appearance.

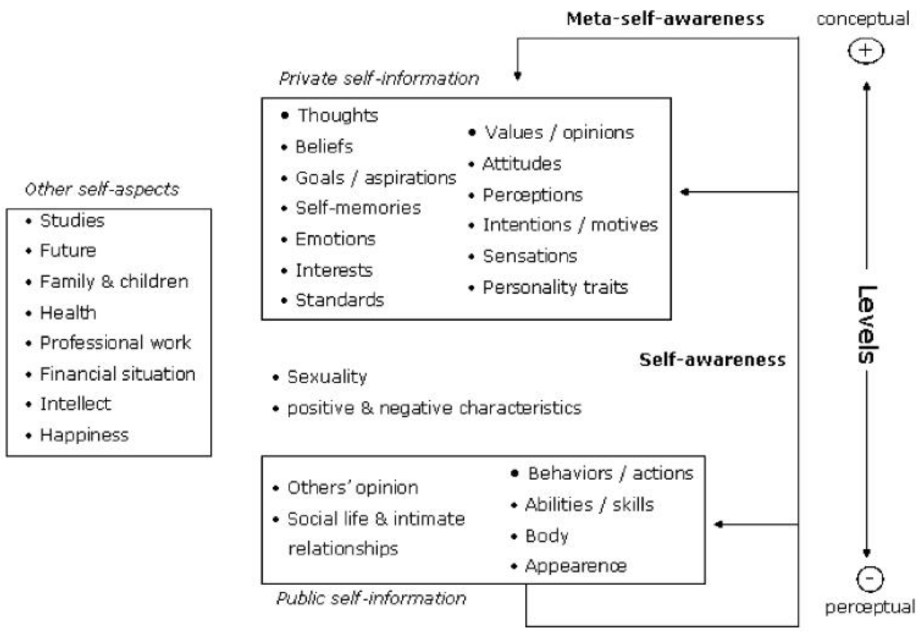

Figure 1. Illustration of conceptual (private) and perceptual (public) self-information (from Morin, 2006).

According to Morin (2006), one important property of public self-information is that it directly affects the conceptual or private self-information. This is such that research protocols in the field of comparative psychology use visual self-referential stimuli as a way to investigate self-awareness (e.g., Chang et al., 2015; Plotnik et al., 2006; Reis & Marino, 2001; Robert, 1986). Moreover, the model proposes that, because of its abstract representation, the conceptual aspects represent the highest level of self-consciousness (Morin, 2006). Thus, someone who is able to access their own values, thoughts or opinions would have a higher level of self-awareness than someone who can only access physical features or behaviour. According to Morin (2006), visual-self recognition is therefore an important aspect of identity and self-consciousness because it affects more complex aspects of identity such as intentions, motives, values, goals and emotions.

1.3 Is the self-face special?

The knowledge that people have about their physical features appears to be an important aspect of identity and self-consciousness (Morin, 2006). Both the face and the body reflect one's physical appearance and are useful means by which people can recognize us. However, these parts differ in the degree of representativeness of our identity. Because of its distinctiveness, people tend to recognize others by their face, and not by the body. It is perhaps for this reason that there is more research in the field of self-face than self-body recognition (for a review, see Gillihan & Farah, 2005).

The physical properties of different faces are very similar: all faces have two eyes, which are set above a central nose and a mouth (i.e., the so-called first-order relations between facial features, see Maurer, Le Grand, & Mondloch, 2002). Despite this similarity among faces, the experience that people gather with their own face seems to be both quantitatively (e.g., Tong & Nakayama, 1999) and qualitatively different (e.g., Brédart, 2003; Greenberg & Goshen-Gottstein, 2009) to the experience they have with the faces of others.

An early study in this field compared the time to detect the own and an unfamiliar face among a set of distractor faces, and showed that observers were quicker in detecting the former (see Tong & Nakayama, 1999). This advantage for the own face suggests that it is strongly represented as a consequence of overlearning. However, this study only compared the performance of the own face with unfamiliar faces, so it is not clear whether this advantage reflects processing of the own face *per se* or a more general advantage for over-learnt faces, such as those of famous or personally familiar people. Using a face naming paradigm, Troje and Kersten (1999) compared the time to name frontal and profile versions of highly familiar faces and observers' own faces. They found that observers were faster to respond to the own face in both orientations. These results have been replicated with other paradigms such as face matching (Laeng & Rouw, 2001), recognition (e.g., Keenan et al., 1999), and orientation identification (e.g., Sui, Zhu, & Han, 2006).

All of the reviewed studies so far report an advantage for the self-face in terms of reactions times. However, this advantage is not as clear in accuracy measures (e.g., Brédart & Devue, 2006; Thompson, 2002). For example, observers' accuracy to detect changes in the interocular distance of faces is similar for personally familiar faces and the own face (Brédart & Devue, 2006). This shows that there is a quantitative advantage for the self-face compared with both unfamiliar and familiar faces, but only in reaction times.

Overlearning could explain the self-face advantage for the own face (Tong & Nakayama, 1999). However, while people might see their own face more often than others' faces, they usually can only do so when a mirror is used. This different experience might also affect the way in which we process our own face. In support of this reasoning, observers tend to rate mirror-reversed photographs of themselves as more representative than non-reversed photographs (Rhodes, 1985, 1986), but this preference is reversed when the close friend of an observer judges the same pictures (Mita, Derme, & Knight, 1977). This indicates that people prefer stimuli that they have been exposed to: as we tend to see our own faces mostly in mirrors, we prefer mirror-orientation pictures. On the other hand, when seeing a friend's face, this is preferred in its normal orientation as this is most frequently encountered.

These differences between the self and others also seem to affect how faces are encoded at a featural level. According to Galton (1883), 'a face is perceived as an undecomposed whole', rather than a collection of individual features (i.e., holistic processing). Some evidence has shown that familiar faces are associated with more holistic processing than unfamiliar faces (e.g., Clutterbuck & Johnston, 2005; Jackson & Raymond, 2008). In contrast, the own face appears to be processed more at a featural level (see Greenberg & Goshen-Gottstein, 2009). This is such that observers are quicker to create a holistic mental image of an unfamiliar face than their own face. By contrast, they are quicker to create a mental image of a facial feature of their own face (e.g. the nose) than of a familiar face (Greenberg & Goshen-Gottstein, 2009). These differences might relate to the fact that people use others' faces for identification purposes whereas they do not need to identify *themselves* in a mirror. In contrast, such time might be used to inspect individual facial features during activities such as grooming and shaving. Therefore, to create a mental image of one's own face, people might be more likely to process individual facial features (see Greenberg & Goshen-Gottstein, 2009).

In summary, research in self-face processing has shown that the own face has special properties that create differences in how it is processed in comparison to other familiar and unfamiliar faces. These differences could explain the advantage for self-face detection and recognition compared to others' faces.

1.4 Neural markers of self-face processing

Considering the advantage for processing the self-face compared to others' faces, it is possible that this is reflected in neural markers of face processing. The aim of this section is, therefore, to review these neural markers.

1.4. 1 Behavioural studies

Early research found evidence of a right hemispheric dominance in the processing of the self-face. For example, observers responded faster to their own face compared to the face of a friend or unfamiliar faces, but only when responses were made with the left hand (Keenan et al., 1999). Similar results have been found using self-other discrimination task (Keenan, Freund, Hamilton, Ganis, & Pascual-Leone, 2000). In this task, observers see a video showing a blend between the observer's face and a famous face. The video starts with a 0% self-face - that is, by showing exclusively the famous face. The blend between the faces increased with time, so that the face image gradually changes into the observer's face. Observers then have to press a key to stop the video when they find that the onscreen face more closely resembles themselves than the famous identity. Results showed that observers stopped the video sooner when responses were made with the left than the right hand, indicating a right-hemisphere advantage for the own-face.

More recent behavioral evidence has also shown an important role of the left hemisphere in self-face recognition. For example, when observers are presented with two symmetric chimeric faces of their own face (see Figure 2), which are either constructed only from the left side of their face or the right side, they tend to judge the latter as more similar to their own face (Brady, Campbell, & Flaherty, 2004). This side corresponds with the half face that lies in their right visual field when they look at themselves in the mirror. Interestingly, when observers were presented with two symmetric chimeric images of a close friend, they showed a bias toward the chimeric face that was created from the left side. That is, in this case an advantage is found for the side of the face that lies in the left visual field when observers interact face to face with their friend (Brady et al., 2004).

Thus, behavioural studies are inconclusive regarding the hemisphere dominance for self-face recognition. However, it is possible that task- or stimulus-specific factors such as spatial frequency of the stimuli, content and duration affect the hemispheric advantage (see Brady et al., 2004; Sergent, 1988). For this reason, future studies should control these factors systematically.

Figure 2. An illustration of chimeric faces. The left side face is the original face. The central face is made only with the left part of the original face. The right side face is made only with the right side of the original face. Face Image taken from the Glasgow Face Database (Burton, White & McNeill, 2010).

1.4.2 Neuropsychological and neuropsychiatric studies

Further evidence for hemispheric differences in self-face and other-face recognition comes from neuropsychological studies with split-brain patients. However, these have also yielded mixed results. For example, while early studies showed a right hemisphere dominance for the self-face compared to familiar faces (Preilowski, 1977; Sperry, Zaidel, & Zaidel, 1979), more recent studies have found a left-hemisphere dominance (Turk et al., 2002) or no difference between hemispheres (Uddin, Rayman, & Zaidel, 2005). However, Gallois, Ovelacq, Hautecoeur and Dereux (1988) also reported the case of a patient with localised damaged in the left occipital lobule, including the left fusiform gyrus. This patient presented alexia, agnosia and achromatopsia. Although the patient had problems in recognizing her own face, her autobiographical memory and her ability to recognize familiar faces were preserved. This case report not only shows the involvement of the left hemisphere in self-recognition but also of a specific brain structure, the left fusiform gyrus.

However, other disorders, such as mirrored-self misidentifications, again appear to provide conflicting evidence. This is a neuropsychiatric disorder that consists of the belief that one's own mirror image reflects another person (Breen, Caine, & Coltheart, 2000, 2001; Feinberg & Keenan, 2005; Van den Stock, de Gelder, De Winter, Van Laere, & Vandenbulcke, 2012). Evidence from this disorder has shown right hemisphere dominance in self-face recognition. For example, these patients have relatively preserved left hemisphere function, but severe visuoconstructional deficits and a poor visual memory, which are evidence of right hemisphere dysfunction (Breen et al., 2001).

In conclusion, although most neuropsychological evidence has showed evidence for right-hemisphere dominance in self-face recognition, some studies have shown that specific brain structures in the left hemisphere also play a role in this process (Gallois et al., 1988; Turk et al., 2002). At first glance, these results seem contradictory, but this discrepancy might, in fact, indicate that both hemispheres play an important role in self-face recognition.

1.4.3 Neuroimaging studies

Except for Gallois and colleagues' study (Gallois et al., 1988), all of the reviewed studies so far provide evidence about lateralization in self-face recognition but not about specific brain structures. Neuroimaging techniques, such as functional magnetic resonance imaging (fMRI) or positron emission tomography (PET), explore brain activity while observers perform a cognitive task. This allows for the localisation of brain structures involved in self-face recognition.

A PET study found activation of the left fusiform gyrus and the right supramarginal gyrus in both passive self-recognition (i.e., observers do not perform any action when they see their own face) and active self-recognition (i.e., observers press a key when the own face is presented) compared to the presentation of unfamiliar faces (Sugiura et al., 2000). A follow-up fMRI study that included familiar faces as a control also showed that the left fusiform gyrus, the right occipito-temporo-parietal junction and the frontal operculum were selectively activated for the own face (Sugiura et al., 2005).

Devue et al. (2007) compared the brain activation for the own face with the activation of personally familiar faces. Observers had to discriminate between normal and altered faces of themselves and a close friend. Devue and colleagues (2007) found activation of the right inferior frontal gyrus and of the right insula for the self-face compared with the personally familiar face. However, in contrast to the preceding studies, they did not find activation of the left fusiform gyrus. Other studies have replicated these results, but also obtained additional activation of the inferior occipital gyrus for the own face compared to familiar faces (Kaplan, Aziz-Zadeh, Uddin, & Iacoboni, 2008; Uddin, Kaplan, Molnar-Szakacs, Zaidel, & Iacoboni, 2005).

In summary, neuroimaging studies have shown the implication of brain structures in both hemispheres in self-face recognition. Although these studies are incongruent regarding specific brain regions, it seems that a complex bilateral network is involved in self-recognition. This network seems to comprise frontal, parietal and occipital brain structures of both hemispheres (for a review, see Devue & Brédart, 2011).

1.4.4 Event-related potential studies

Given its high temporal resolution, event-related potentials (ERPs) are a useful technique to identify the time course of information processing (see Luck, 2014). The ERP technique has been used extensively in face processing research (for a review, see Schweinberger, 2011). By comparison, research about the ERPs involved in the processing of the own face is scarce.

The N170 component is probably the best-known face-related component. This negative inflection peaks approximately 170 ms after stimulus presentation at lateral occipital electrodes sites and is larger for faces than for other visual stimuli (Bentin, Allison, Puce, Pérez, & McCarthy, 1996). This component is considered to reflect early perceptual stages of face processing which precede recognition (Bruce & Young, 1986; Eimer, 2000, 2011). However, recent research suggests also that this component is modulated by the own face (e.g., Caharel et al., 2002; Keyes, Brady, Reilly, & Foxe, 2010; but see Sui et al., 2006). For example, when observers are asked to monitor a sequence of different images consisting of their own face, an observer's friend's face, an unfamiliar face and flowers, the N170 is larger for the own face compared to the other stimuli (Keyes et al., 2010). This result contradicts the assumption that the N170 simply reflects the structural encoding of a face and suggests a strong representation for the self-face in early perceptual stages.

A subsequent component that has been linked more strongly to the activation of identity representations for familiar faces is the N250 (Schweinberger, Pickering, Jentzsch, Burton, & Kaufmann, 2002; Schweinberger, 2011; Tanaka, Curran, Porterfield, & Collins, 2006). This component consists of a negative inflection, which peaks 250 ms after the presentation of a known face at temporal electrodes. For this reason, this component has been related to the activation of the identity representations of familiar faces (see Schweinberger, 2011). Some research has also shown that this component is more negative for the own face compared to unfamiliar faces (Pierce et al., 2011; Tanaka et al., 2006). For example, Tanaka et al. (2006) showed that the N250 component was enhanced for the own face compared to an unfamiliar target face in the first half of the experiment. However, in the second half of the experiment, the N250 was similar for both the own face and the target face. These results suggest that the N250 reflects two different indexes of facial memory: one for pre-existing familiar face representation, such as the own face, and one for newly acquired face representation, such as the target face (for related results, see Kaufman, Schweinberger, & Burton, 2009).

Later ERP components have also been implicated in self-face processing. For example, the P300 is considered to reflect the arousal or emotional saliency of stimuli. An early self-face ERP study, showed that the P300 component was larger for the own face compared with unfamiliar faces (Ninomiya, Onitsuka, Chen, Sato, & Tashiro, 1998). By contrast, the N400 component seems to reflect semantic access. In the face processing domain, it has been linked to access to biographical information (Kaufmann et al., 2009). Buttler, Mattingley, Cunnington and Suddendorf (2013) showed a larger N400 amplitude for the own face compared to the faces of observer's dizygotic twin siblings (see also Caharel, Courtay, Bernard, Lalonde, & Rebaï, 2005).

In conclusion, although a specific ERP component for the processing of the self-face does not appear to exist, ERPs components reflecting the structural encoding (N170), recognition (N250), stimulus saliency (P300) and semantic identity representations (N400) show a stronger response to the own face compared to others' faces.

1.5 Face learning

Face recognition requires that a seen face is matched to a stored, internal representation of that identity (Bruce & Young, 1986). Theories of face recognition postulate that this internal representation is not tied to a specific instance of a seen face, but is activated by any facial exemplar of this person (see, e.g., Burton, Bruce, & Johnston, 1990; Bruce & Young, 1986). Thus, this internal representation should be tolerant to changes in the appearance of a face, such as variation in lighting direction or facial pose (see, e.g., Bruce, 1982; Longmore, Liu, & Young, 2008). A question that arises is how this internal representation is created so that a previously unfamiliar face - the face of someone unknown - becomes sufficiently familiar for recognition to occur. Current theories suggest that one way to operationalize this process could be the creation of face averages (see Figure 3).

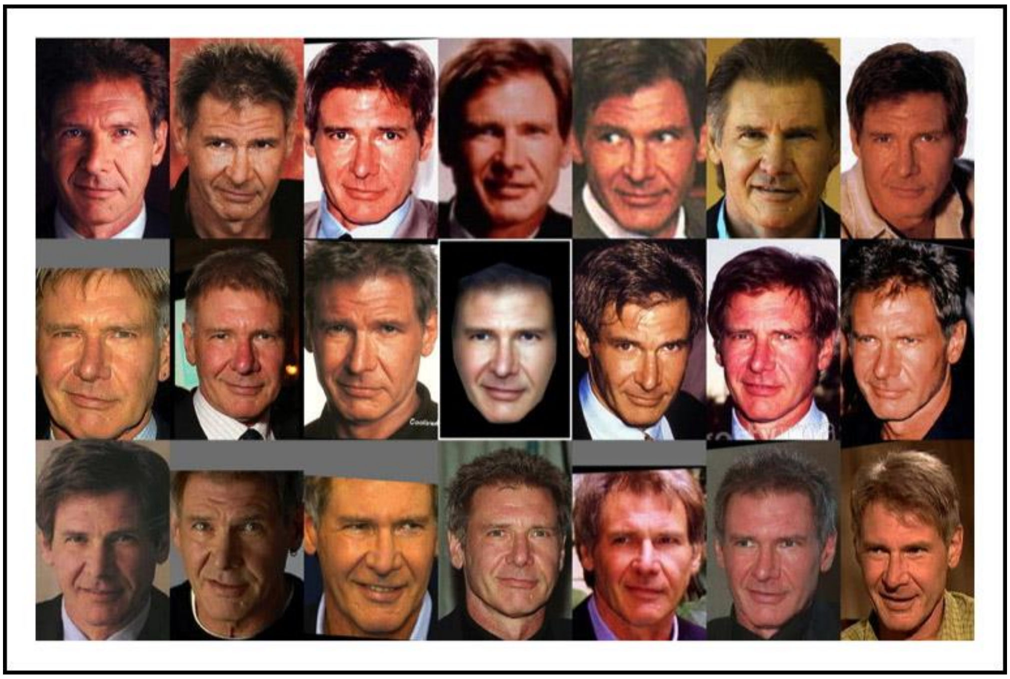

Figure 3. An illustration of a face average (the central image) and its constituent photographs. Sourced from http://homepages.abdn.ac.uk/m.burton/pages/averages.html.

The averaging process consists of the integration of different instances of the same face into a single representation (Burton, Jenkins, Hancock, & White, 2005). This process works as follow (for further details, see Burton et al., 2005; Jenkins & Burton, 2011). Firstly, the shape of each face is captured by marking the *xy* coordinates of key facial features (e.g., positions of corners of mouth, eyes, tip of the nose, etc.). During this stage, the face region is segmented from the background. In a subsequent stage, the marked images are then coregistered by morphing them to a standard template using bi-cubic interpolation. For each face, the average texture from each co-registered images is derived by calculating the mean intensity values at each pixel, and the average shape of the corresponding unregistered images by calculating the mean *xy* coordinates of each marked key facial feature. Then each person's average texture is morphed to their average shape to produce the stabilized image of their face. Information that is relevant to the identity of a person, and therefore present consistently across encounters, is combined to form this stabilized image. In contrast, non-diagnostic information, such as lighting direction, which is not relevant to identity, is eliminated naturally because their effect will be cancelled out across different instances.

This theoretical account can provide a robust method to simulate face recognition (Burton, Jenkins, & Schweinberger, 2011; Jenkins & Burton, 2008; Robertson, Kramer, & Burton, 2015). Importantly, however, these theories also provide a good account of face learning (see, e.g., Burton, Kramer, Ritchie, & Jenkins, in press; Kramer, Ritchie, & Burton, 2015; Leib et al., 2014). Accordingly, the created internal representation of a particular face is strongly tied to the experience of that identity, whereby every additional exposure to a face strengthens its average and thus leads to a stronger internal representation (Burton et al., 2005, 2011; Jenkins & Burton, 2008).

More relevant for the current purpose, this theoretical approach can also explain two interrelated aspects of self-face recognition, namely how a visual representation of the own face is created (see Nielsen, Dissanayake, & Kashima, 2003) and how this representation accommodates changes in physical appearance during the lifespan (e.g. age, hairstyle, etc.). According to this perspective, any new instance of the own face would be incorporated into the averaging process to naturally deal with changes in the appearance. However, although such perspectives can explain how the representation of the own face is created and updated, it does not explain the self-referential process of knowing that one particular face is, in fact, one's own (e.g., Devue & Bredart, 2011; Morin, 2006). A possible theoretical framework for understanding this self-referential process comes from the study of embodiment (Shapiro, 2011).

1.6 Embodied cognition: a new perspective in cognitive psychology

The embodied cognition perspective is considered 'the next step in the evolution of cognitive sciences' (Shapiro, 2011, p. 1). This new perspective distinguishes three different themes of discussion or theoretical positions. The first of these theoretical positions is 'conceptualization'. Proponents of this view considerer that the concepts that an organism acquires are limited by its body. In this sense, the body is treated as the door to knowledge, so organisms differing in the properties of their bodies will differ in their understanding of the surrounding world. The second theoretical position is 'replacement'. According the classical view, in order to interact with the surrounding world, the organism need to create a mental representation of the environment (i.e., symbolic representation, Neisser, 1967). In contrast, the embodied cognition view assumes that the mere interaction of the organism with its surrounding world replaces the need of the concept of mental representation (see Hurley, 2001). In fact, radical embodiment cognition approaches deny the existence of such mental representations (e.g., Van Gelder, 1995; Wilson & Golonka, 2013; but see also Barsalou, 2008; Shapiro, 2011; Svensson & Ziemke, 2005). The third theoretical position is 'constitution', which reflects the view that the body and the environment, are the components of cognition, but not the cause.

Some embodiment cognition approaches deny the concept of symbolic representation. This stance also implies the denial of the classical cognitive view that these symbolic representations are manipulated by the use syntactic structures (i.e., a systematic set of rules to encode semantic information about the world; see Fodor & Pylyshyn, 1988). Advocates of embodied cognition criticises two additional aspects of the traditional cognitive perspective (see Hurley, 2001). The first concerns the view that perception and action are dissociable processes. According to the embodiment perspective, these two processes are interactive and closely linked, such that one cannot be understood without the other. The second view suggests that cognition is the central core of the mind but can be decomposed into different modules. The classical cognitive perspective assumes that these modules would operate independently from each other and from lower-level cognitive processes, such as perception and action. Moreover, perception and action would not only be dissociable from each other but also from higher-level cognitive processes such as language and reasoning. The embodiment perspective does not deny the existence of such modules but assumes that these are interactive. Therefore, higher-level cognitive processes, such as reasoning and language, would affect lower-level cognitive processes, such as perception and action, and vice versa.

In conclusion, the embodiment approach offers a new perspective for understanding cognition and behaviour. This new approach asserts that the brain is not the only cognitive resource available to solve problems. Instead, it is the interaction between the whole body - including the brain - and its actions in the environment that determines cognitive processes (see Wilson & Golonka, 2013).

1.7 Embodiment and body experience: the rubber hand illusion

Models of identity and self-awareness (see Morin, 2006) assume that the body, or public self-information, directly affects our cognitive processes, or private self-information (see Morin, 2006). However, these models do not explain the self-referential process of knowing that a body, or a particular body part is, in fact, one's own. On the contrary, the embodiment perspective assumes that the interaction between the body and its actions builds cognitive processes. Thus, according to this perspective a sense of body ownership will be acquired as consequence of the mutual interaction of the organism with the environment.

A striking aspect of this assumption is that it leaves open the possibility of ‘embodying’ objects during interacting with them. In support of this notion, watching a rubber-hand being stroked in synchrony, but not in asynchrony, with one’s own hand produces the feeling that the rubber hand is, in fact, one’s own (Botvinick & Cohen, 1998; see also Tsakiris & Haggard, 2005; see Figure 4). This illusion is such that observers judge their unseen own hand to be located closer to the rubber hand (i.e., proprioceptive drift) and also report a sense of *owning* the rubber hand. Interestingly, it is possible to induce the rubber hand illusion even when colour properties of the rubber hand are different from the colour properties of the observer’s hand (Farmer, Tajadura-Jiménez, & Tsakiris, 2012; Maister, Sebanz, Knoblich, & Tsakiris, 2013a). These results show that synchronous multisensory stimulation (SMS) affect the sense of body ownership.

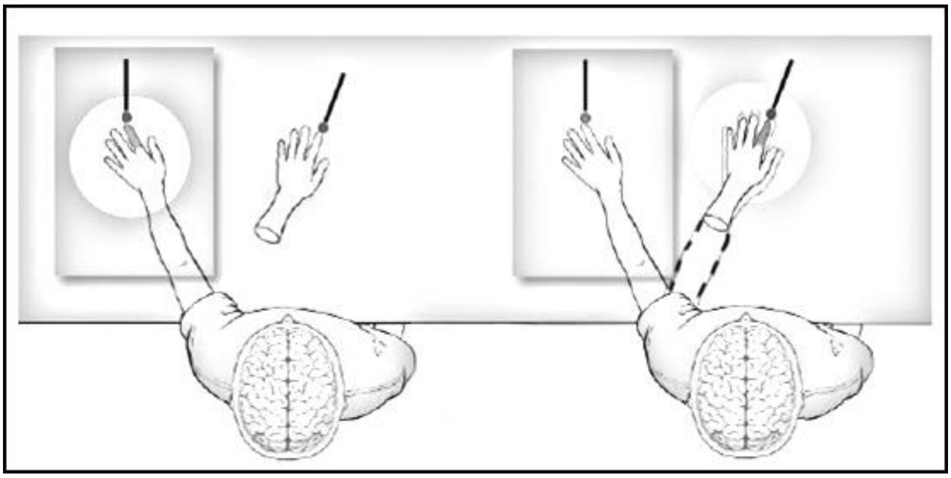

Figure 4. An illustration of the rubber hand illusion paradigm. When observers receive synchronous multisensory stimulation with a rubber hand, they experience a sense of ownership over this fake hand. The effect disappears when there is a small delay between strokes to the own and the rubber hand.

Rubber-hand effects have also been obtained without touching, for example, when there is synchrony of movement between a rubber and one's own hand (e.g., Dummer, Picot-Annand, Neal, & Moore, 2009; Riemer et al., 2014). This shows that the sense of body ownership is not specific to the multisensory integration of vision and tactile information, but to the detection of self-specifying intersensory correlations (see Ehrsson, Holmes, & Passingham, 2005; Dummer et al., 2009; Tsakiris & Haggard, 2005).

But what does it mean to embody a hand? Psychometric studies (see Longo, Schüür, Kammers, Tsakiris, & Haggard, 2008) have identified four different components which explain the experience of the rubber hand ownership. These components are present in both the synchronous and asynchronous conditions, but to different extents. The first component, which is called *self-identification*, is related to the sense of owing the hand. The subcomponents of this components are: ownership (i.e., the feeling that the rubber hand was part of one's own body), location (i.e., the feeling that the rubber hand was in the same place as the own hand), and agency (i.e., the feeling of being able to move the rubber hand). The second component, which is called *loss of own hand*, is related to the displacement of an observer's own hand. This component suggests that, during the illusion, observers not only incorporate the rubber hand as part of their own body, but the rubber hand also displaces observers' own hand. The third component, which is called *movement,* is related to the feeling of movement of the own hand. This reflects that observers report a stronger feeling of movement of the own hand after the asynchronous than the synchronous stimulation condition in the rubber hand paradigm. Lastly, the fourth component, which is called *affect,* is related to how enjoyable the touch on the hand was.

The sense of body ownership has been studied mainly with hands. However, the hands are not the only body part that is susceptible to rubber hand illusion-like effects. Similar effects have been reported with arms (Guterstam, Petkova, & Ehrsson, 2011) and even the whole body (Lenggenhager, Tadi, Metzinger, & Blanke, 2007; Petkova & Ehrsson, 2008; Petkova et al., 2011). This embodiment of a limb or an entire body that is not ones' own is striking from a phenomenological point of view. However, the hands or arms of different people can be highly similar in appearance and not very distinctive. Interestingly, more distinctive body parts, such as the face, which plays an important role key for the recognition of the self and others, are also susceptible to rubber hand-like effects (e.g., Tsakiris, 2008; Tajadura-Jiménez, Grehl & Tsakiris, 2012a; Sforza, Bufalari, Haggard & Aglioti, 2010; Maister, Tsiakkas & Tsakiris, 2013b). This 'enfacement effect' (Sforza et al., 2010) not only affects the phenomenological experience of owning another person's face but also affects performance in self-recognition tasks.

1.8 Embodying others' faces: the enfacement illusion

It has been classically assumed that the visual representation of the own face is rather stable (Miyakoshi, Kanayama, Nomura, Iidaka, & Ohira & 2008, Porciello et al., 2014). This implies that people would recognize their own face because they can match the visual input from mirrors or photographs with their view-invariant internal representation (Bruce, 1982; Bruce & Young, 1986). However, the fact that faces are also susceptible to rubber hand-like effects (e.g., Tsakiris, 2008; Tajadura-Jiménez et al., 2012a; Sforza, et al., 2010; Maister et al., 2013) suggests that this self-face representation is much more malleable than was previously thought. This is striking, as faces form a distinctive aspect of human appearance and play an important role in the recognition of the self and others.

In the classical 'enfacement' paradigm, observers were presented with a sequence of morphed images between their own and an unknown face (Tsakiris, 2008). This sequence started either with 0% of the self-face, that is by showing exclusively the unknown face, or with 100% self-face, that is by showing one's own face. The blend of the faces increased with time from self-to-other or vice versa. Observers' task was to stop the video when they considered that the face looked more like the self. After this baseline stage, observers were shown a morphed face, which consisted of an even blend (50/50%) between their own and the unknown face. This image was stroked with a paint brush on the cheek every two seconds. Observers were stroked either in spatial-temporal synchrony or in temporal asynchrony (i.e., at a 1-second delay). After that, observers performed the same self-recognition task, so that they had to stop the video when they considered that the face looked more like the self (see Figure 5). Compared with the baseline stage, observers accepted more aspects of the other face as their own at this post-stimulation test. However, this bias in self-recognition was found after synchronous but not after asynchronous stimulation. In addition, an enfacement questionnaire showed that observers experienced a stronger subjective enfacement illusion after the synchronous than the asynchronous condition (see Tsakiris, 2008). These results seem to indicate that synchronous, but not asynchronous, multisensory stimulation updates the cognitive representations of our own face and produces a bias in self-recognition.

This effect has been replicated with 'live' models (Sforza et al., 2010). In this study, observers were recruited in pairs of the same gender. Observers were also already familiar with each other. During the stimulation stage, both observers received either synchronous or asynchronous multisensory stimulation. Then, observers performed the self-other discrimination task. As in previous studies, they saw more aspects of themselves in the model after synchronous than asynchronous stimulation. However, the fact that this was observed with 'live' models rather than static face photographs has important theoretical implications for face recognition research. This shows that enfacement does not modify simple pictorial codes but structural, cognitive face representations (see Bruce & Young, 1986).

Figure 5. An illustration of the enfacement paradigm (taken from Tsakiris, 2008). Figure 5a shows the self-other discrimination task (from 'self to other' and from 'other to self'). Figure 5b shows the stimulation stage of the enfacement paradigm.

SMS of the face not only produces behavioural and subjective changes, but also changes in autonomic physiological responses, such as electrodermal activity (EDA) and heart rate deceleration (HRD). Tajadura-Jiménez et al. (2012a) compared these autonomic physiological responses during synchronous and asynchronous multisensory stimulation and found that HRD increased in the former compared to the latter condition. This increased response appears to reflect a higher attentional level for the synchronous compared to the asynchronous condition (Tajadura-Jiménez et al., 2012a; see also Lang, Bradley, & Cuthbert, 1990). EDA activity was also increased for the synchronous stimulation. This was such that when a threatening object, such as a knife, approached the onscreen model's face, observers' EDA responses increased after synchronous but not asynchronous stimulation. This response was also evident in the synchronous condition when the threatening object approached the model's face compared to a non-threatening object (e.g., a spoon, see Tajadura-Jiménez et al., 2012a).

Psychometric research has tried to characterize the different aspects of the experience of identifying with a face (Tajadura-Jiménez, Longo, Coleman, & Tsakiris, 2012b). Three different components, which were common to the synchronous and the asynchronous condition, were found. The first of these component, which explained most variance, shows a qualitative difference between the conditions and was termed *self-identification*. In the synchronous condition, this reflects the visual identification of the observer with the onscreen face. In the asynchronous condition, on the other hand, this reflects a disruption of this visual identification and the simply imitation of the onscreen face. This component is similar to the *self-identification* component found for the rubber hand illusion (see Longo et al., 2008). However, it seems to differ in its structure in both illusions as no further subcomponents for self-identification have been found in the enfacement illusion (Tajadura-Jiménez et al., 2012b). It has been proposed that this reflects the different importance that faces and hands have for self-identity, which should be stronger for faces (see Tajadura-Jiménez et al., 2012b). The second and the third components reflect quantitative differences between the synchronous and the asynchronous conditions. The second component, termed *similarity*, reflects the extent to which observer perceive a model's face as similar to their own face, whereas the third component, termed *affect*, reflects the extent to which observers judge the model's face as trustworthy and attractive.

An interesting question that arises from this framework concerns the mechanism of the enfacement illusion. Are observers incorporating features of the model into their self-face representation or are they modifying the representation of the model's face? Tajadura-Jiménez et al. (2012a) tried to answer this question by manipulating the directionality of the self-other discrimination task, by asking observers to perform this task in both the self-to-other and the other-to-self directions. In the first case, observers had to stop the video when the face looked more like the model. In the case of the other-to-self direction, observers had to stop the video when the face looked more like the self. Their results revealed an enfacement effect only in the other-to-self direction, whereby observers stopped the morphing sequence earlier in the synchronous than the asynchronous condition. That is, after synchronous stimulation, observers accept more features of the model as self, but not more features of self as the model. This seems to indicate that observers tend to incorporate the model's face into their own self-face representation during SMS, but not vice versa.

Further evidence for the directionality of this effect comes from research on gaze-following. Eye-gaze produces reflexive changes of visual attention, whereby observers shift their attention in the direction of a seen gaze (Crostella, Carducci, & Aglioti, 2009; Ricciardelli, Bricolo, Aglioti, & Chelazzi, 2002). These changes are more prominent when observers watch their own eye-gaze, as error rates for detecting targets in an incongruent position with the gaze direction of an onscreen face is higher when this face is one's own (Hungr & Hunt, 2012). This indicates that the gaze of one's own face has a stronger distracting power than that of other faces and highlighted the relevance of the own face in social cognition. Intriguingly, SMS reduces this distracting power of the self-gaze, but it does not affect the distracting power of an enfaced face's gaze (Porciello et al., 2014). This constitutes further evidence that the enfacement illusion induces changes in the representation of one's own face rather than the faces of others.

In summary, although it has been assumed previously that the representation of the own face is stable, recent research has challenged this view by showing that faces are readily susceptible to rubber hand-like effects. This enfacement effect appears to modify representations of the own face, but not representations of the model's face that is presented for such stimulation purposes.

1.9 Embodiment and social cognition

The research reviewed in the preceding sections shows that the borders of the own body define the experience of one's self, by demonstrating that observers can embody others' physical features, such as hands or faces. One question that arises from these findings is whether the factors that affect the perceptual cognitive representations of the own body also affect this cognitive representation at a more conceptual or private level (see Morin, 2006). Some accounts of self-consciousness and identity suggest that feedback from the own body affects the self-concept (see Baumeister, 1999; Morin, 2006; de Vignemont, 2007). Interestingly, this body experience also seems to affect the understanding that people have of others (for review, see Maister, Slater, Sanchez-Vives, & Tsakiris, 2015). For example, studies into the *mirror neuron system* have shown that people activate similar brain structures when performing an action and seeing others performing this action (Keysers & Gazzola, 2009; Maister et al., 2015). An example of how the mirror neuron system works comes from the body resonance literature and the *visual remapping of touch* effect (e.g., Làdavas & Serino, 2010; Serino, Pizzoferrato, & Làdavas, 2008, 2009). This effect refers to the increased sensitivity to tactile stimulation when seeing someone else being touched. This effect seems to be modulated by similarity in physical features, such as the face, and more conceptual terms, such as political preference and ethnic group (see Serino et al., 2009).

Based on these studies, embodied accounts of social cognition suggest that the perception of the cognitive states of others activates similar states in the self (e.g., Baumeister & Bushman, 2014; Kubota, Banaji, & Phelps, 2012; Niedenthal, 2007; Serino et al., 2009). Thus, according to these theories we do not only incorporate physical features of an embodied person but also social and conceptual features. This implies that the limits of humans' physical and conceptual features are vague.

Research into the rubber hand and enfacement illusion seems to support these embodied accounts of social cognition. For example, after SMS of the face observers not only report to be physically more similar to the model, but also feel personally closer and more attracted toward the model (see Paladino, Mazzurega, Pavani, & Schubert, 2010). In addition, when observers are asked to estimate the number of a set of onscreen elements and are informed about the estimate made by the enfaced face, the differences between the observer and the enfaced face's estimates are smaller after synchronous stimulation (see Paladino et al., 2010).

As SMS seems to blur the perceptual distance between the self and other, according to embodied simulation theories of emotion recognition (e.g., Niedenthal, 2007), it should also be possible to enhance emotion recognition after such stimulation. A recent study showed this effect (see Maister, Tsiakkas, & Tsakiris, 2013b). In a pre-stimulation stage, participants were asked to perform an emotion recognition task. In a second stage, participants watched a two-minute video and received either synchronous or asynchronous stimulation or no stimulation (no-touch condition). Then, they completed a post-stimulation emotion recognition task. Importantly, each participant received a total of three blocks (synchronous, asynchronous and no-touch) randomized between participants and the model used was kept constant during the whole experiment. The results showed that observers recognise fearful facial expressions better after synchronous stimulation than asynchronous stimulation.

In this context, one factor that is physically and sociologically salient is racial group (see Maister et al., 2015). On the whole, people tend to show negative biases toward members of a different racial group (e.g., Hall, Crisp, & Suen, 2009; Inzlicht, Gutsell, & Legault, 2012; Maister et al., 2013a). Interestingly, it has been suggested that SMS might modulate such racial prejudice. For example, after enfacing a black face, observers showed an increase of the *visual remapping of touch* effect for that particular black face. This effect seems to be amplified in observers who have a stronger implicit bias against outgroup members (Fini, Cardini, Tajadura-Jiménez, Serino, & Tsakiris, 2013). However, this study did not include a post-stimulation measure of racial prejudice. Consequently, it is impossible to determine whether increased visual remapping of touch was simply due to an increased preference toward the enfaced black face or whether this reflects a more general decrease of racial prejudice (see Paladino et al., 2010). Whereas this research suggests that implicit bias affects the body experience, the question arises also whether this relationship is bidirectional, so that the body experience can affect racial prejudice. A recent study showed that observers who reported a stronger sense of ownership over a black rubber hand also show less implicit racial prejudice, as measured with the Implicit Association Task (IAT: Greenwald, McGhee, & Schwartz, 1998). However, this effect was independent of whether synchronous or asynchronous stimulation was delivered (Maister et al., 2013a), which indicates that it is the feeling of ownership, and not the type of stimulation delivered, that produced the reduction in racial prejudice. It is unresolved whether different effects can be obtained with faces. This is therefore an important question for further research.

1.10 Thesis structure

The aim of this thesis is to further explore the effects of synchronous multisensory stimulation of the face on physical and psychological aspects of the self. Chapter 2 investigates whether synchronous multisensory stimulation of white Caucasian observers with a black face can reduce racial prejudice. Across three experiments, white observers' faces are stroked with a cotton bud while they watch a black face being stroked in synchrony on a computer screen. This is compared with a neutral condition, in which no tactile stimulation is administered during exposure to a black face (Experiment 1 and 2), and with a condition in which observers' faces are stroked in temporal asynchrony with the black onscreen face (Experiment 3). After the stimulation stage, racial prejudice is measured both implicitly, with a name-race IAT (e.g., Hall et al., 2009), and explicitly, with Lepore and Brown's racial prejudice scale (Lepore & Brown, 1997). In Experiment 2, the name-face IAT is then replaced with face-race version to provide a more sensitive test of racial prejudice (Dasgupta, McGhee, Greenwald, & Banaji, 2000). In the last experiment in this chapter (Experiment 3), several changes are then introduced, by replacing the neutral stimulation condition with asynchronous stimulation and by using a single category IAT as a more specific measure of attitudes toward black people (Karpinski & Steinman, 2006).

Chapter 3 then explores whether it is possible to induce an enfacement-like illusion with a novel gaze-contingent eye-tracking paradigm, which is more similar to the experience of looking at one's own face in a mirror. This paradigm has been inspired by the enfacement literature but tries to provide a more direct method for stimulation. In this gaze-contingent paradigm, the eye-gaze direction of an unfamiliar face on a computer screen follows observers' eye-gaze, which is tracked with millisecond accuracy. Thus, when observers' eyes move, the eyes of the onscreen face move in synchrony. This congruent condition is compared with an incongruent condition, in which the eyes of the onscreen face move in different directions to that of the observer (Experiment 4 and 6), and with a neutral condition, in which the eyes of the onscreen face are static and unresponsive (Experiment 5).

There are two main advantages of this new method compared to the traditional enfacement paradigm. Firstly, in the latter observers always receive stimulation passively, by being stroked on the cheek with a cotton bud by an experimenter (but see Tajadura-Jiménez, Lorusso, & Tsakiris, 2013). In the new method introduced in Chapter 3, observers control such stimulation actively with their own eye movements. Secondly, while stroking that observers receive in the traditional enfacement paradigm must be synchronized with that of the model, the new method of Chapter 3 acts like a mirror reflection. Thus, it is always the model's face that responds to the observers' behaviour. To measure the effect of this manipulation on self-recognition, the same measures that have been used to study the enfacement illusion were applied: a self-other discrimination task and an enfacement questionnaire (e.g., Maister et al., 2013; Tajadura-Jiménez et al., 2012).

The final experimental chapter then examines the cognitive locus of the enfacement effect using Event-Related Potentials (ERPs). The fact that the own face modulates ERP components involved in the early perceptual stages of face processing (i.e., the N170 component, see Eimer, 2011), the activation of facial identity (i.e., the N250 component, see Schweinberger, 2011), and the emotional response to stimuli (i.e., the P300, see Renault, Signoret, Debruille, Breton, & Bolgert, 1989) suggest that these components can be used also to explore the cognitive locus of the enfacement effect. In Experiment 7, observers therefore were exposed to blocks of synchronous and asynchronous stimulation. After each block, ERPs were recorded while observers performed a face target detection task. In this task, observers were presented with pictures of their own face, a synchronously or asynchronously stimulated face, filler faces, and a learned target face. Observers were instructed to respond when the target was presented. If enfacement affects the early perceptual encoding of faces, then the N170 elicited by the own face should be similar to that elicited by a synchronously stimulated face, but not an asynchronously stimulated face. If, on the other hand, enfacement causes the updating of identity representations, then the N250 should be more similar for the own face and the synchronously stimulated face. Finally, if enfacement triggers an emotional arousal response, then the P300 component should be similar for the own face and the synchronously-stimulated, but not the asynchronously-stimulated, face.

Chapter 2:

Multisensory stimulation with other-race faces and the reduction of racial prejudice

Introduction

The cognitive representation of our own body is flexible and constantly updated. A striking illustration of this effect comes from the rubber hand illusion. Watching a rubber-hand being stroked in synchrony with one's own hand produces the feeling that the rubber hand is, in fact, one's own (Botvinick & Cohen, 1998; Tsakiris & Haggard, 2005). This illusion does not appear when observers simply watch a rubber hand (that is not stroked) or when asynchronous stimulation is given, by inducing a delay between the stroking of the rubber hand and observer's own. Moreover, a similar effect has also been observed with other body parts, such as arms (Guterstam et al., 2011), and even the whole body (Lenggenhager et al., 2007; Petkova et al., 2011).

Interestingly, faces are also susceptible to rubber hand-like effects (see, e.g., Maister et al., 2013b; Sforza et al., 2010; Tajadura-Jiménez et al., 2012a; Tsakiris, 2008). For example, when observers' own face is stroked in synchrony with a target face, they tend to perceive the target face as more similar to their own face (see, e.g., Paladino et al., 2010; Sforza et al., 2010; Tajadura-Jiménez et al., 2012a; Tsakiris, 2008). This perceptual effect is accompanied by a phenomenological illusion that the other face *belongs* to the observer. This bias in self-recognition or "enfacement effect" (Sforza et al., 2010) is not found after asynchronous stimulation. This indicates that synchronous, but not asynchronous, multisensory stimulation supports the updating of the cognitive representations of the own face.

These embodiment effects are not only informative about the characteristics of cognitive representations of the body, but also provide insight into social cognition. Embodied accounts suggest that the body experience determines sociocognitive processing (e.g., Gallese, Keysers, & Rizzolatti, 2004), and research of the rubber hand and enfacement illusions support this claim (e.g., Bufalari, Lenggenhager, Porciello, Serra-Holmes, & Aglioti, 2014; Fini et al., 2013; Maister et al., 2013a; Maister et al., 2013b; Paladino et al., 2010). For example, after synchronous multisensory stimulation (SMS) with an unfamiliar face, observers report more positive affective reactions and show more conformity behaviour (i.e., yielding to others' views or opinions) toward the unfamiliar face, than after asynchronous stimulation (Paladino et al., 2010). This effect is also seen in the domain of emotion recognition, as SMS of the face enhances observers' sensitivity to others' fearful facial expressions (Maister et al., 2013b). These findings suggests that synchronous multisensory stimulation blurs self-other boundaries not only with regard to physical appearance but also in a more social sense, by reducing the differences between the self and the face presented during the stimulation stage (i.e., enfaced face). As consequence, the enfaced face is held to be included into the mental representation of the self (i.e., self-space, Paladino et al., 2010; Schubert, & Otten, 2002), by producing an overlapping of the representations of the self and the enfaced face (see Tsakiris, 2010; Paladino et al., 2010).

Such *differences reduction* also seems to be an important concept for understanding other social behaviours, such as intergroup relations (Billing & Tajfel, 1973; Roccas & Schwartz, 1993; Hall et al., 2009). For example, when white Caucasian observers are asked to list attributes that white and black people share, the differences between these groups are blurred, which produces a positive effect in the reduction of prejudice (Hall et al., 2009). Other tasks, such as behavioural mimicry and intergroup contact, are also based on the reduction of self-other differences and have been employed to decrease prejudice toward outgroup members (see Crips & Turner, 2009; Davis, Conklin, Smith, & Luce, 1996; Gaertner & Dovidio, 2000; Inzlicht et al., 2012; Pettigrew & Tropp, 2006; Turner, Crisp, & Lambert, 2007). For example, when white observers mimic some simple actions of a black actor, such as reaching and grasping a glass, they subsequently show reduced implicit racial prejudice on the Affect Misattribution Paradigm (Inzlicht et al., 2012; Payne, Cheng, Govorun, & Stewart, 2005). Similarly, contact between members of different groups seems to reduce prejudice toward the outgroup (see Pettigrew & Tropp, 2006), even when this intergroup contact is imagined (Crips & Turner, 2009; Turner et al., 2007; Turner & Crisp, 2010). For example, observers who imagine contact with an elderly person subsequently demonstrate less implicit bias toward the elderly compared to control observers (Turner & Crisp, 2010; Experiment 1), and similar results are found when non-Muslim observers imagine contact with Muslims (Turner & Crisp, 2010; Experiment 2).

This research shows that SMS, intergroup contact and behavioural mimicry share two important features. Firstly, all of these tasks require that observers have some contact with other people. In SMS, this contact is produced through mirror-like reflection, as observers receive specular stimulation with the onscreen face (see, e.g., Sforza et al., 2010; Tsakiris, 2008). In behavioural mimicry, the contact with the other is produced through the imitation of others' actions (Inzlicht et al., 2012). And in the case of intergroup contact, the contact is produced face-to-face or simply can be imagined (see, e.g., Pettigrew & Tropp, 2006; Turner & Crisp, 2010). Secondly, in all of these tasks the differences between the self and the other is reduced by increasing the overlap of their mental representations (see, e.g., Hall et al., 2009; Paladino et al., 2010; Farmeret al., 2012; Inzlicht et al., 2012; Turner & Crisp, 2010).

If SMS, imagined intergroup contact and behavioural mimicry share these features, and imagined intergroup contact and behavioural mimicry reduce prejudice toward outgroup members, then it is possible that SMS produces a similar effect in prejudice reduction. Some recent research already supports this idea. For example, after enfacing a black face, observers showed an increase of the *visual remapping of touch* effect, which is an increased tactile sensitivity in observers when viewing another person being touched (see Cardini, Tajadura-Jiménez, Serino, & Tsakiris, 2012; Marcoux et al., 2013), for that particular black face. This effect seems to be amplified in observers who have a stronger implicit bias against outgroup members (Fini et al., 2013). However, this study did not include a post-stimulation measure of racial prejudice. Consequently, it is not possible to determine whether the increased visual remapping of touch was simply due to an increased preference for the enfaced black face (see, e.g., Paladino et al., 2010) or whether this reflects a more general decrease of racial prejudice. Another study showed that observers' who reported a stronger sense of ownership over a black rubber hand also show less implicit racial prejudice, as measured with the Implicit Association Task (IAT: Greenwald et al., 1998). However, this effect was independent of whether synchronous or asynchronous stimulation was delivered (Maister et al., 2013a), which indicates that it was the feeling of ownership, and not the type of stimulation delivered, what produced the reduction in racial prejudice.

In light of these findings, the present study sought to directly investigate the effect of SMS of the face on the reduction of racial prejudice. For this purpose, in Experiment 1 and 2, white observers received facial tactile stimulation that was synchronous with the stroking of a black onscreen face, or received no stimulation while the black face was being watched (i.e., neutral stimulation). In Experiment 3, Caucasian observers then received either synchronous or asynchronous stimulation with a black face. To measure the effect of this manipulation on racial prejudice, the IAT (Greenwald et al., 1998), which provides an implicit measure of intergroup attitudes toward different ethnic groups, nationalities, religions and sexes (see

Schnabel, Asendorpf, & Greenwald, 2008) was employed. In the current study, the IAT compares the fluency, in terms of reaction times, with which observers match stimuli that correspond either to ingroup or outgroup categories (e.g., white and black faces) with words that carry a positive or negative meaning (e.g., peace and anger). In this paradigm, an increase in reaction times to match outgroup related stimuli with positive words and a decrease to match outgroup related stimuli with negative words is considered to reflect implicit prejudice toward the outgroup. Racial prejudice was also measured explicitly with Lepore and Brown's (1997) subtle racial prejudice questionnaire. This questionnaire measures prejudice toward black people on Likert scales and is suitable for British participants (see Lepore & Brown, 1996). It is predicted that observers would show less prejudice toward the model's ethnic group after synchronous multisensory stimulation than in the neutral and asynchronous conditions.

Experiment 1

This experiment investigated whether SMS of the face produces a modulation in prejudice toward outgroup members, as is the case in imagined intergroup contact and mimicry paradigms (see, e.g., Turner & Crisp, 2010; Inzlicht et al., 2012). White observers were exposed to both a synchronous and a neutral stimulation condition with the face of a black model. After the stimulation stage, racial prejudice was measured implicitly, using the name-race IAT (Hall et al., 2009), and explicitly, with the subtle racial prejudice questionnaire (Lepore & Brown, 1997). If multisensory stimulation can reduce racial prejudice, then observers should show less prejudice toward the model's ethnic group after stimulation in the synchronous condition than in the neutral condition.

Method

Participants

Thirty Caucasian females, with a mean age of 19 years (SD = 2.1), participated in this study. All were students at the University of Kent, who gave their informed consent to take part, and received either course credits or a small payment for participation. All reported normal or corrected-to-normal vision.

Stimuli

Preparation of multisensory stimuli

To create the stimuli for the multisensory stimulation, three black female models were video-recorded in full colour. Two different videos were recorded for each model. In both videos, the models look straight at the camera with a neutral expression. In the first video, which was recorded for the synchronous condition, the models' right cheek was stroked with a cotton bud every two seconds for two minutes. In the second video, the models did not receive any tactile stimulation. This video was used in the neutral condition

The videos were presented in full-screen mode on a 21'' screen monitor placed approximately 75 cm from observers. The faces in full-screen mode measured approximately 9 (W) by 19 (H) degrees of visual angle. A still image from the video is illustrated in Figure 6.

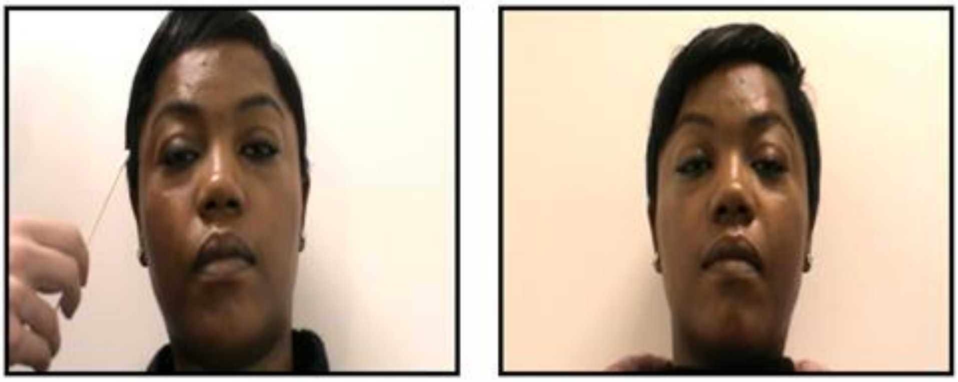

Figure 6. Example video stills from the synchronous/asynchronous condition (left panel) and the neutral condition (right panel).

The name-race IAT

To measure racial attitudes, the Implicit Association Test (IAT; Greenwald et al., 1998) was displayed with Inquisit software Inquisit (Millisecond Software). Concepts and associations underpin semantic memory (see Collins & Quillian, 1969). Accordingly, related concepts (e.g., eagle-feathers) are not only more strongly associated in memory but also more efficiently processed than non-related concepts (e.g., eagle-bark). Based on these premises, the IAT measures the strength of associations between concepts (see Greenwald et al., 1998; Greenwald, Nosek, Banaji, & Klauer, 2005). More specifically, it compares the fluency with which people match exemplars of a category (e.g., white and black; straight and gay, republican and democrat, etc.), with positive and negative meaning concepts. If an exemplar is positively associated, it would be matched more efficiently with positive meaning concepts than with negative meaning concepts. On the contrary, if an exemplar is negatively associated, it would be matched more efficiently with negative meaning concepts than with positive meaning concepts. In the specific case of the name-race IAT, it compares the fluency with which observers match stimuli that correspond either to ingroup or outgroup categories (e.g., white and black names) with words that carry a positive or negative meaning (e.g., peace and anger).

The stimuli in this IAT have been used in previous research (Hall et al., 2009) and comprise names for black and white people and words with a positive or negative meaning. The names were suitable for a British context and consisted of *John, Paul, Brian, Pete, Robert, Katie, Sara, Susie, Melanie, Emily* for white people, and of *Latonya, Tanisha, Malika, Teretha, Lakisha, Leroy, Rasaan, Tyree, Deion, Lamont* for black people. The positive words were *Rainbow, Gift, Joy, Paradise, Laughter, Cuddle, Glory, Gold, Kindness, Peace*, while the negative words were *Sadness, Anger, Vomit, War, Hell, Slum, Slime, Filth, Stink, Cockroach.*

In this name-race IAT, the observers' task is to classify words as positive or negative and names as black or white. These stimuli were presented in the centre of the screen in black Arial font at size 36. The task is comprised of five blocks (See Figure 7). In Block 1, observers were presented with words, which had to be classified as positive or negative as quickly as possible by pressing the 'z' or 'm' key on a standard computer keyboard. In Block 2, observers were asked to classify names as ingroup (i.e., white names) or outgroup exemplars (i.e., black names). In Block 3, observers then performed the combined categorization of words and names. In this block, observers were presented with positive and negative words and ingroup and outgroup names. Observers were required to press the 'z' key if the stimulus was a white name or a positive word and the 'm' key if the stimulus was black or a negative word. Block 4 was identical to Block 1 but with reversed keys. In Block 5, observers then also performed the combined categorization, but in this case the name-word relation was reversed compared to Blocks. Thus, if Blocks 3 combined white with positive and black with negative, then Block 5 combined white with negative and black with positive. In line with previous work (Hall et al., 2009), Blocks 1, 2 and 4 were included for practice purposes. Blocks 3 and 5 were the critical blocks that were used to calculate a measure of prejudice. As all of our observers were Caucasian, the pairings white/positive words and black/negative words were congruent in this framework. On the other hand, white/negative words and black/positive words were incongruent. Blocks 1, 2 and 4 had 24 trials each and Blocks 3 and 5 had 48 each.

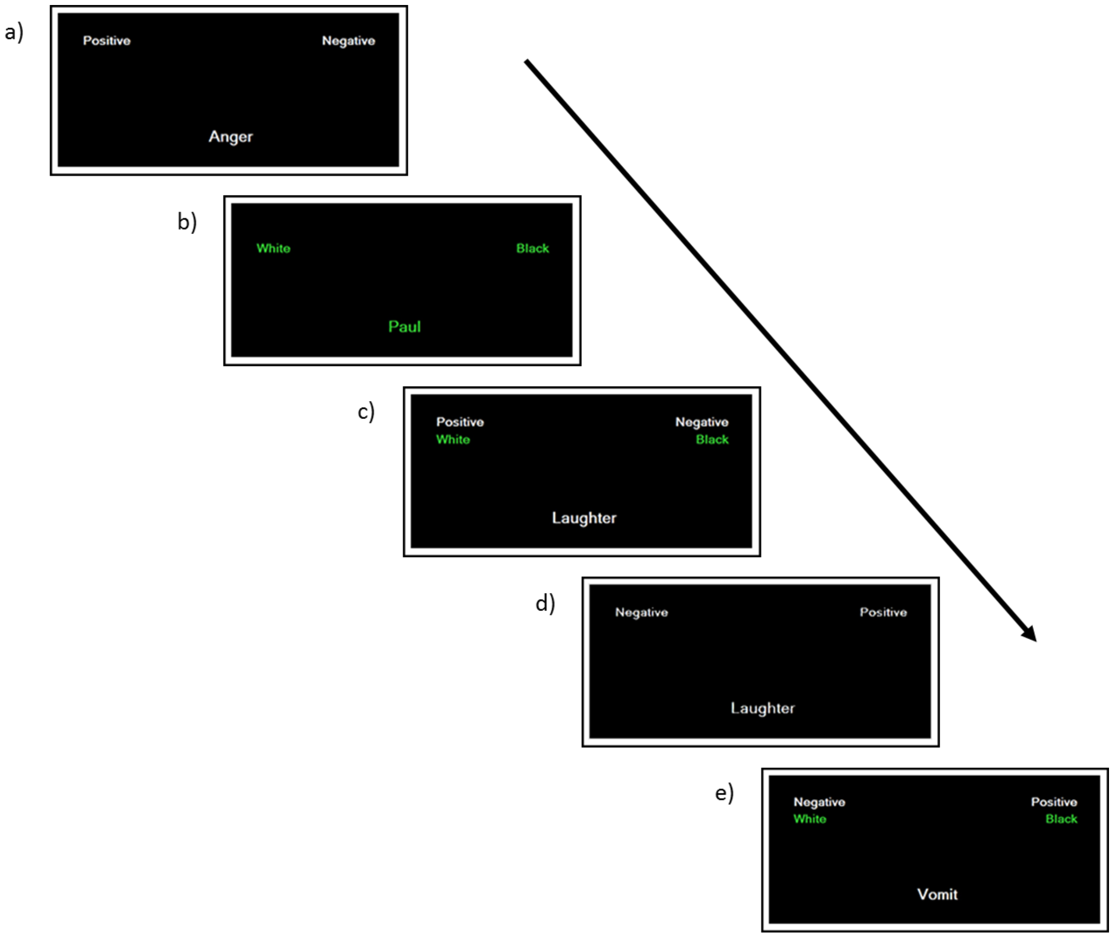

Figure 7. Representation of the name-race IAT procedure. In the first block (a), observers had to classify words as positive or negative. In the second block (b), observers had to classify names as white or black exemplars. In Block 3 (c), observers performed the combined categorization of words and names. In the fourth block (d), as in Block 1, observers classified words as positive or negative, but in this block, they keys were reversed. In Block 5 (e), observers performed the combined categorization of words and names, but the name word relation was reversed compared to Blocks 3.

IAT scores, also known as D scores, were calculated using the improved scoring algorithm (Greenwald, Nosek, & Banaji, 2003). The algorithm to calculate D scores is as follows (for further details see Greenwald et al., 2003). Firstly, mean reaction times for correct responses in Blocks 3 and 5 is calculated. Secondly, the standard deviation of all items (regardless if they were incorrect) is calculated in Blocks 3 and 5, but ignoring the block the trials came from. Thirdly, RTs in incorrect trials in Block 3 are replaced for the mean of correct items in this block (calculated in the first step) plus 600 ms. The same is applied to Block 5. In the fourth step, the mean RTs for Blocks 3 and 5 is again calculated, but this time, incorrect trials in each block are replaced by the corrected average calculated in the previous step. Finally, the D score is computed as the average corrected RTs for the congruent block (Block 3 in Figure 7) minus the average corrected RTs for the incongruent block (Block 5 in Figure 7), divided for the standard deviation calculated in the second step. The resulting scores range between -2 and +2.

Prejudice scale

Lepore and Brown's (1997) racial prejudice scale was used to measure subtle explicit racial prejudice. This scale comprises 15 statements to assess prejudice toward black people (see Appendix). Participants rate their agreement with each statement on a 7-point Likert scale, ranging from "*strongly disagree*" to "*strongly agree*". Scores on this scale range from 15 to 105, with a midpoint of 60 and high scores indicating lower prejudice. Previous research (see Lepore & Brown, 1997) has shown that this questionnaire is suitable for the British context and has good construct validity and a high internal reliability (Cronbach's $\alpha = .85$).

Enfacement questionnaire

A questionnaire was administered to assess observers' enfacement experience. A set of 8 items was taken from Tajadura-Jiménez et al. (2012a; see also Maister et al., 2013b). These items consist of statements that assess the subjective enfacement experience (see Table 1). Observers record their agreement with each statement on a 7-point Likert scale, ranging from *"strongly disagree"* to "*strongly agree"*. These items are analysed separately but an overall enfacement score can also be calculated by summing the scores of all items. A high overall score indicates that observers felt that the onscreen face had become integrated with the internal representation of their own face during the stimulation stage (see Tajadura-Jiménez, Longo, Coleman, & Tsakiris, 2012b).

Enfacement Item
1. I felt like the other's face was my face.
2. It seemed like the other's face belonged to me.
3. It seemed like I was looking at my own mirror reflection.
4. It seemed like my own face began to resemble the other person's face.
5. It seemed like my own face was out of my control.
6. It seemed like the other's face began to resemble my own face.
7. It seemed like the experience of my face was less vivid than normal.
8. I felt that I was imitating the other person.
9. The touch I felt was caused by the cotton bud touching the other's face.
10. The touch I saw on the other's face was caused by the cotton bud touching my own face

Table 1. The Enfacement Questionnaire

Procedure

In this experiment, observers first watched a two-minute video of a black model being stroked on the cheek with a cotton bud (in the synchronous condition) or without any tactile stimulation (in the neutral condition). While watching the videos of the synchronous condition, an identical cotton bud to that seen in the video was used to provide specular tactile stimulation to the observers' left cheek. During the neutral video, no tactile stimulation was administered. After each of the videos, observers performed the IAT, the prejudice scale and the enfacement questionnaire. Each participant performed this sequence twice, once for the synchronous condition and once for the neutral condition. The model was kept constant for each observer. The order of these conditions and the identity of the model for each observer, was counterbalanced over the course of the experiment.

Results

Enfacement questionnaire

To determine whether SMS affects how observers *feel* about the black onscreen face, responses to the enfacement questionnaire were analysed. These data are provided in Figure 8 as mean Likert responses to each of the items for the synchronous and the neutral condition. As can be seen in Figure 8, compared with the neutral condition, SMS influenced observers' feelings about the black face. This effects was such that observers were more likely to report that the black face was their own face in the synchronous condition than in the neutral condition (items 1, 2 and 3), paired sample t-tests, all $ts(29) \geq 3.28$, $ps < .01$. Observers also reported feeling a greater resemblance between their own and the black face in the synchronous than in the neutral condition (items 4 and 6), both $ts(29) \geq 2.42$, $ps < .05$. In addition, observers were more likely to report that their own face was out of control and that the experience of their face was less vivid than normal in the synchronous than in the neutral condition (items 5 and 7), both $ts(29) \geq 2.33$, $ps < .05$. However, observers were not more likely to report that they were imitating the other person (item 8) in the synchronous compared with the neutral condition, $t(29) = 1.94$, $p = .06$.

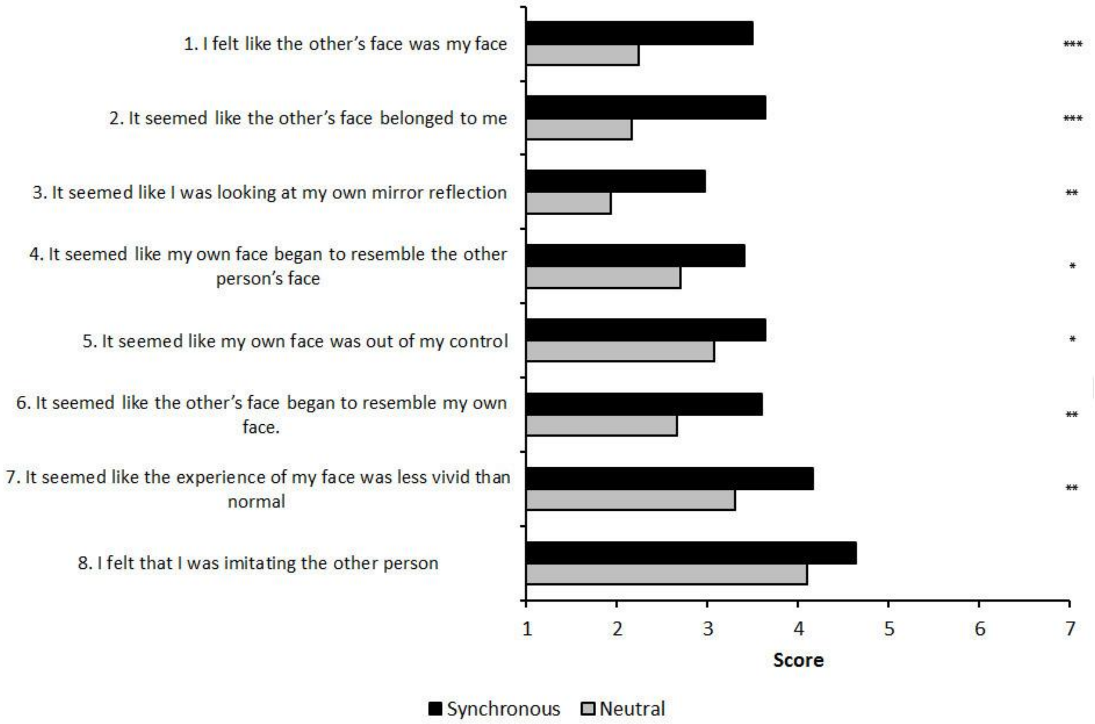

Figure 8. Mean Likert responses to each enfacement item for the synchronous (black bars) and the neutral (grey bars) condition in Experiment 1. Note: * $p < .05$; ** $p < .01$; *** $p < .001$.

In addition, the overall enfacement score was calculated for each observer by summing the scores for items 1 to 8. A 2 x 2 mixed-factor ANOVA, with the within-subjects factor stimulation (synchronous vs. neutral) and the between-subjects factor block order (synchronous first vs. neutral first) did not show a main effect of block order, $F(1, 28) = 0.16$, $p = .68$, $\eta^2_p = .00$, or interaction between block order and stimulation, $F(1, 28) = 1.13$, $p = .29$, $\eta^2_p = .03$. However, a main effect of stimulation was found, $F(1, 28) = 18.23$, $p < .001$, $\eta^2_p = .39$, which reflects a higher total enfacement score in the synchronous (M = 29.5, SD = 10.9) than in the neutral condition (M = 22.1, SD = 9.8).

Racial prejudice measures

In a further step of our analysis, the scores for the IAT and the racial prejudice scale were analysed. For the IAT, D scores using the improved scoring algorithm (see above and Greenwald et al., 2003 for further details). This score ranges between -2 and +2. In this study, the pairings of white/positive words and black/negative words were congruent. Thus, positive scores indicated a preference toward ingroup members (white people in our case), which is interpreted as a sign of racial prejudice (e.g., Hall et al., 2009). IAT scores were similar across stimulation conditions (synchronous: M = 0.43, SD = 0.35; neutral: M = 0.35, SD = 0.39) and block order (synchronous first: M = 0.32, SD = 0.39; neutral first: M = 0.45, SD = 0.42). A 2 (stimulation: synchronous vs. neutral) x 2 (block order: synchronous first vs. neutral first) mixed-factor ANOVA did not show a main effect of stimulation or block order, or an interaction, all $Fs(1, 28) \leq 1.90$, $ps \geq .17$, $\eta s^2_p \leq .06$.

For Lepore and Brown’s racial prejudice scale, responses to items 1, 6, 10, 11 and 14 were reversed, in line with the standard evaluation of this questionnaire. An overall score was then calculated for each observer by adding items 1 to 15 for each condition. These scores were similar across stimulation conditions (synchronous: M = 71, SD = 10, max = 90, min = 52; neutral: M = 70, SD = 10, max = 89, min = 52) and block order (synchronous first: M = 70, SD = 14; neutral first: M = 71, SD = 15). The main effects of stimulation and order, and the interaction between these factors, were not significant, all $Fs(1, 28) \leq 2.37$, $ps \geq .14$, $\eta s^2_p \leq .01$.

Overall, the scores from the IAT and the racial prejudice scale therefore suggest that SMS did not affect observers' racial prejudice levels. However, recent research has also shown that the degree of the sense of ownership that observers experience over a black rubber hand relates to their racial prejudice (Maister et al., 2013a). Thus, it is still possible that the feeling of ownership over the black face affected racial prejudice, regardless of the type of stimulation delivered. To explore whether a similar relationship exists in the current study, Pearson correlations were conducted between the total enfacement score and the IAT and the explicit prejudice scale. As each subject performed a synchronous block and a neutral block, each of them gave two scores for each of the tasks (i.e., IAT, prejudice scale and enfacement questionnaire). Pearson correlations showed no correlation between the total enfacement score and the IAT, $r(58) = -.05$, $p = .68$, or between the total enfacement score and the prejudice scale, $r(58) = -.01$, $p = .93$.

Discussion

Experiment 1 explored whether SMS of the face modulates racial prejudice. This was investigated by comparing a stimulation condition, in which observers' faces were stroked in synchrony with a black face, with a neutral stimulation condition, whereby neither the observers nor the black onscreen face were stroked. The enfacement illusion was measured using an established enfacement questionnaire (Maister et al., 2013b; Tajadura-Jiménez, et al., 2012a), while racial prejudice was measured implicitly with the IAT (Greenwald et al., 1998) and with the explicit racial prejudice scale (Lepore & Brown, 1997). Observers' scores in the enfacement questionnaire indicate a persistent subjective enfacement effect after SMS that was evident in seven out of eight items. This result supports previous research, by showing that it is possible to enface black faces (Bufalari et al., 2014; Fini et al., 2013). However, an effect of SMS on racial prejudice was not found, both when this was measured with the IAT and the racial prejudice scale. Thus, SMS did not appear to reduce implicit or explicit racial prejudice. These findings converge with previous research that has found no effect of SMS on racial prejudice (Farmer et al., 2012), but also contrasts with reports of a positive correlation between the total embodiment experience and prejudice reduction (Maister et al., 2013a).

Two possible reasons may explain the absence of racial prejudice modulations in our experiment. Firstly, it remains possible that observers represent the onscreen model's features better after synchronous stimulation than in the neutral condition. However, this enhanced representation might not be strong enough to modulate racial prejudice. Secondly, it is also possible that SMS is able to modulate racial prejudice but neither our implicit (the IAT) or explicit (Lepore and Brown's subtle racial prejudice scale) measures are sufficiently sensitive to detect such a modulation. In line with this reasoning, recent research has questioned the validity of the name-race IAT to measure racial prejudice, as the preference toward white names could reflect an effect of familiarity toward those names rather than racial prejudice toward black people (see van Ravenzwaaij, van der Maas, & Wagenmakers, 2011). To rule out these possibilities, a second experiment, which used a different version of the IAT, was conducted.

Experiment 2

This experiment is identical to Experiment 1, except that the name-race IAT was replaced with a face-race version (Dasgupta, McGhee, Greenwald, & Banaji, 2000). In this test, the black- and white-associated names are replaced with black and white faces. This IAT cannot be undermined by (lack of) familiarity with the race stimuli, as it replaces names by faces (van Ravenzwaaij et al., 2011), and should therefore provide a more sensitive measure. This face-race IAT explores whether observers would show less prejudice toward black people after synchronous multisensory stimulation than in the neutral condition.

Method

Participants

Thirty new Caucasian students from the University of Kent, with a mean age of 19 years (SD = 3.1), participated in this study for course credits or a small payment. All observers were female and gave their informed consent for participation. They all reported normal or corrected-to-normal vision.

Stimuli and procedure

The stimuli and procedure were identical to Experiment 1, excepting for the IAT. In this experiment, the face-race IAT was applied (see Dasgupta et al., 2000). This particular IAT is comprised of eight white faces and eight black faces and words with positive or negative meaning (the same words as in Experiment 1). All face images were presented in greyscale format and measured maximally 104 by 138 pixels (see Figure 9). As in Experiment 1, observers classified the faces according to their ingroup or outgroup status (i.e., white versus black faces) and the words according to their meaning (i.e., positive versus negative).

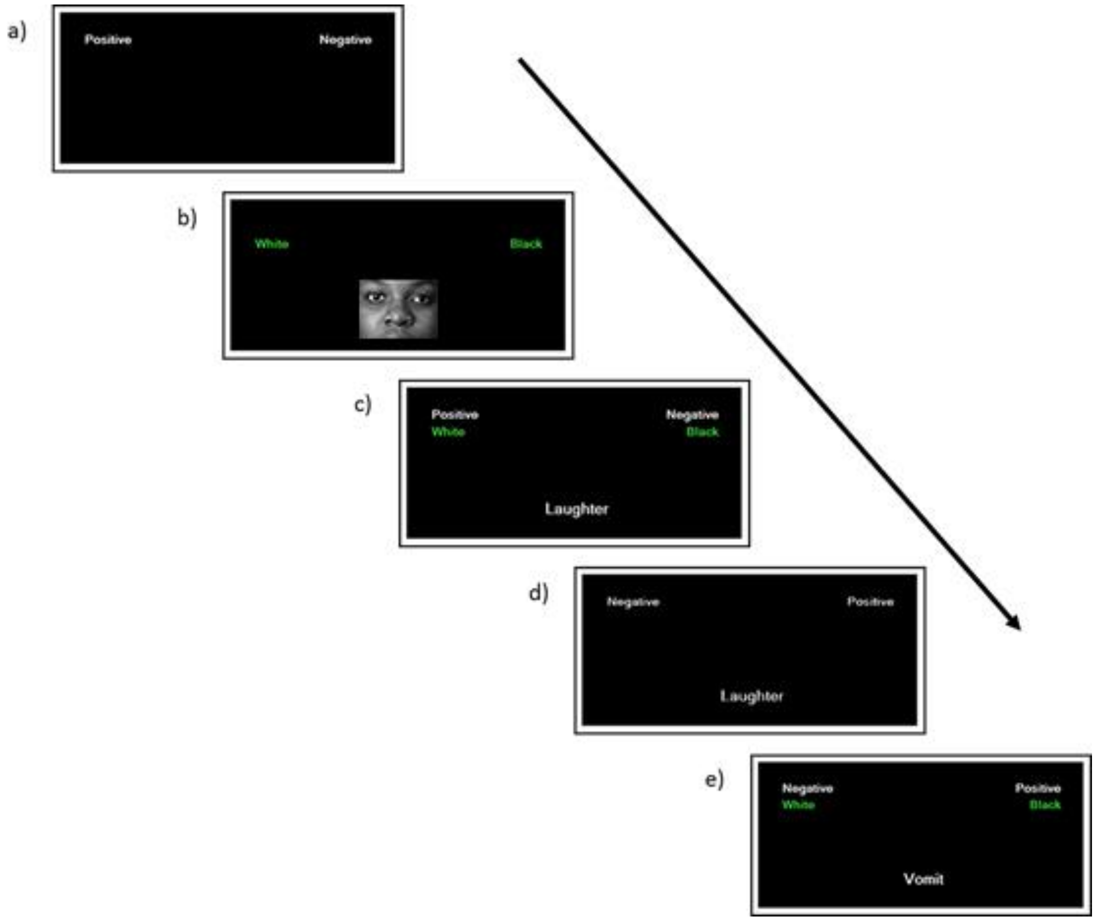

Figure 9. Representation of the face-race IAT procedure. In the first block (a), observers had to classify words as positive or negative. In the second block (b), observers had to classify faces as white or black exemplars. In Block 3 (c), observers performed the combined categorization of words and faces. In the fourth block (d), as in Block 1, observers classified words as positive or negative, but in this block, they keys were reversed. In Block 5 (e), observers performed the combined categorization of words and faces, but the face word relation was reversed compared to Block 3.

Results

Enfacement questionnaire

The data for the enfacement questionnaire are provided in Figure 10, as mean Likert responses to each of the items for the synchronous and the neutral conditions.

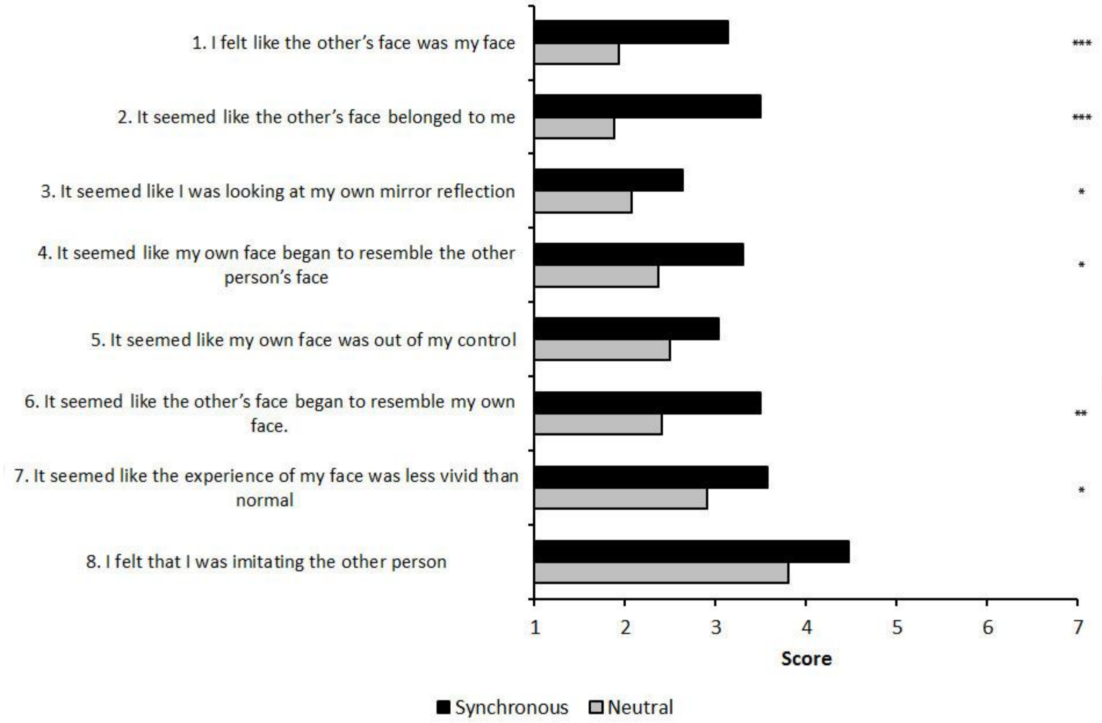

Figure 10. Mean Likert responses to each enfacement item for the synchronous (black bars) and the neutral (grey bars) condition in Experiment 2. Note: * $p < .05$; ** $p < .01$; *** $p < .001$.

As it can be seen in Figure 10, compared with the neutral condition, SMS affected how observers reported to feel about the black face. This effect was such that observers were more likely to report that the black face was their own face in the synchronous condition than in the neutral condition (items 1, 2 and 3), all $ts(29) \geq 2.06$, $ps < .05$. Observers also reported feeling a greater resemblance with the black face in the synchronous than in the neutral condition (items 4 and 6), both $ts(29) \geq 2.72$, $ps < .05$. In addition, observers were more likely to report that the experience of their own face was less vivid in the synchronous than in the neutral condition (item 7), $t(29) = 2.05$, $ps < .05$. However, an effect of SMS was not always evident, as observers did not feel that their face was out of control (item 5), $t(29) = 1.50$, $p = .14$, or that they were imitating the onscreen face (item 8), $t(29) = 1.80$, $p = .08$. Finally, for the overall enfacement score, a 2 (stimulation: synchronous vs. neutral) x 2 (block order:

synchronous first vs. neutral first) mixed-factor ANOVA showed a main effect of stimulation, $F(1, 28) = 13.24$, $p < .001$, $\eta^2_p = .32$, due to a higher enfacement score in the synchronous (M = 27.1, SD = 10.0) than the neutral condition (M = 19.9, SD = 7.0). The main effect of order and the interaction between order and stimulation were not significant, both $Fs(1, 28) \leq 0.47$, $ps > .49$, $\eta s^2_p \leq .01$.

Racial prejudice measures

As in Experiment 1, a D score was computed for the IAT. D scores were similar across stimulation conditions (synchronous: M = 0.21, SD = 0.27; neutral: M = 0.25, SD = 0.28) and block order (synchronous first: M = 0.23, SD = 0.29; neutral first: M = 0.44, SD = 0.30). This was confirmed by a 2 (stimulation: synchronous vs. neutral) x 2 (block order: synchronous first vs. neutral first) mixed-factor ANOVA, which did not show main effects or an interaction, all $Fs(1, 28) \leq 0.38$, $ps > .54$, $\eta s^2_p \leq .01$. Observers' scores were also similar across the stimulation conditions (synchronous: M = 72, SD = 12; neutral: M = 71, SD = 12, max = 94, min = 51) and block order (synchronous first: M = 73, SD = 16; neutral first: M = 70, SD = 17, max = 91, min = 46) in the subtle racial prejudice questionnaire, which did not show main effects or an interaction, all $Fs(1, 28) \leq 0.74$, $ps > .39$, $\eta s^2_p \leq .02$.

Finally, it was explored again whether racial prejudice was modulated by the subjective feeling of ownership over the black face, regardless of stimulation condition. No correlation was found between the total enfacement score and the IAT, $r(58) = -.06$, $p = .61$, or between the total enfacement score and the prejudice scale, $r(58) = .17$, $p = .18$.

Discussion

Experiment 2 explored further whether SMS of the face modulates racial prejudice. In contrast to Experiment 1, the face-race IAT was used (Dasgupta et al., 2000). This test avoids possible familiarity effects of the name-race IAT test as consequence of the bigger experience that people might have with white names (see van Ravenzwaaij, 2011). Despite these changes, the main findings of Experiment 1 were replicated. Thus, observers felt a stronger subjective enfacement illusion after synchronous stimulation than in the neutral condition. This effect was such that observers felt that the onscreen face was, in fact, their own face. This result supports previous research by showing that it is possible to enface black faces (Bufalari et al., 2014; Fini et al., 2013). As in Experiment 1, however, no effect of either SMS or the subjective embodiment experience on implicit or explicit racial prejudice arose.

Although the face-race IAT in Experiment 2 does not suffer from the limitations of the name-face IAT in Experiment 1, it is still possible that this test is not sufficiently sensitive to detect differences in racial prejudice between conditions here. Both of these IATs compare two complementary categories (i.e. black- and white people). Thus, these traditional versions of the IAT (Greenwald & Farnham, 2000; Karpinski & Steinman, 2006) give a measure of implicit attitudes toward the outgroup based on the *comparison* with the ingroup (Karpinski & Steinman, 2006; Maister et al., 2013a). Such relative measures can create ambiguity in the interpretation of IAT scores. For this reason, a third experiment was conducted. In this experiment a single-category IAT was employed. This test does not include white stimuli, but only measures attitudes toward black people (i.e., the outgroup) to provide a more direct measure of racial prejudice (see Karpinski & Steinman, 2006).

A further manipulation was added in an attempt to improve the sensitivity of the stimulation paradigm. The synchronous and the neutral displays are similar, in the sense that the video content of both condition is congruent with observers experience (i.e., either synchronous stimulation or no stimulation at all). Consequently, it is possible that these conditions are too similar to modulate racial prejudice. To provide a stronger contrast, the neutral condition was replaced with an asynchronous stimulation condition in Experiment 3. In this condition, observers watched the stroking of the onscreen face and also received concurrent tactile stimulation of their own face. However, this stimulation was applied with a one-second delay, so that it occurred out of synchrony with the onscreen face. A between-subjects design was employed to avoid potential confounding effects from receiving both types of stimulation (i.e., synchronous and asynchronous).

Experiment 3

Experiment 3 modified the stimulation paradigm and the IAT in a further attempt to increase the sensitivity of our measures. In the stimulation task, the neutral condition was replaced with an asynchronous stimulation condition, which is a common comparison condition for both the rubber hand illusion and the enfacement paradigm (see, e.g., Tajadura-Jiménez, et al., 2012a; Tsakiris & Haggard, 2005). In the asynchronous condition, observers receive the same tactile stimulation as in the synchronous condition, but this is administered with a one-second delay to the observed stimulation of the onscreen face. Compared with the synchronous condition, the asynchronous condition therefore provides temporal incongruence between what observers feel when they are touched and what the touch that they see applied to the onscreen model. If this stimulation produces an enfacement effect that also modulates racial prejudice, then observers should show less prejudice toward the model's ethnic group after synchronous but not asynchronous stimulation.

In addition, the IAT was also replaced with a single-category version, which does not contrast attitudes to the outgroup with the ingroup, but measures attitudes toward the outgroup only (see Karpinski & Steinman, 2006; Maister et al., 2013a). For this reason, the single-category IAT is considered a more direct measure of observers' attitudes toward black people (Karpinski & Steinman, 2006). In contrast to the preceding experiments, this IAT was administered on a between-subjects basis, so that observers were only exposed to one of the stimulation conditions (i.e., synchronous or asynchronous). However, observers now performed single-category IAT twice, prior to and after stimulation stage, to determine whether any change in racial prejudice occurred as a consequence of SMS of the face.

Method

Participants

Sixty Caucasian students from the University of Kent, with a mean age of = 19 years (SD= 4.9), participated in the experiment for course credits or a small payment. All reported normal or corrected-to-normal vision. Half of these participants were allocated to the synchronous and half to the asynchronous stimulation condition.

Stimuli

This experiment is identical to the preceding experiments, except for the following changes. In the stimulation task, the neutral condition was replaced with an asynchronous stimulation condition. In this condition, observers always watched the same videos as in the synchronous condition, in which the face of a models' right cheek was stroked with a cotton bud every two seconds for two minutes. While watching these videos, an identical cotton bud to that seen in the video was used to provide specular tactile stimulation to the observers' cheek either in temporal synchrony with the onscreen face, in the synchronous condition, or with a temporal offset of one second, in the asynchronous condition. To fully accommodate the asynchronous condition, two new items were also included in the enfacement questionnaire (see items 9 and 10 in Table 1). These items assess the source of the tactile sensation and seek to determine the extent to which observers associate the touch of the cotton bud on their own face with that of the onscreen face.

In addition, the standard IAT was replaced with a single-category version. As in the preceding experiments, this IAT is comprised of words and faces but only black faces are included. Observers have to categorize words as either positive or negative and black faces as black, using either the 'z' or 'm' keys on a standard computer keyboard. The task consisted of two different blocks. In one block, positive words and black faces shared the same response key, whereas, in the other block, negative words and black faces shared a response. Each of these block contained 24 practice trials and 72 experimental trials (for further details, see Karpinski & Steinman, 2006). Response keys assigned to positive and negative words categories were fully counterbalanced.

Procedure

In the experiment, observers began by performing the single-category IAT and the score of this test was used as a baseline measure of racial prejudice. This IAT consisted of two different stages, each containing 24 practice trials and 72 experimental trials. In one stage, positive words and black faces were assigned to the same response key, whereas, in the other stage, negative words and black faces shared the same response.

Each stage started with a set of instructions about the categorization task and the keys assigned for each option. Each target picture or word was displayed in the centre of the screen. The target word remained on the screen until the observers responded or for 1,500 ms. If observers did not respond, a message ("please, respond more quickly") appeared for 500 ms.

Synchronous or asynchronous stimulation was then administered by stroking observers' faces with a cotton bud at two-second intervals, while they watched a video of a black female being stroked at the same rate. In the synchronous, this stimulation was administered in time with the onscreen face. In the asynchronous condition, the tactile stimulation of the observer and the onscreen face was offset by one second. The allocation of observers to these conditions was randomized. After the stimulation stage, observers repeated the single category race IAT.

Results

Enfacement questionnaire

Observers were more likely to report that the onscreen black face was their own in the synchronous than the asynchronous condition (see items 1, 2 and 3 in Figure 11), all $ts(58) \geq 3.13$, $ps < .01$. Observers were also more likely to report that their face was out of control in the synchronous than the asynchronous condition (item 5), $t(58) = 2.25$, $p < .05$. In addition, observers were more likely to feel that they were imitating the black face in the synchronous condition (item 8), $t(58) = 2.88$, $p < .01$, and that the cotton bud stroking their own face and the cotton bud stroking the black face were the same (items 9 and 10), both $ts(58) \geq 2.52$, $ps < .05$. However, despite the clear convergence in *felt* resemblance between observers' own and the onscreen face, they did not report that these faces *actually* began to resemble each other (items 4 and 6), both *ts*(58) ≤ 1.89, *ps* > .07. In addition, observers also did not report that the experience of their own face was less vivid than normal (item 7), *t*(58) = 1.93, *p* = .07. Finally, the overall enfacement effect, by combining scores across each item, was stronger in the synchronous (M = 33.6, SD = 11.9) than in the asynchronous condition (M = 23.2, SD = 9.0), *t*(58) = 3.81, *p* < .01.

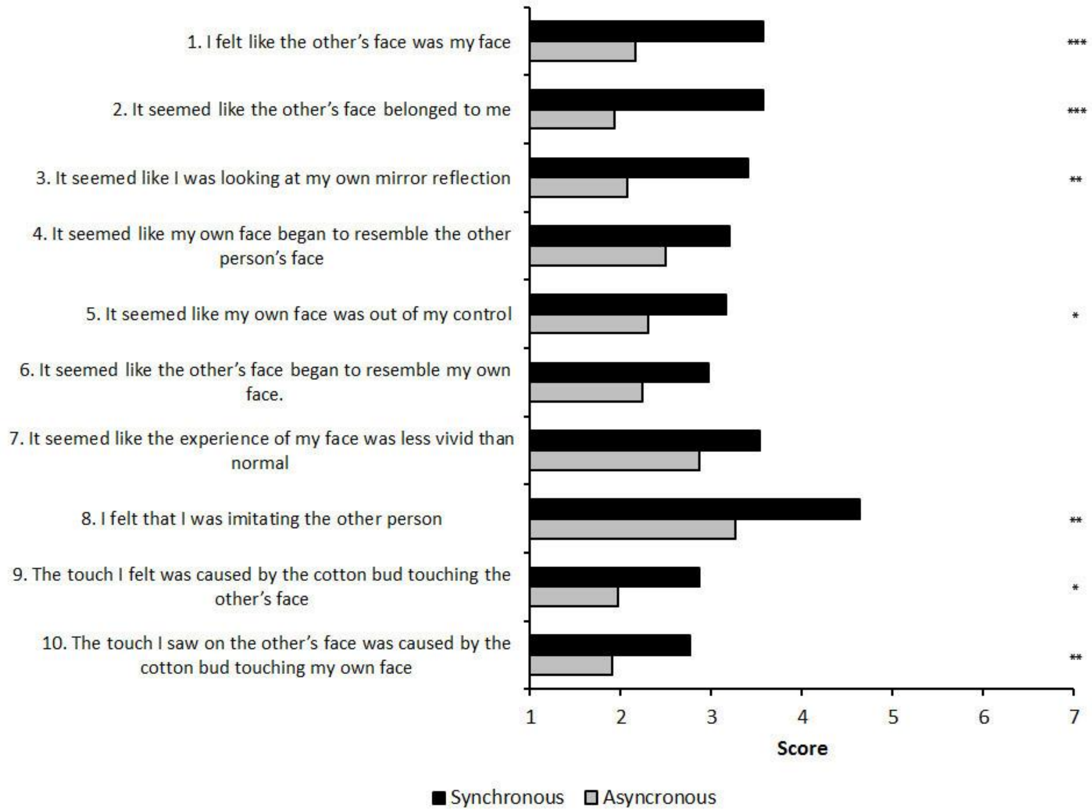

Figure 11. Mean Likert responses to each enfacement item for the synchronous (black bars) and the neutral (grey bars) condition in Experiment 3. Note: * p < .05; ** p < .01; *** p <.001.

Racial prejudice measures

The scores for the single category IAT were analysed according to Karpinski and Steinman (2006). This adapted D score for the single category IAT is calculated by subtracting the average response times when black faces shared the same key with negative words from the average response times when black faces shared the same key with positive words. This quantity is then divided by the standard deviation of all the correct responses in the experimental trials (for further details, see Karpinski & Steinman, 2006). Thus, a positive score reflects a positive attitude toward black people. Scores in the single category IAT were similar for the synchronous (pre-test, M = -.06, SD = .18; post-test, M = -.01, SD = .14) and the asynchronous (pre-test, M = -.04, SD = .18; post-test, M = -.02, SD = .11) conditions. This was confirmed by a 2 x 2 ANOVA with the within-subjects factor time (pre-test vs. post-test) and the between-subject factor condition (synchronous vs. asynchronous). This showed neither a main effect of time, $F(1,58) = 1.50$, $p = .24$, $\eta^2_p = .02$, or condition, $F(1,58) = 0.02$, $p = .85$, $\eta^2_p < .01$, and no interaction between factors, $F(1,58) = 0.19$, $p = .59$, $\eta^2_p < .01$.

To explore whether racial prejudice was modulated by observers' feelings of ownership over the black face, Pearson correlations were also conducted between the total enfacement score and the score in the post-test single category IAT. This correlation was not significant, $r(58) = .17$, $p = .18$.

Discussion

This experiment explored whether SMS of the face modulates racial prejudice by comparing synchronous with asynchronous stimulation of observers' faces. Before and after the stimulation, observers performed the single category IAT, to provide an implicit measure of their attitudes toward black faces. As in previous experiments, observers reported a stronger subjective enfacement illusion in the synchronous condition. In contrast to Experiments 1 and 2, which compared synchronous stimulation with a neutral condition, in which no stroking was administered to the onscreen face or the observers, this effect was now found by comparing synchronous with temporally asynchronous stimulation. This effect was such that observers were more likely to report that the onscreen face was, in fact, their own face. Despite this clear multisensory stimulation effect, we once again did not find any effect of SMS on in racial prejudice. This replicates the findings of Experiments 1 and 2.

General discussion

This study investigated whether multisensory stimulation of a white observer with a black face produces an enfacement effect that can reduce racial prejudice. In Experiment 1, participants were exposed to multisensory stimulation, whereby their own face was stroked in synchrony with an observed black face. This was compared with a neutral condition, in which no tactile stimulation was delivered. Racial prejudice was measured implicitly, with the name-race IAT (e.g., Hall et al., 2009), and explicitly, with the subtle prejudice questionnaire (Lepore & Brown, 1996). After synchronous stimulation, observers were more likely to feel that the onscreen black face 'was' their own face and 'belonged' to them than after the neutral condition. This effect was consistently found, across 7 of the 8 items on the enfacement questionnaire. However, this change in the onscreen face ownership experience was not accompanied by a modulation of racial prejudice, both on the implicit and explicit measures.

Further experiments explored whether the stimulation paradigm and the racial prejudice measures can be modified to improve the sensitivity of this approach. In Experiment 2 the name-face IAT of Experiment 1 was replaced with a face-race version (Dasgupta et al., 2000), which removes possible familiarity confounds. For example, it is possible that the name-race IAT does not measure racial prejudice if observers cannot attribute ethnic origin accurately to the name stimuli (see van Ravenzwaaij et al., 2011). Despite this change, Experiment 2 replicated the main findings. Thus, observers exhibited a stronger enfacement effect after synchronous stimulation compared to neutral stimulation, but this did not affect implicit or explicit racial prejudice. Finally, Experiment 3 also compared synchronous and asynchronous stimulation and employed a single category IAT to provide a more specific measure of racial prejudice attitudes against an outgroup (see Karpinski & Steinman, 2006). Once again, observers were more likely to feel that the black onscreen face was their own after synchronous stimulation, but this did not reduce racial prejudice.

The findings of this study converge with previous research, by showing that it is possible to embody physical features of an outgroup member, such as a black hand (Maister et al., 2013a) or black faces (Fini et al., 2013; Bufalari et al., 2014). In contrast to previous work, however, a positive effect of SMS of the face on prejudice reduction was not found. For example, a recent study has shown that after enfacing a black face, observers displayed an increased visual remapping of touch effect (i.e., the tactile sensitivity caused by watching another person being touched) toward that black face up to the level normally associated with ingroup members (Fini et al., 2013). This could suggest a reduction of racial prejudice after the SMS of the face. However, as the visual remapping of touch effect was measured exclusively for the enfaced face, it is also possible that this effect reflects an increase of positive attitudes toward the enfaced face, but not more generally toward its race. This explanation would be consistent with the finding that SMS produces a positive affective reaction toward an enfaced face (e.g., Paladino et al., 2010).

The current experiments also indicate that the feeling of ownership experience over an enfaced black face does not modulate racial prejudice. There is evidence that the intensity level of observers' illusion of ownership over an enfaced black stimulus relates to their racial prejudice (see Maister et al., 2013a). In contrast to the current experiments, however, this effect was observed with hands. Faces are more distinctive physical features and are important not only for recognizing others but also for self-recognition. Moreover, whereas several neuropsychological studies have reported denial of ownership over hands or feet in brain-damaged patients (see, e.g., Berlucchi & Aglioti, 1997; Giummarra, Gibson, Georgiou-Karistianis, & Bradshaw, 2008), deficits in self-face recognition appear to be less frequent and are, in most of the cases, transient (see Brédart & Young, 2004). This raises the possibility that other peoples' faces are more difficult to embody than other body parts, such as hands. In line with this reasoning, phenomenological evidence from Experiments 1, 2 and 3, and from other studies (e.g., Sforza et al., 2010; Tajadura-Jiménez et al., 2012a; Tajadura-Jiménez et al., 2012b) suggests that the effect of SMS of the face, although significant when compared with both the asynchronous and neutral stimulation, it was small in absolute terms. This is such that observers' responses in the enfacement questionnaire were generally below the mid-point of the Likert scale. On the contrary, the phenomenological effect of SMS on the rubber hand illusions is not only greater when compared with both asynchronous and neutral conditions, but also observers' responses are, generally, above the mid-point of the scale (see, e.g., Longo et al., 2008). This shows that the enfacement illusion is less vivid than other body illusions (Botvinick & Cohen, 1998; Lenggenhager et a., 2007; Sforza et al., 2010; Tsakiris & Haggard, 2005).

From a cognitive perspective, these differences between findings could indicate that the rubber hand and enfacement illusions reflect different aspects of self-identity. Psychometric studies have found a *self-identification* component in the rubber illusion and the enfacement illusion (see Longo,et al., 2008; Tajadura-Jiménez et al., 2012b). However, this component seems to differ in its structure in both illusions. In the case of the rubber hand illusion, this component is constituted of the subcomponents ownership (i.e., the feeling that the rubber hand was part of the body), location (i.e., the feeling that the rubber hand was in the same place as the own hand), and agency (i.e., the feeling of being able to move the rubber hand; see Longo et al., 2008). In the case of the enfacement illusion, on the other hand, no subcomponents for self-identification were found (Tajadura-Jiménez et al., 2012b). It has been proposed that this reflects the different importance that faces and hands have for self-identity, which should be stronger for faces (see Tajadura-Jiménez et al., 2012b). This could also explain why the rubber-hand illusion can modulate racial prejudice (Maister et al., 2013a), but the enfacement illusion does not.

In the current experiments, we had sought to investigate the effect of SMS on racial prejudice because it blurs self-other boundaries by reducing the difference with the enfaced face (see Paladino et al., 2010). The finding that this manipulation does not affect racial prejudice contrasts with other procedures that seem to rely on a similar mechanism of differences reduction for prejudice reduction (see Gaertner & Dovidio, 2000 for review), such as intergroup contact, shared attribute generation (Hall et a., 2009) and behavioural mimicry (e.g., Inzlicht et al., 2012; Tuner & Crisp, 2010). Therefore, the question arises why SMS is unable to modulate racial prejudice, when other methods of differences reduction do.

One possibility is that observers' prejudice was already low (i.e., at floor level) at the start of the current experiments and therefore could not be susceptible to the current manipulation. Across the three experiments, observers' scores fell just above the midpoint of the IAT scale (e.g., at ~ 0.4 in Experiment 1, with the scale ranging from -2 to +2). Thus, these scores rule out a floor (or ceiling) effect and indicate some prejudice toward the outgroup (i.e., black people). Previous studies have successfully modulated racial prejudice on the IAT with other manipulations despite reporting similar baseline scores (see, e.g., Hall et al., 2009; Maister et al., 2013a; Peck, Seinfeld, Aglioti, & Slater, 2013). This indicates that we did not fail to obtain an enfacement modulation because observers' racial prejudice was too low.

Alternatively, it might be possible that the enfacement effect is able to modulate complex processes such as self-face recognition (Tskiris, 2008; Sforza et al., 2010; Tajadura-Jiménez et al., 2012a) and social cognition processes (Paladino et al., 2010), but the mechanism involved in the enfacement illusion would be unable to modulate racial prejudice. For example, such differences could be found if observers can switch their perspective to that of the model during enfacement but, conversely, are unable to adapt the model's perspective (see Petkova et al., 2011). In other words, observers might tend to perceive the onscreen face as more similar to their own, but not the opposite (see Tajadura-Jiménez et al., 2012a). As a consequence, modulation in racial prejudice is not produced because observers perceive the model as more similar to themselves (e.g., as more white in the current experiments), but because they do not perceive themselves as more similar to the model (e.g., as black, see Tajadura-Jiménez et al., 2012a; Tajadura-Jiménez et al., 2012b). In the current experiments, the responses of the enfacement questionnaire cannot distinguish these possibilities (see items 6 and 7 in Table 1). However, behavioural evidence from other research programmes has shown that observers indeed perceive an enfaced face as more similar to the own face, but not vice versa (see Tajadura-Jiménez et al., 2012a).

This appears to be a critical difference to other manipulations which decrease racial prejudice, such as behavioural mimicry (Inzlicht et al., 2012), shared attribute generation (Hall et al., 2009), or intergroup contact (Tuner & Crisp, 2010). In these procedures, observers must take the model's perspective and should therefore "look" more like the model. In the case of behavioural mimicry, for example, observers have to copy a model's action. The current findings also suggest that such perspective-taking might be important for prejudice reduction.

Chapter 3:

Can gaze-contingent mirror-feedback from unfamiliar faces alter self-recognition?

Introduction

Despite the absence of an effect of SMS on racial prejudice, a clear enfacement effect was obtained in all experiments in Chapter 2. This converges with previous research to suggest that SMS of the face is a remarkably robust effect in self-face recognition (e.g., Sforza et al., 2010; Tajadura-Jiménez et al., 2012a; Tsakiris, 2008). However, the enfacement paradigm relies on observing the tactile stimulation of another person, which is a scenario that is not encountered outside of the laboratory. Chapter 3 therefore examined whether a similar updating of observers' facial representations occurs with a stimulation method that is more similar to the experience of studying one's own reflection in a mirror.

Recognition requires that a seen face is matched to a stored, internal representation of that identity. Theories of face processing postulate that this internal representation is not tied to a specific instance of a seen face, but is activated by any image of this person (see, e.g., Burton et al., 1990; Bruce & Young, 1986). Thus, this internal representation should be tolerant to changes in the appearance of a face, such as variation in lighting direction or facial pose (see, e.g., Bruce, 1982; Longmore et al, 2008). A question that arises is how this internal representation is created so that a previously unfamiliar face, of someone that we have not met before, becomes sufficiently familiar for recognition to occur.

Current theories suggest that one way to operationalize this process could be the creation of face *averages*, in which different instances of the same face are integrated into a single representation (Burton et al., 2005). In this process, information that is relevant to the identity of a person, and therefore present consistently across encounters, is combined to form a robust facial representation for recognition. By contrast, variable visual information that is irrelevant to identity, such as superficial changes in the appearance of a particular face, is eliminated naturally during averaging because their effect will be cancelled out across different instances.

This theoretical account can provide a robust method to simulate face recognition (Burton et al., 2011; Jenkins & Burton, 2008; Robertson et al, 2015). It also provides an account of face *learning* (see e.g., Burton et al., in press; Kramer et al., 2015; Leib et al., 2014). Accordingly, the created internal representation of a face is tied in an additive manner to the experience of that identity, whereby every new exposure strengthens its average and leads to a stronger internal representation (Burton et al., 2005, 2011; Jenkins & Burton, 2008). Interestingly, this theoretical approach can also explain two interrelated aspects of self-recognition, namely how a visual representation of the own face is created and how this representation accommodates changes in physical appearance during the lifespan. According to this perspective, any new instance of the own face would be incorporated into the averaging process to naturally deal with changes in the appearance.

However, current theories stop short of explaining an important component of self-recognition, namely the self-referential process of knowing that a particular face is, in fact, one's own (e.g., Devue & Bredart, 2011; Morin, 2006). A potential answer to this question emerges from the domain of body perception, where research has shown the importance of *body-awareness* for self-recognition (e.g., Botvinick & Cohen, 1998; Tsakiris, 2010; Tsakiris & Haggard, 2005). Mental representations of our bodies are held to be created through the interaction and integration of different senses, such as visual, tactile and proprioceptive information (Blanke, Landis, Spinelli, & Seeck, 2004; Tsakiris & Haggard, 2005). This information appears to be used not only in the formation of a representation of our body, but also for updating and modifying that representation when necessary (Botvinick & Cohen, 1998; Lenggenhager et al., 2007; Petkova et al., 2011; Tsakiris & Haggard, 2005).

Evidence for such accounts comes from the rubber hand illusion. In this paradigm, observers watch a rubber-hand being stroked while their own hand is stroked out of sight in synchrony. This simultaneous stimulation produces the feeling that the rubber hand is, in fact, one's own hand (Botvinick & Cohen, 1998; Tsakiris & Haggard, 2005). This effect relies on the multi-sensory combination of touch (of one's own hand) and sight (of the rubber hand being stroked). However, a rubber-hand effect has also been obtained without touching, for example, when there is synchrony of movement between a rubber hand and one's own hand (e.g., Dummer et al., 2009; Riemer et al., 2014). Similar effects have been reported with arms (Guterstamet al.,, 2011) and even with the whole body (Lenggenhager et al., 2007; Petkova & Ehrsson, 2008; Petkova et al., 2011).

With respect to face learning, these findings are interesting in that they could provide a self-referential process to update internal representations. Accordingly, such updating could be supported if observers can *see* and, through proprioceptive feedback, *feel* their own face move at the same time. Outside of the laboratory, such feedback is available daily from mirrors, for example, during hygiene activities such as washing and grooming. In these conditions, a person's mirror reflection provides synchronous visual feedback for motor, proprioceptive and tactile information (Botvinick & Cohen, 1998; Tajadura-Jimenez et al., 2012a; Tsakiris, 2008, 2010). This feedback provides direct evidence that a looked-at face is, in fact, one's own. The question arises of whether this contributes to the *updating* of a person's facial presentation.

Studies of multisensory integration already provide some evidence to support this idea. For example, when observers' faces are stroked in synchrony with a target that consists of a 50:50 morph of their own face and that of another person, they subsequently tend to see more of their own features in the other person's face (Tsakiris, 2008). This perceptual effect is accompanied by a subjective illusion that the other face *belongs* to the observer. This bias in self-recognition or "enfacement effect" (Sforza et al., 2010) has been shown with totally unfamiliar (Tajadura-Jiménez et al., 2012a), familiar (Sforza et al., 2010) and other-race faces (Bufalari et al., 2014; Fini et al., 2013).

While these findings point to a remarkably robust effect, multi-sensory paradigms rely on observing the tactile stimulation of another agent. This presents a scenario that is not encountered outside of the laboratory. In this study, we therefore wish to examine whether a similar updating of observers' facial representations occurs with a stimulation method that is more similar to the experience of studying one's own reflection in a mirror. For this purpose, we present a novel gaze-contingent paradigm, in which the eye movements of a face on a computer screen directly mimic the looking behaviour of an observer.

To measure the effect of this manipulation in self-recognition, we compared several conditions. In Experiment 4, the gaze behaviour of the onscreen face provided a direct "mirror-reflection" for observers' gaze behaviour, by mimicking their eye movements in the *congruent* condition. This was contrasted with an *incongruent* condition in which the eyes of the onscreen face responded to observers eye-gaze but moved in a different direction. If mirror-reflection is used to update facial representations of the own face, then it should be possible to induce an enfacement-type effect in this paradigm. In line with studies of multi-sensory stimulation (e.g., Fini et al., 2013; Sforza et al., 2010; Tajadura-Jiménez et al., 2012a; Tsakiris, 2008), this effect should be found in the *congruent* gaze condition in comparison with *incongruent* displays.

To assess this possibility, we adopted established measures of the enfacement illusion from multi-sensory stimulation paradigms (see, e.g., Keenan et al., 1999; Maister et al., 2013; Tajadura-Jiménez et al., 2012a; Tsakiris, 2008). This comprised a self-other discrimination task, in which observers were shown a morphing sequence between the face viewed in the stimulation stage and observers' own face. In this task, observers were asked to determine at which point they could perceive their own face in the sequence. This measure was complemented with an enfacement questionnaire, which assessed different aspects of observers' phenomenological experience of identifying with the face of the stimulation stage.

Experiment 4

In this experiment, observers watched an onscreen stimulation face in a gaze-contingent paradigm, which comprised of two conditions. In the congruent condition, the eyes of this face mimicked observers' eye-gaze direction to imitate, in this particular aspect, the experience of looking in a mirror. Observers triggered the eye-gaze of the onscreen face by moving their own eyes, which were tracked concurrently, around the display screen. To encourage such eye movements, the onscreen face was surrounded by eight boxes, which, upon fixated, revealed a visual icon. Performance in this task was contrasted with an incongruent condition, in which the eyes of the onscreen face moved in temporal synchrony with an observer eye-gaze but in a different direction.

Before and after this task, observers performed a self-other discrimination task. This consisted of a morphing sequence between the onscreen face from the stimulation stage and observer's own face. This sequence always began with the onscreen face, which was gradually morphed into the observer's own face. Observers had to stop this sequence as soon as they felt that the face resembled their own face more than that of the stimulation face. In addition, observers' phenomenological experience of the gaze-contingent task was also assessed with an established enfacement questionnaire.

If this gaze-contingent mirror-reflection paradigm can be used to update observers' representations of their own face, then the onscreen face should become integrated into this representation in the congruent condition. As a consequence, observers should detect their own face earlier in the morphing sequence in the congruent than in the incongruent condition. This effect should also be evident from the questionnaire, with observers reporting a greater resemblance with the stimulation face in the congruent condition.

Method

Participants

Twenty Caucasian students (13 females) from the University of Kent, with a mean age of 22 years (SD = 4.2), participated in this study. All provided informed consent prior to taking part and received course credits or a small fee for participation. All reported normal or corrected-to-normal vision.

Stimuli

Gaze-contingent stimulation displays

For the stimuli of the gaze-contingent task, a male and a female frontal face were taken from the Glasgow Face Database (Burton et al., 2010). These faces were digitized with FaceGen Modeller software (Singular inversions Inc., Toronto). The resulting faces provided artificial representations of the original stimuli, in which gaze direction can be controlled with the same software. This was used to create nine images of each face, in which the eye-gaze systematically varied across three horizontal (left, middle, right) and three vertical positions (up, middle, down). To enhance the salience of these gaze directions, the brightness of the sclera was increased by 25% using Adobe Photoshop.

In the experiment, each of these faces was presented at a width and height of 325 x 420 pixels at a screen resolution of 72 ppi in the centre of a white display. These faces were surrounded by eight boxes, which measured 220 x 220 pixels. When fixated, these boxes were replaced by images of objects (e.g., a radio, cd, glove), which measured maximally 200 x 200 pixels. These displays are illustrated in Figure 12.

Figure 12. Example stimuli of the congruent condition for Experiment 4 and 5, showing direct eye-gaze (left panel) and the eyes pointing up (centre) or down (right). In the neutral condition, the eye-gaze remained direct and static throughout. In the incongruent condition, the eyes of the onscreen face pointed in a different direction to observers' own eye-gaze, and therefore did not point at the revealed object.

Self-other discrimination task

For the self-other discrimination task, a digital photograph of each observer was taken prior the experiment. For consistency with the model's face, these pictures were also modelled with FaceGen. The digitalized images were morphed with the stimulation face that matched the observer's sex in 1% steps using Fantamorph (Abrasoft) software. This resulted in a sequence of 100 images, which provided a smooth continuum between the stimulation face and an observer's own face. Each of these images was presented at a size of 254 x 313 pixels at a screen resolution of 72 ppi.

A pilot experiment was conducted to assess the similarity of the digitalized faces with each of the corresponding observers in Experiment 4, 5 and 6. Eight independent participants were presented with pairs of faces depicting the internal features of the digitalized face and the actual observer's picture. Participants had to perform two different tasks. Firstly, they rated the resemblance between both images on a 10-point Likert scale, ranging from "no resemblance" to "strong resemblance". Mean resemblance rating for all the pair of faces was 8.3 (SD: 1.2; minimum rating: 7; maximum rating: 10), which indicates that the digitalized version and the actual picture were highly similar. Secondly, participants had to indicate which of the picture the digitalized version was, but they also had the option to skip to the next pair of pictures if they were not sure. In total, participants skip 94% of the trials, which indicates that they could not distinguish between the real and the digitalized versions of the observers' faces.

Enfacement questionnaire

A questionnaire was administered to assess observers' subjective experience of the gaze-contingent paradigm. This questionnaire was adapted from studies of the "enfacement" effect (Tajadura-Jiménez et al., 2012a; see also Maister et al., 2013) and consisted of 11 items (see Table 2).

The first seven questions assessed observers' enfacement experience and included items such as "I felt like the onscreen face was my face" and "I felt like I was looking at my own face in the mirror". A high score in these items indicates that observers felt that the onscreen face had become integrated with the internal representation of their own face during the experiment (see Tajadura-Jiménez et al., 2012b). The four remaining items assessed whether observers perceived the eye-gaze of the stimulation face, such as "I felt like the onscreen face's eyes followed my eyes", to provide a manipulation check. Responses to all items were recorded on 7-point Likert scales, which ranged from *"strongly disagree"* to "*strongly agree"*.

Type of Item	**Enfacement Item**
Enfacement	**1.** I felt like the onscreen face was my face
	2. I felt like the onscreen face belonged to me
	3. I felt like I was looking at my own face reflected in a mirror
	4. I felt like my own face was out of my control
	5. I felt like my face began to resemble the onscreen face
	6. I felt like the onscreen face began to resemble my face
	7. I felt like if the onscreen face's eyes had moved, my eyes would have moved too
Verification	**8.** I felt like the onscreen face's eyes followed my eyes
	9. I felt like if I had moved my eyes, the onscreen face's eyes would have moved too
	10. The onscreen face's eyes moved in the same direction as my eyes
	11. The onscreen face's eyes moved in a different direction as my eyes

Table 2. The Enfacement Questionnaire.

Procedure

In the experiment, observers participated in the self-other discrimination task first to obtain a baseline measure of self-recognition (the pre-test), which was conducted using E-prime on a computer with a 21" screen. In this task, observers viewed the sequence of the morphed faces. This sequence always began with the stimulation face (100% stimulation face, 0% observer), which was gradually morphed, in 1% segments, into an observer's own face. This sequence was presented at a rate of one segment per second. While watching this sequence, observers were asked to press the space bar as soon as they felt that the displayed face resembled their own more than that of the stimulation face. Prior to this pre-test, observers were trained on this discrimination task by watching a sequence that morphed the face of David Cameron (British Prime Minister) into Barack Obama (American President).

The pre-test was followed by the gaze-contingent stimulation task. For this task, observers' eye movements were tracked using the SR-Research Eyelink 1000 desk-mounted eye tracking system. Observers sat at a distance of 50 cm from a 21" screen, which was held constant by a chinrest. Although viewing was binocular, only the left eye was tracked. To calibrate eye-gaze, the standard nine-point Eyelink procedure was used. Thus, observers fixated a set of nine fixations targets, which was followed by a second sequence of nine targets to validate calibration. If this procedure indicated poor measurement accuracy (i.e., a measurement error of > 1° of visual angle), calibration was repeated.

At the beginning of the stimulation task, observers fixated a central dot so that an automatic drift correction could be performed. The stimulation face was then displayed in the centre of the screen. The sex of this was always kept congruent with that of the observer. The stimulation face was surrounded by eight boxes, which were depicted in different colours (see Figure 12). Each of these boxes hid an object, which was revealed when it was fixated by the observers, to provide a task demand that would encourage eye movements around these displays. Observers were asked to look at these boxes and to memorize their contents. Crucially, the onscreen location of these boxes served as trigger regions to manipulate the eye-gaze of the stimulation face. Observers received either congruent or incongruent stimulation. In the congruent condition, the onscreen face's gaze changed only 150 ms after a trigger region was fixated to follow the observer's gaze. In the incongruent condition the gaze of the stimulation face was always incongruent with observers' own eye-gaze direction. This spatial incongruence was created by randomly assigning a different gaze direction to the stimulation face for each of the observer's possible gaze directions.

This task lasted for two minutes and, to assess any effects of this stimulation on self-recognition, was followed by a repetition of the self-other discrimination task and the enfacement questionnaire. Observers were then presented with a second block of the stimulation task, but they received different stimulation to that received in the first block (i.e., if the stimulation was congruent in the first block, it was incongruent in the second block). This was followed by a further repetition of the discrimination task and the questionnaire. Over the course of the experiment, the presentation order of the congruent and incongruent conditions was counterbalanced across observers.

Results

Self-other discrimination task

Performance in the discrimination task was assessed first. Figure 13 shows the mean percentage of frames that were perceived as the stimulation face or as observers' own face in the morphing sequence. This data is given for the baseline measure and after the gaze-congruent and incongruent stimulation conditions were administered.

A one-factor ANOVA (baseline, congruent, incongruent condition) of this data showed a main effect of condition, $F(1,19) = 7.13$, $p < .01$, $\eta_p^2 = .27$. Paired sample t-tests (Bonferroni-corrected) revealed that observers perceived their own face earlier in the morphing sequence after the application of the gaze-congruent condition in comparison with the baseline, $t(19) = 2.80$, $p < .05$. However, a similar effect was observed also in the incongruent condition in comparison to baseline, $t(19) = 3.44$, $p < .01$, and the congruent and incongruent condition did not differ from each other, $t(19) = 0.50$, $p = .98$. Taken together, these results suggest a practice effect as observers perceived their own face earlier in both the congruent and incongruent conditions compared with the baseline.

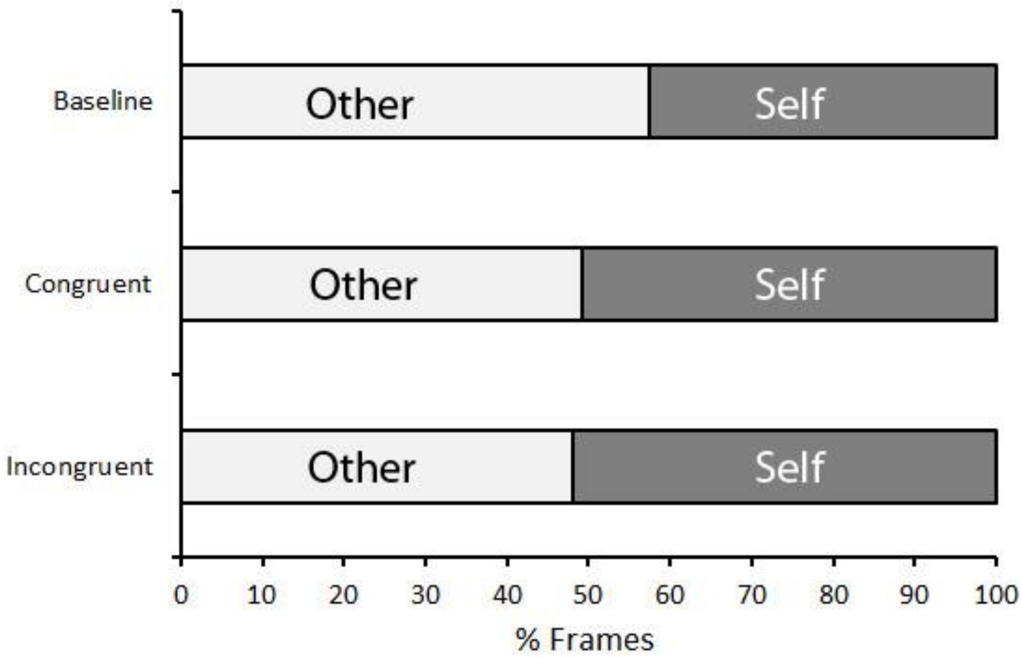

Figure 13. Performance in the self-other discrimination task in Experiment 4, expressed as the number of frames that observers judged to show their own face or that of the onscreen face, for the baseline measure and after congruent and incongruent stimulation.

Enfacement questionnaire

The self-other discrimination task indicates that the gaze-contingent paradigm did not affect observers' perceptual self-representations. We also assessed observers' questionnaire responses to determine if this paradigm affected how they *felt* regarding the stimulation face. These data are provided in Figure 14, as mean Likert responses to each of the enfacement items, for the congruent and incongruent conditions. Four of the questionnaire items are verification items, which assess whether observers were sensitive to the gaze-contingent task. The differences in ratings for these verification items show that observers were aware that the onscreen face followed their own eye-gaze in the congruent compared to the incongruent condition (items 8 and 9), both $ts(19) \geq 4.00$, $ps < .001$. The ratings also show a clear difference between conditions in terms of the directionality of the eye-gaze (items 10 and 11), whereby observers were more likely to report that the eyes of the stimulation face moved in the same direction as their own eyes in the congruent condition, $t(19) = 7.28$, $p < .001$. In contrast, observers noted that the eyes of the stimulation face moved in a different direction to their own in incongruent displays, $t(19) = 5.98$, $p < .001$. However, when the ratings for items 10 (eyes moved in the same direction) and 11 (eyes moved in a different direction) are compared directly, it emerges that these are more similar in the incongruent condition, $t(19) = 1.60$, $p = .12$, than the congruent condition, $t(19) \geq 15.79$, $p < .001$. This suggests that observers always perceived movement of the stimulation face's eyes, but were less sensitive to the *direction* of these movements in the incongruent condition.

A comparison of the congruent and the incongruent condition also shows that the gaze contingent paradigm did not affect observers' feelings about the onscreen face, which were comparable across these conditions in all enfacement questions (items 1-7), all *ts*(19) ≤ 1.65, *ps* >.07. An overall enfacement score, which was also calculated by summing the scores for items 1 to 7 also shows that the congruent (M = 20.4, SD = 8.2) and incongruent (M = 17.9, SD = 9.1) conditions did not differ, *t*(19) = 1.14, *p* = .14.

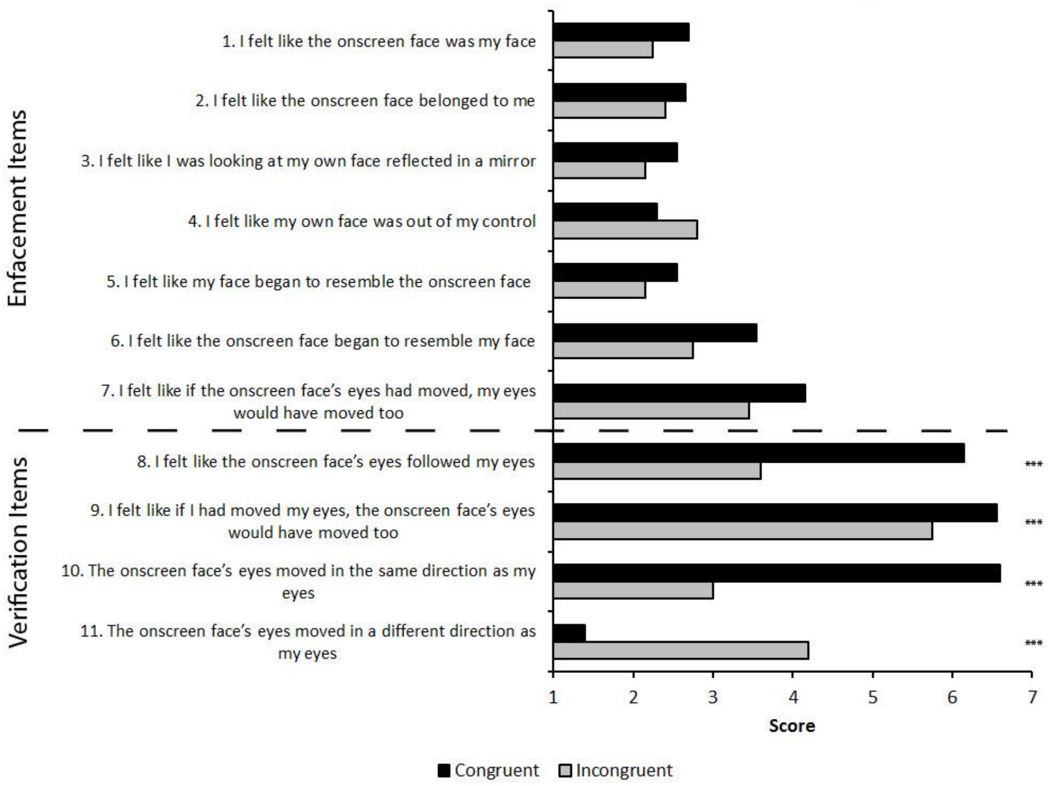

Figure 14. Mean Likert responses to each enfacement item for the congruent (black bars) and the incongruent (grey bars) conditions in Experiment 4. * p < .05; ** p < .01; *** p <.001.

Discussion

Experiment 4 explored whether it would be possible to update the internal representation of one's own face with a gaze-contingent paradigm that simulates the mirror-reflection experience. This was investigated by comparing a congruent condition, in which the eye-gaze of an onscreen face follows that of the observer, with an incongruent condition, in which the gaze of the onscreen face was spatially incongruent with observers. To assess whether this stimulation affected observers' self-representation, they were asked to detect their face in an image sequence that began with the onscreen face and gradually morphed into their own face. In comparison with a baseline measure, which was obtained prior to the administration of the stimulation task, a shift in self-recognition was found in the congruent condition, whereby observers recognized their own face at an earlier stage of the morphing sequence. However, the same effect was also observed after the administration of an incongruent condition. Taken together, these results suggest that the gaze-congruent condition did not affect observers' self-recognition *per* se. Instead, these findings hint at a practice effect whereby observers perceived their own face earlier in the morphing sequence of the congruent and incongruent conditions in comparison to the initial measure at baseline. In line with these findings, the results indicate also that the mirror-like gaze-contingent paradigm did not affect how observers feel about the onscreen face and their own face.

A possible explanation for these findings is that the difference in eye-gaze between the congruent and incongruent conditions was insufficient to elicit a mirror effect and affect self-recognition. The verification items of the questionnaire reveal that observers were sensitive to the eye movements of the stimulation face in the congruent condition. However, this effect was considerably smaller with incongruent displays. Here, observers showed some false agreement that the stimulation face followed their eyes (see item 8 in Figure 14), and a direct comparison of items 10 and 11 indicates limited insight into whether the onscreen gaze was moving in the same or a different direction to observers' own eyes.

This situation might arise because eye-gaze direction cannot be perceived easily outside the focus of attention (Burton, Bindemann, Langton, Schweinberger, & Jenkins, 2009). In the current paradigm, observers have to explore the boxes surrounding the stimulation face to trigger its eye movements. As a result of this, however, this face is unattended when any changes in its gaze direction occur. If observers have limited awareness of these changes, then this cannot produce the mirror-type effects that might be required to affect self-recognition. To explore this possibility, we conducted a further experiment in which the incongruent condition was replaced with a neutral display, in which the eyes of the onscreen face looked straight ahead regardless of the observers' gaze behaviour. Such direct gaze is more salient than averted gaze outside the focus of attention (Yokoyama, Sakai, Noguchi, & Kita, 2014) and should therefore produce a stronger contrast to the congruent eye-gaze condition.

Experiment 5

In contrast to Experiment 4, which compared congruent gaze-contingent displays with an incongruent condition, this experiment compared congruent with neutral displays, in which the gaze of the onscreen face remained static and unresponsive. Extrapolating from previous research, we predicted that this condition should provide a stronger contrast to the moving eye-gaze of the congruent condition, particularly when the stimulation face is not attended (see Burton et al., 2009; Yokoyama, et al., 2014). If it is possible to update the representation of the own face using a gaze-contingent paradigm, then such an effect might now be observed here, by comparing observers' cognitions after the congruent and neutral displays.

Method

Participants

Twenty new Caucasian students (10 females) from the University of Kent, with a mean age of 21 years (SD = 5.1), participated in this study. All provided informed consent prior to taking part and received course credits or a small fee for participation. All reported normal or corrected-to-normal vision.

Stimuli and procedure

The stimuli and procedure were identical to Experiment 4, except that the incongruent condition was replaced with neutral gaze displays. In this condition, the eye-gaze of the onscreen was always directed straight at the observers and unresponsive. As in Experiment 4, the self-other discrimination task was administered initially to obtain a baseline measure of self-recognition. Observers then performed two blocks, one for the congruent condition and one for the neutral condition, which comprised the stimulation phase, the self-other discrimination task, and the enfacement questionnaire. The order of these blocks was counterbalanced across observers.

Results

Self-other discrimination task

Figure 15 illustrates performance in the discrimination task for the baseline condition and after the administration of the congruent and neutral displays. A one-factor ANOVA (baseline, congruent, neutral condition) showed a main effect of condition, $F(1,19) = 20.37$, $p < .001$, $\eta_p^2 = .51$. Paired sample t-tests (Bonferroni-corrected) show that observers perceived their own face earlier in the morphing sequence after the application of both the congruent and neutral conditions in comparison with the baseline, $t(19) = 6.68$, $p < .001$ and $t(19) = 4.51$, $p < .001$, respectively. Discrimination performance in the congruent and neutral conditions did not differ, $t(19) = 0.75$, $p = 1.00$.

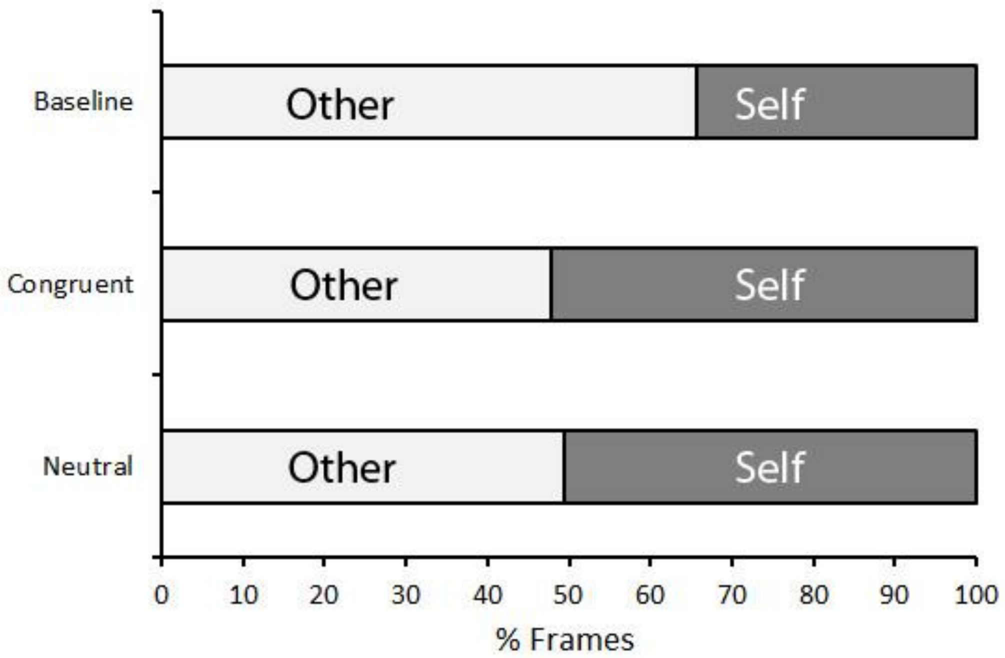

Figure 15. Performance in the self-other discrimination task in Experiment 5, expressed as the number of frames that observers judged to show their own face or that of the onscreen face, for the baseline measure and after congruent and neutral stimulation.

Enfacement questionnaire

Observers' questionnaire responses are summarized in Figure 16. The difference in mean ratings for the verification items between the congruent and neutral condition demonstrates that observers were aware that the onscreen face followed their own eye-gaze (see items 8-10 in Figure 16), all $ts(19) \geq 6.55$, $ps < .001$. In addition, when asked whether the onscreen face's eyes moved in a different direction to observers' own (item 11), ratings were low in both conditions and no difference was found, $t(19) = .92$, $p = .36$.

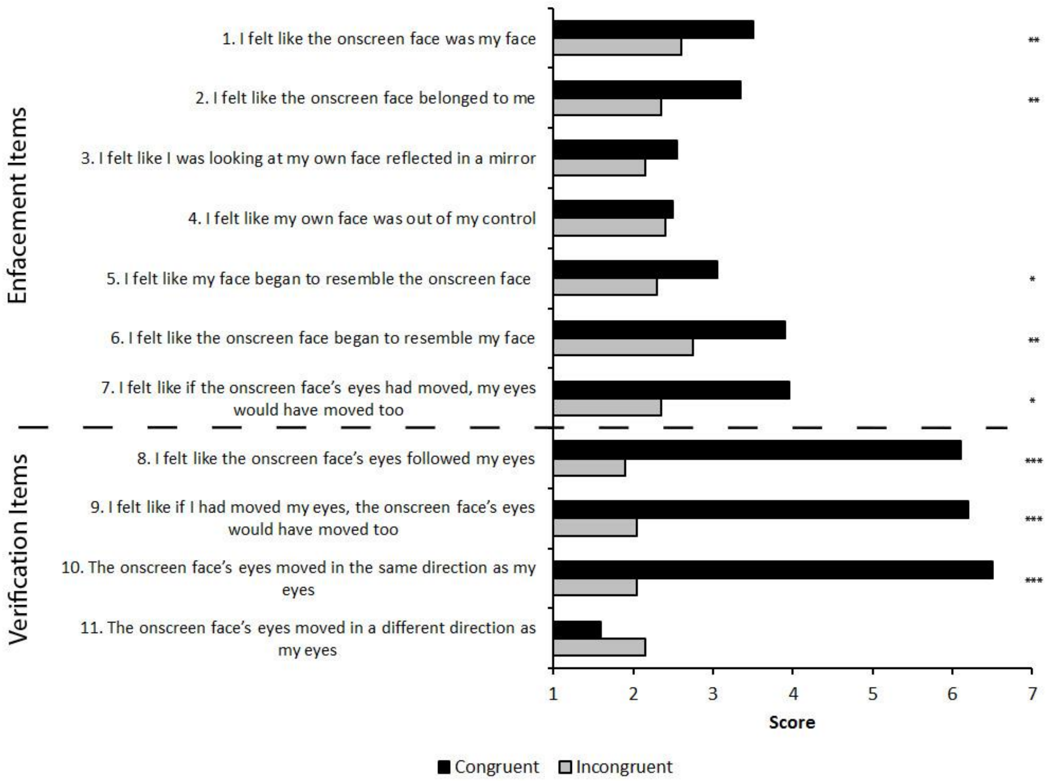

Figure 16. Mean Likert responses to each enfacement item for the congruent (black bars) and the neutral (grey bars) conditions in Experiment 5. * p < .05; ** p < .01; *** p <.001.

A comparison of the congruent and neutral condition also shows that the gaze-contingent paradigm affected how observers felt about the stimulation face. Observers were more likely to report that this face looked like their own in the congruent than the neutral condition (items 1 and 2), both *ts*(19) ≥ 2.87, *ps* < .01, and also reported a closer resemblance between their own face and that of the onscreen face (items 5 and 6), both *ts*(19) ≥ 2.44, *ps* < .05. This effect was such that, if the eyes of the onscreen face had moved, they expected their own eyes to move too in the congruent condition (item 7), *t*(19) = 2.72, *p* < .05. However, an effect of condition was not universally found. Observers did not report that their own face felt out of control (item 4), *t*(19) = 0.19, *p* = .84, or, despite the clear convergence in felt resemblance between their own and the onscreen face, that they were looking at their own face in a mirror (item 3,) *t*(19) =

0.98, p = .33. Finally, an overall enfacement score was also calculated for each observer, by summing the scores for items 1 to 7. This enfacement score was higher in the congruent (M = 22.8, SD = 10.6) than the neutral condition (M = 16.9, SD = 8.4), $t(19) = 3.24$, $p < .01$.

Discussion

This experiment explored whether it is possible to update the representation of one's own face with a gaze-contingent paradigm. In contrast to Experiment 4, this was investigated by comparing a congruent condition, in which the eye-gaze of an onscreen face follows that of the observer, with a neutral condition, in which the onscreen face was static and unresponsive. As in Experiment 4, observers were sensitive to the eye movements of the onscreen faces and their directionality in the congruent condition. However, a clearer contrast between conditions was now found, by replacing the incongruent with neutral gaze displays (c.f., items 8-10 in Figures 12 and 14). Once again, however, this did not exert a clear effect on observers' self-recognition in the discrimination task, which revealed identical effects for congruent and neutral stimulation displays in comparison to the initial measure at baseline.

Despite the absence of an effect on self-recognition in the visual discrimination task, the gaze-contingent paradigm affected observers' reports of how they felt about the onscreen and their own face. These reports revealed that observers felt that the onscreen face 'was' their own face and 'belonged' to them, and also that both faces began to resemble each other. This effect was such that, if the eyes of the onscreen face had moved, observers increasingly expected their own eyes to move too.

These results indicate that this mirror-like gaze-contingent paradigm can affect how observers feel about their own faces. This finding converges with recent enfacement experiments, in which similar effects are found when observers view the tactile stimulation of another agent while their own face is also stimulated (e.g., Maister et al., 2013; Tajadura-Jiménez et al., 2012a, 2012b; Tsakiris, 2008). However, in these studies a concurrent effect in the self-other discrimination task is typically also found (e.g., Tajadura-Jiménez et al., 2012a; Tsakiris, 2008).

A possible explanation for the absence of such an effect here might relate to the objects surrounding the target face, which acted as trigger-regions to change its gaze-direction and were required to elicit mirror-like responses. As a result of this manipulation, observers were actually drawn away from the onscreen face during stimulation. If this limits the encoding of the stimulation faces in our visual displays, by presenting these outside of foveal vision (see, e.g., Rousselet, Thorpe, & Fabre-Thorpe, 2004; Rousselet, Husk, Bennett, & Sekuler, 2005), then this could eliminate the integration of the stimulation face into observers' self-representations. To address this limitation, we conducted a third experiment in which the eight boxes surrounding the onscreen face were replaced with the same face. The aim of this manipulation was to maximize encoding of this identity even when observers were not viewing the central stimulation face in the display directly.

Experiment 6

In this experiment, we sought to maximise the encoding of the face identity in the stimulation task. As in the preceding experiments, an unfamiliar face was placed in the centre of the screen and responded to observer's eye-gaze. However, to increase the encoding of this identity, the eight surrounding boxes were replaced with copies of the same face. In contrast to Experiments 1 and 2, observers were therefore able to view the stimulation face directly, in the centre of the screen or one of the surrounding locations, throughout this task. These surrounding faces also responded to observer's eye-gaze by copying the actions of the central face. This manipulation overcomes the potential limitations of Experiment 4, in which eye-gaze direction could be perceived only from the unattended central face. In the current experiment, this allowed us to revert to incongruent gaze displays, in which the onscreen gaze moves in temporal synchrony but a different direction to observers' own eye-gaze.

To introduce a task demand, after a two-minute stimulation period, one of the surrounding faces would close its eyes and observers were asked to detect this change. If it is possible to update self-representations with this gaze-contingent paradigm, then such an effect should be more likely under these conditions, which maximise encoding of the stimulation face, than the preceding experiments.

Method

Participants

Twenty new Caucasian students (17 females) from the University of Kent, with a mean age of 22 years (SD = 8.5), participated in this study. All provided informed consent prior to taking part and received course credits or a small fee for participation. All reported normal or corrected-to-normal vision.

Stimuli and procedure

The stimuli and procedure were identical to Experiment 4, except for the following changes. In the stimulation task, the eight boxes surrounding the central face, and the objects within, were now replaced by copies of the stimulation face (see Figure 17). Each of these peripheral faces measured 160 by 210 pixels at a screen resolution of 72 ppi. In the congruent condition, the central face and each of these peripheral copies mirror-mimicked observers' eye-gaze direction. In the incongruent condition, the eye-gaze direction of the central face and the peripheral copies was spatially incongruent with observers' gaze. After a two-minute stimulation period, one of the surrounding faces closed it eyes. Observers were asked to scan the surrounding faces and to press <SPACE> as soon as they detected this change.

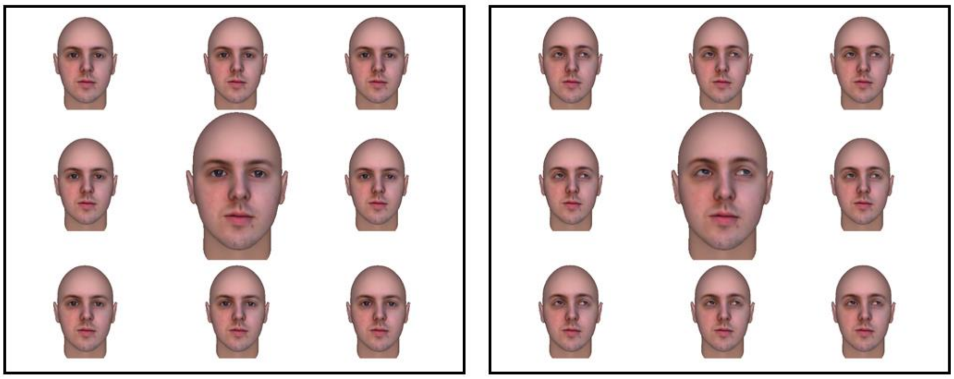

Figure 17. Example stimuli for Experiment 3, showing direct and averted eye-gaze.

Results

Self-other discrimination task

Figure 18 summarizes performance in the discrimination task for the baseline condition and after the administration of the congruent and incongruent stimulation displays. A one-factor ANOVA (baseline, congruent, incongruent) showed a main effect of condition, $F(1,19) = 11.57$, $p < .001$, $\eta_p^2 = .38$. Paired sample t-tests (Bonferroni-corrected) show that observers perceived their own face earlier in the discrimination sequence in the congruent condition compared to the baseline, $t(19) = 3.12$, $p < .05$. However, a similar effect was observed in the incongruent condition, $t(19) = 3.40$, $p < .05$, and performance was indistinguishable when the congruent and incongruent conditions were compared directly, $t(19) = 0.95$, $p = 1.00$.

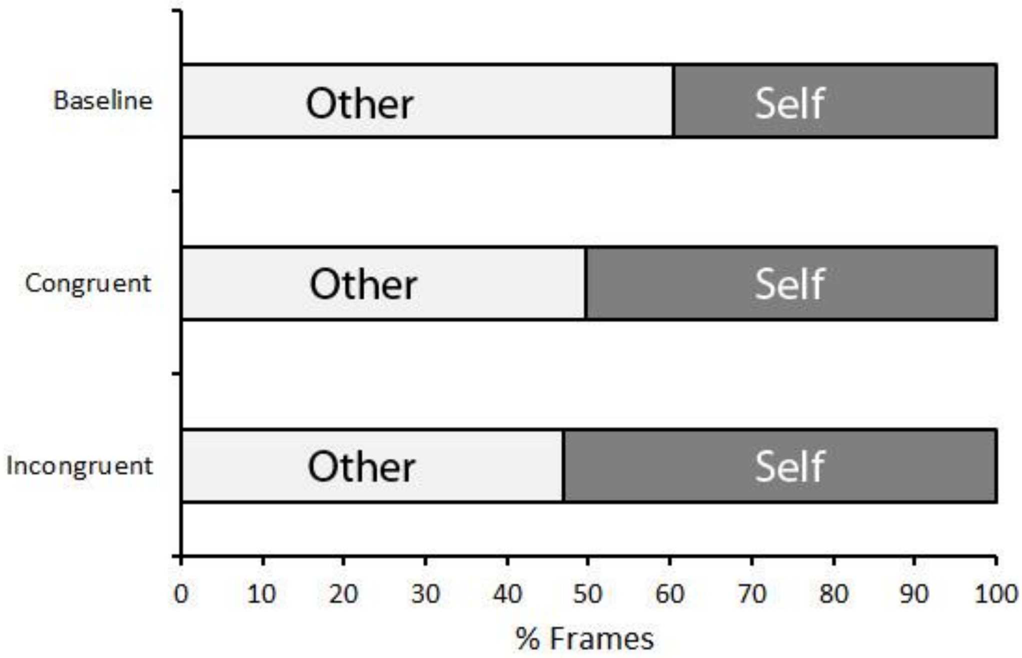

Figure 18. Performance in the self-other discrimination task in Experiment 3, expressed as the number of frames that observers judged to show their own face or that of the onscreen face, for the baseline measure and after congruent and incongruent stimulation.

Enfacement questionnaire

The questionnaire responses indicate that observers were aware of the onscreen face following their own eye-gaze in the congruent compared to the incongruent condition (see items 8 and 9 in Figure 19), both $ts(19) \geq 2.19$, $ps < .05$. Observers were also much more likely to report that the target's eyes moved in the same direction as their own eyes in the congruent condition (item 10), $t(19) = 7.13$, $p < .001$, and in a different direction in the incongruent condition (item 11), $t(19) = 6.66$, $p < .001$. In addition, a direct comparison of the ratings for items 10 (eyes moved in the same direction) and 11 (eyes moved in a different direction) confirms that observers discriminated the directionality of the onscreen eye movements in both the congruent, $t(19) = 12.15$, $p < .001$, and incongruent condition, $t(19) = 3.10$, $p < .001$.

The gaze contingent paradigm also influenced how observers felt about the onscreen face. In the congruent compared to the incongruent condition, observers were more likely to report that the onscreen face looked like their own face (item 1), that it belonged to them (item 2), and that they felt they were looking at their own face in a mirror (item 3), all $ts(19) \geq 2.06$, $ps < .05$. This effect was such that observers expected their own eyes to move too if the eyes of the target face had moved (item 7), $t(19) = 2.96$, $p < .01$.

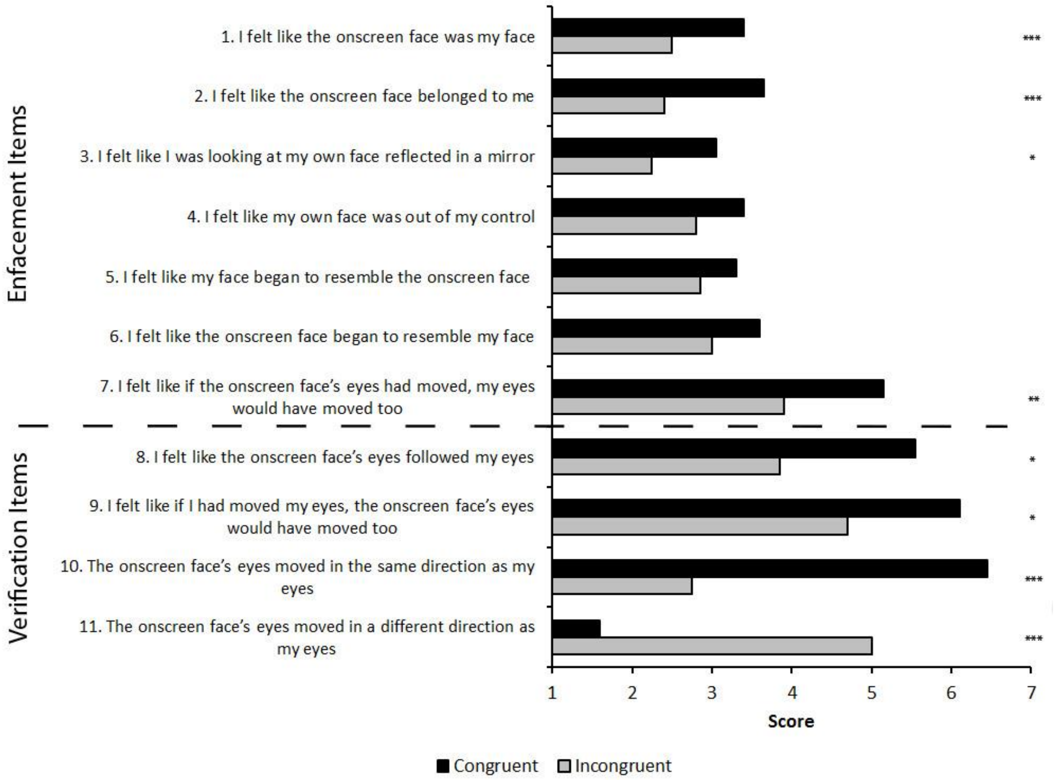

Figure 19. Mean Likert responses to each enfacement item for the congruent (black bars) and incongruent (grey bars) conditions in Experiment 3. * p < .05; ** p < .01; *** p <.001.

However, an effect of condition was not universally found. Despite the clear convergence in *felt* resemblance between observers' own and the onscreen face, they did not report that these faces *actually* began to resemble each other (items 5 and 6), both $ts(19) \leq 1.65$, $ps > .07$. In addition, observers also did not report that their own face felt out of control (item 4), $t(19) = .19$, $p = 1.67$. Despite these similarities across conditions, observers' overall ratings, which was calculated by summing the scores for items 1 to 7, also revealed a higher enfacement score in the congruent (M = 25.5, SD = 9.1) than the incongruent condition (M = 19.7, SD = 8.8), $t(19) = 3.42$, $p < .01$.

Discussion

In this experiment, the objects surrounding the onscreen face during the stimulation phase were replaced with further images of this identity to maximize its encoding. In this context, observers were clearly sensitive to the onscreen face's eye movements in the congruent and incongruent conditions. As in Experiment 5, the gaze-contingent stimulation paradigm also influenced how observers felt about the onscreen face, whereby they were more likely to report that it looked like their own face and that it belonged to them in the congruent than in the incongruent condition. This effect was sufficiently strong for observers to be more likely to report that they felt as if they were looking at their own face in a mirror in the congruent condition, and that their own eyes might move to mimic the actions of the onscreen face. Despite this impact on observers' reports, the gaze-contingent task did not produce separable effects for the congruent and incongruent conditions in the discrimination task. This converges with the findings of Experiments 3 and 4 to suggest that the gaze-contingent paradigm does not influence observers' perceptual facial self-representation.

General discussion

In the present chapter, a new paradigm to study how human observers might update mental representations of their own face has been presented. This paradigm simulates the mirror reflection experience by mimicking observers' eye-gaze behaviour with an onscreen face. In Experiment 4, observers were exposed to congruent stimulation, in which the movement of the onscreen face was synchronized with their own gaze behaviour, and an incongruent condition, in which the eyes of the onscreen face moved in a different direction to observers' eye-gaze. This experiment did not reveal an effect of gaze stimulation on observers' subjective reports or in the self-other discrimination task. The verification items of the questionnaire suggest that observers were sensitive to onscreen eye-gaze in the congruent condition only. By contrast, however, observers did not report a clear directionality for the onscreen face's eye movements in the incongruent condition. This suggests that they misperceived the direction of the onscreen face's eye movements, which might have undermined any stimulation effects of the gaze-contingent task.

Subsequent experiments explored whether the gaze-contingent paradigm can be modified to elicit such effects. Experiment 5 replaced the incongruent condition with neutral displays, in which the onscreen eye-gaze was static and unresponsive, to provide a stronger contrast with congruent displays (see Burton et al., 2009; Yokoyama et al., 2014). Observers' self-reports showed that they were sensitive to the difference in the eye movements between conditions, and also the mimicry that these eye-movements exerted in the congruent condition. This was accompanied by a feeling that the onscreen face 'was' their own face and 'belonged' to them, and that both faces began to resemble each other. This effect was such that, if the eyes of the onscreen face had moved, observers would have expected their own eyes to move too. Once again, however, these changes were not accompanied by a corresponding effect in the self-other discrimination task, which indicates that the gaze-contingent task did not modify observers' perceptual representations of the own face.

It is possible that the encoding of the onscreen face was limited in these experiments because observers were drawn from its location to the peripheral object-triggers during the stimulation phase. A third experiment was conducted in which these peripheral objects were replaced with further photos of the onscreen face to promote further encoding of this identity. These additional face images also responded to observers' gaze in an attempt to further enhance this manipulation. In contrast to Experiment 4, observers were now clearly sensitive to gaze direction in both the congruent and incongruent condition. As in Experiment 5, this was accompanied by stronger reports in the congruent condition that the onscreen face was observers' own face than with incongruent displays, and that observers felt like they were looking at their own face in a mirror. Once again, however, the stimulation conditions did not affect the perceptual discrimination task.

Taken together, these results indicate that our gaze-contingent mirror-experience paradigm can alter observers' subjective reports about their own face, by creating a higher 'felt' resemblance between their own face and an onscreen target in the congruent than in the neutral or incongruent conditions. At the same time, this stimulation was not effective in altering observers' perceptual self-representations, as measured with the self-other discrimination task. A possible explanation for these differences between observers' subjective reports and their perceptual performance could be that these reflect independent pathways in the cognitive face recognition system. One of these might be responsible for the perceptual recognition of a face, whereas the other provides an accompanying arousal response (see Ellis & Young, 1990; Schweinberger & Burton, 2003). This idea derives from the study of Capgras patients, who can identify familiar faces but do not exhibit the appropriate corresponding feelings of familiarity. As a consequence, these patients believe that familiar people are replaced by impostors or aliens (Ellis, 1997). It is possible that our gaze-contingent paradigm exerts the reverse effect, by manipulating affective evaluations of the own face but not perceptual representations.

This idea receives some support from explorations of the enfacement effect, where visuotactile stimulation mediates arousal responses to target faces (e.g., Bufalari et al., 2014; Fini et al., 2013; Maister et al., 2013; Paladino et al., 2010; Tajadura-Jiménez et al., 2012a). However, it remains unresolved why perceptual processing was not affected as well in the current experiments. One possibility is that a stimulation phase of only two minutes is insufficient to manipulate self-representations that have been built up over twenty years in our participants. This explanation would be consistent with theories of face recognition, such as average-based accounts, in which different instances of the same face are integrated into a single representation (Burton, et al., 2005). Such averages appear to be remarkably resistant to contamination by other identities. For example, changes to the average of a person's face appear to be imperceptible even when 20% of the source images are photographs of the wrong person (Jenkins & Burton, 2011). If this approach corresponds to the cognitive system for face recognition, then one would also expect internal facial representations to be immune to the brief perceptual stimulation that is applied in the experiments here.

In future studies, this could be explored further by extending the stimulation phase or by applying this paradigm to developmental populations, in which self-representations have been established for fewer years and facial appearance is undergoing more pronounced age-related changes. In such studies, the effect of mirror-feedback might also be enhanced by mimicking more than observers' eye-gaze, such as facial expression and speech. By encompassing further facial information in this way, the mirror-mimicry may exert more direct effects on visual encoding and the updating of representations of the own face.

Chapter 4:

Does multisensory stimulation modulate cognitive representations of facial identity? Evidence from Event-Related Potentials.

Introduction

Chapter 3 presented a new paradigm to study the process of updating the own face presentation. This gaze contingent paradigm simulates the mirror reflection experience by mimicking observers' eye-gaze behaviour with an onscreen face. However, although this stimulation altered observers' subjective reports about their own face, it was not effective in altering observers' perceptual self-representations. One question that arises refers to the cognitive locus of the processes of updating the own face representation. Chapter 4 explores this issue using ERPs.

According to models of face processing (see Breen et al., 2001; Bruce & Young, 1986; Schweinberger & Burton, 2003), the enfacement might arise at three different loci. Firstly, it might arise at early perceptual processing stages (i.e., structural encoding). In support of this reasoning, an fMRI study has shown activation of the inferior occipital gyrus (IOG), a brain structure that has been linked to structural encoding of faces (see Haxby, Hoffman, & Gobbini, 2000), while observers experienced the enfacement illusion (Apps, Tajadura-Jiménez, Sereno, Blanke, & Tsakiris, 2015). In addition, there is experimental evidence that the lateral part of this structure, the occipital face area (OFA), is involved in the processing of individual facial features but not in the representation of the identity (see Barton, 2008; Kanwisher & Barton, 2011).

Alternatively, the enfacement effect could also arise during later processing stages, such as a pre-semantic stage at which visual stimuli are matched to a stored identity representation (i.e., a "Face Recognition Unit", FRU; see Breen et al., 2001; Bruce & Young, 1986; Schweinberger & Burton, 2003). Some evidence also supports this view. For example, psychometric approaches have shown that the main component of the enfacement illusion reflects the identification of the other face as own (Tajadura-

Jiménez et al., 2012b). In addition, that the enfacement illusion affects performance in self-recognition tasks also suggests an identity locus in the process of updating the own face representation (e.g., Tajadura-Jiménez et al., 2012a; Tsakiris, 2008).

Lastly, the enfacement effect could arise during the affective evaluation of the face (i.e., arousal response) that mediates recognition (see Breen et al., 2001; Schweinberger & Burton, 2003). Some research also supports this hypothesis. For example, familiar faces produce changes of autonomic physiological responses, such as electrodermal activity (see, e.g., Damasio, Tranel & Damasio, 1990). These changes are considered to reflect the mediation of an arousal emotional response to that face (Damasio et al., 1990; Schweinberger & Burton, 2003). Interestingly, Tajadura-Jiménez et al. (2012a) also showed that these physiological changes toward the enfaced face were higher during the synchronous than asynchronous multi-sensory facial stimulation. In addition, it has been found that the level of positive perception of the enfaced face is positively related to the strength of the enfacement illusion (Bufalari et al, 2014; see also, Paladino et al., 2010; Sforza et al., 2010). This suggests also that the enfacement illusion might depend on positive emotions toward the enfaced face.

In the present study, we investigated directly which of these processes the enfacement illusion affects by using ERPs. This technique has been used widely to explore the time course and models of face processing (see, e.g., Eimer, 2011; Schweinberger, 2011). Given its high temporal resolution, ERPs are well suited to exploring the process by which representations of the own face are updated. Here we were specifically interested in three ERP components as potential correlates of the three purported cognitive loci of enfacement. The N170 is a negative deflection over occipito-temporal sites approximately 170 ms after stimulus onset. It is enhanced in response to faces compared to non-face objects (Bentin et al., 1996; Eimer, 2000, 2011) and is considered to reflect early perceptual stages of face processing which precede identity recognition (Bruce & Young, 1986; Eimer, 2000, 2011). However, recent research also suggests that this component is modulated by “self-information”, as it is more negative for the own face compared to familiar and unfamiliar faces (Caharel et al., 2002; Keyes et al., 2010, but see Sui et al., 2006; Tanaka et al., 2006).

A subsequent component that has been more specifically linked to the activation of identity-specific representations for familiar faces is the N250 (Kaufmann, Schweinberger, & Burton, 2009; Schweinberger et al., 2002; Schweinberger, 2011; Tanaka et al., 2006). This component consists of a negative deflection that peaks around 250 ms after the presentation of a known face at inferior-temporal electrodes. This deflection is larger for familiar compared to unfamiliar faces and has therefore been related to the activation of stored facial identity representations (see Schweinberger, 2011). In addition, research has shown that this component is more negative for the own face compared to unfamiliar faces (Pierce et al., 2011; Tanaka et al., 2006). Tanaka et al. (2006) found, for example, that the N250 was enhanced for the own face compared to an unfamiliar target face in the first half of an experiment. However, in the second half of the experiment, the N250 was similar for both types of faces. This could suggest that the N250 reflects two different indexes of facial memory: one for pre-existing familiar face representations, such as the own face, and one for newly acquired face representations, such as the target face. Furthermore, the increase of N250 amplitude during experimental face familiarization is not restricted to the repetition of identical images, which indicates further that this component is related to person identification (Kaufmann et al., 2009).

The P300 component is a positive deflection at centro-parietal sites, which peaks approximately 300 to 600 ms after stimulus onset. This component is considered to be modulated by the arousal or emotional saliency of stimuli, as it is larger for stimuli with affective connotations (see, e.g., Carretié, Iglesias, Garcia, & Ballesteros, 1997). This component is also larger for the own face compared to unfamiliar faces (Ninomiya et al., 1998). Some prosopagnosic patients also show a preserved P300 response after the presentation of a familiar face (Bobes et al., 2004; see also Renault et al., 1989), which indicates that this component may also reflect covert face recognition (Bobes et al., 2004; see also Meijer, Smulders, Merckelbach, & Wolf, 2007).

The fact that the own face modulates ERP components in the early perceptual stages of the face processing (N170), the activation of facial identity (N250) and the emotional response to stimuli (P300) suggests that these components can be used to explore the cognitive locus of the enfacement illusion. Experiment 7 explores this question.

Experiment 7

Experiment 7 explores the cognitive locus of the enfacement effect. In an initial stimulation stage, observers were exposed to blocks of synchronous and asynchronous stimulation. ERPs were then recorded during a subsequent face target detection task in which they were presented with pictures of their own face, the synchronously and asynchronously stimulated faces, two novel faces, and the target, which was the only face that required an overt response. We reasoned that if the process of enfacement affects the early perceptual encoding of the enfaced face, then N170 elicited by the own face should be similar to that of the synchronously but not the asynchronously stimulated face. If, on the other hand, enfacement causes the updating of identity representations or emotional arousal response to the enfaced face, then these effects should be observed at the N250 and the P300, respectively.

Method

Participants

Twenty-eight Caucasian students (10 females) from the Friedrich Schiller University of Jena, with a mean age of 23 years (*SD* = 2.8), participated in this study. All provided informed consent, reported normal or corrected-to-normal vision, and received course credits or a small payment for participation.

Stimuli

To generate the stimuli for the multisensory stimulation stage, video footage of four Caucasian models (two males and two females) was recorded. In this footage, the models looked straight at the camera with a neutral expression while their left cheek was stroked with a cotton bud at two-second intervals for two minutes. An additional face photograph was taken of each model for the target detection task (see below). In the videos and the photographs, the models always wore a white EEG cap.

Face photographs of six additional identities with a white EEG cap were also taken (three males and three females). In the experiment, these photographs were matched to the sex of each observer, with one of these serving as the target and the other two as novel faces. Finally, a photograph of each observer wearing a white EEG cap was also taken prior to the experiment for use in the own face condition. In total, observers therefore saw six face identities of the same sex: their own face (OF), a synchronously stimulated face (SF), an asynchronously stimulated face (AF), a target face (TF) and two novel faces (NV). The pictures measured approximately 350 (W) x

470 (H) pixels (~ 7 x 9 degrees of visual angle) at a screen resolution of 72 ppi and were presented on a black background. Examples are provided in Figure 20.

Figure 20. Example photographs of male (left) and female (right) observers.

Procedure

Participants were seated at a distance of 100 cm from the screen, which was maintained with a chin-rest. Stimuli were displayed using E-prime^{TM} 2.0.8.22 (Psychology Software Tools, Inc., Sharpsburg, PA) on a 16'' monitor with a screen resolution of 768 (H) x 1024 (W) pixels. The experiment consisted of four blocks, comprising two blocks for the synchronous condition and two for the asynchronous condition. The order of blocks was counterbalanced across observers. Apart from the own face, which differed by definition across all participants, all female observers saw the same set of female faces across blocks, and all male observers saw the same set of male faces across blocks. However, within each participant sex, the allocation of faces to experimental conditions (apart from the own-face) was counterbalanced across participants.

Each block included two stimulation and two test phases. In each block (see Figure 21), observers first saw a two-minute video of a model being stroked with a cotton bud on the cheek. At the same time, participants were touched with an identical cotton bud on the specular congruent location in synchrony (synchronous condition) or in asynchrony (with a delay of one second) with the model (asynchronous stimulation). Immediately after the video ended, the observers' subjective experience during the stimulation stage was assessed with a German translation of the statement "I felt I was looking at my own face" ("Ich hatte das Gefühl, dass das Video mein eigenes Gesicht zeigte"). This statement has been used repeatedly in previous work to measure enfacement (e.g., Apps et al., 2015; Tajadura-Jiménez et al., 2012b). Observers rated their level of agreement with this statement on a 7-point Likert scale, ranging from "strongly disagree" to "strongly agree".

After stimulation, participants were presented with the target face and a fictitious name ("Anna" for female targets and "Hans" for male targets) onscreen, which they were asked to memorize. During the recoding of EEG, they were then asked to monitor a sequence of faces and press <SPACE> as fast as possible every time the target face was presented. These experimental trials started with a fixation cross displayed for 500 ms, which was followed by a face for 1500 ms. Feedback was given if observers mistakenly responded to a non-target face (e.g., "This was not Anna!"), or when they failed to respond to the target face (e.g., "This was Anna!"). The Feedback display was presented for 500 ms. No feedback was given for correct responses and correct omissions and a blank screen was presented for 500 ms instead.

Each of the six different identities (OF, SF, AF, TF, and the two NF) was presented 30 times per block, giving a total of 180 trials. After 90 trials, observers were given a short break, after which the stimulation, rating and test phases were repeated once. Therefore, each block consisted of a total of two stimulation, rating and test phases, respectively.

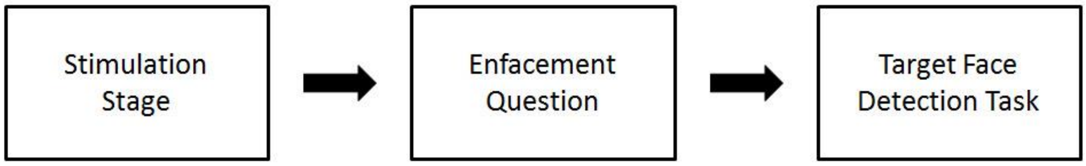

Figure 21. Experimental block procedure.

The structure of the second block was identical to the first block but observers received a different kind of stimulation (i.e., if observers had received synchronous stimulation in the first block, they received asynchronous stimulation in the second block and vice versa). The application of these conditions was counterbalanced across participants (i.e., SASA and ASAS).

EEG/ERP methods

EEG data were recorded with sintered Ag/AgCl electrodes mounted in an electrode cap (EasyCap™, Herrsching-Breitbrunn, Germany) using SynAmps amplifiers (NeuroScan Labs, Sterling, VA). Electrodes were arranged according to the extended 10/20 system at the scalp positions Fz, Cz, Pz, Iz, Fp1, Fp2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T7, T8, P7, P8, FT9, FT10, P9, P10, PO9, PO10, F9, F10, F9’, F10’, TP9 and TP10. Cz served as initial common reference and a forehead electrode (AFz) served as ground. Impedances were kept below 10 kΩ and were typically below 5 kΩ. The horizontal electrooculogram (EOG) was recorded from F9′ and F10′ at the outer canthi of both eyes. The vertical EOG was monitored bipolarly from electrodes above and below the right eye. Signals were assessed with AC (0.05–100 Hz, −6 dB attenuation, 12 dB/octave) and sampled at 500 Hz. Offline, ocular artefacts were automatically corrected using BESA ™ 5.1.8.10 (Berg & Scherg, 1994). Epochs were generated, lasting 1200 ms, including a 200 ms pre-stimulus baseline. Only trials with correct responses were analysed. Trials contaminated by non-ocular artefacts were rejected from further analysis using the BESA™ artefact rejection tool (amplitude threshold 100µV, gradient criterion 75µV). Trials were averaged separately for each channel and experimental condition. Averaged ERPs were low-pass filtered at 20 Hz (zero phase shift), and recalculated to average reference, excluding vertical and horizontal EOG channels. ERPs were quantified using mean amplitudes for the occipito-temporal N170 (155 - 175 ms), the inferior-temporal N250 (250 - 360 ms), and the P300 (370 - 570 ms), all relative to a 200 ms pre-stimulus baseline. Time-windows for these components were selected in accordance with distinct peaks identified in the average of all condition grand mean waveform. Effects were quantified at electrodes of interest, which were selected based on the maxima of a particular component in the grand mean waveform and on previous research (Schweinberger et al., 2004; Schweinberger et al., 2002). Accordingly, N170 was assessed at P7, P8, P9, P10, PO9 and PO10, the N250 was captured at P7, P8, P9 and P10, and the P300 was measured at C3, C4, P3, P4 and Cz.

Results

Self-report

Observers' subjective experience of the enfacement illusion during stimulation was analysed first, by averaging the ratings to the statement "I felt I was looking at my own face" for blocks with synchronous and asynchronous stimulation, respectively. As expected, these ratings were higher for the synchronous (*mean* = 2.53, *SD* = 1.32) than for the asynchronous condition (*mean* = 1.78, *SD* = 1.01), $t(27) = 3.53$, $p < .01$. This indicates that participants perceived the other face as more similar to their own face in the synchronous compared to the asynchronous condition.

Behavioural Results

In the target detection task, accuracy was at ceiling level (over 99% correct across all conditions). Reaction times (RTs) were analysed for hits only, as responses were only required to the target face. When necessary in this and all subsequently reported ANOVAs, degrees of freedom were adjusted according to the Huynh-Feldt procedure. A 2 (stimulation: synchronous vs. asynchronous) x 2 (time: first half vs. second half of experiment) repeated-measures ANOVA was conducted. Observers were faster to respond to the target face in the asynchronous condition (*median* = 573 ms, *SD* = 66 ms) than in the synchronous condition (*median* = 584 ms, *SD* = 67 ms), $F(1,27) = 4.50$, $p < .05$, $\eta_p^2 = .14$. Responses were also faster in the second half of the experiment (*median* = 564 ms, *SD* = 71 ms) than the first (*median* = 595 ms, *SD* = 62 ms), $F(1,27) = 27.69$, $p < .01$, $\eta_p^2 = .50$.

ERP Results

ERP amplitudes were analysed with repeated-measures ANOVAs of the factors stimulation (synchronous vs. asynchronous), time (first half vs. second half of experiment) and face type (OF vs. SF vs. AF vs. TF vs. NF[1]). For the N170 and N250 components, the factors hemisphere (left vs. right) and site (N170: P7/P8 vs. P9/P10 vs. PO9/PO10; N250: P7/P8 vs. P9/P10) were also included, whereas the factor electrode (C3 vs. C4 vs. P3 vs. P4 vs. CZ vs. PZ) was included for the P300. For

[1] Although two different novel faces were included in the task, ERP data for both faces were combined into one level by averaging across both novel faces.

brevity, main effects of face type and interactions with this factor are reported only when significant.

N170

Results for the N170 component are summarized in Figures 21 and 22. ANOVA revealed a main effect of face type for the N170, $F(4,108) = 15.06$, $p < .001$, $\eta_p^2 = .358$, which was qualified by a two-way interaction with hemisphere, $F(4,108) = 2.46$, $p < .05$, $\eta_p^2 = .08$. Subsequent separate ANVOAs for left and right hemispheric electrodes yielded main effects of face type over both hemispheres, with somewhat larger effects at left hemispheric sites, $F(4,108) = 14.00$, $p < .001$, $\eta_p^2 = .34$ and $F(4,108) = 5.30$, $p < .01$, $\eta_p^2 = .16$, respectively.

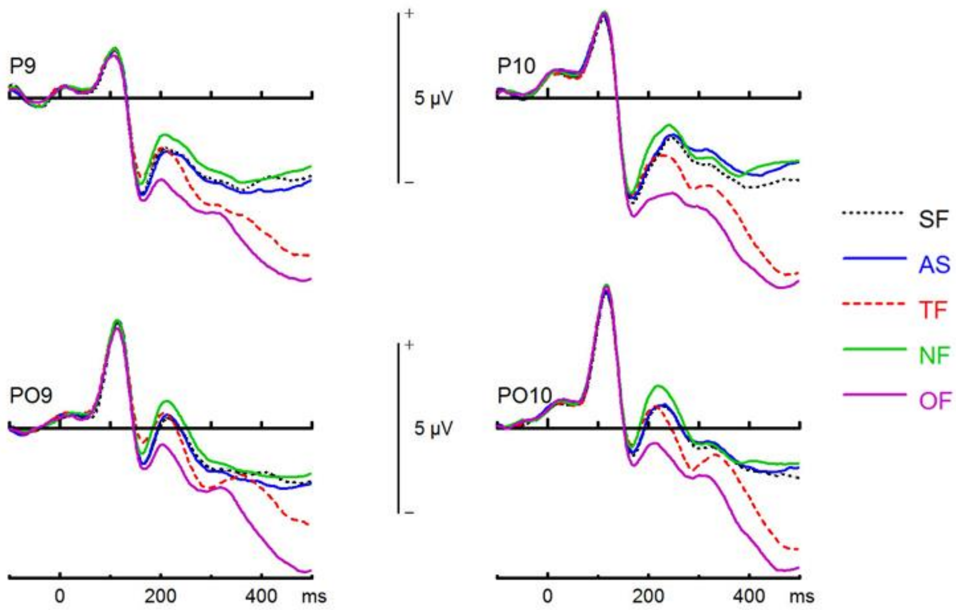

Figure 21. Grand-average ERPs for sites P9/P10 and PO9/PO10 illustrating the N170.

The main effect of face type was also modified by site, as revealed by a two-way interaction, $F(8,216) = 3.05$, $p < .01$, $\eta_p^2 = .10$. Separate ANOVAs for each site revealed main effects of face type at P7/P8, $F(4,108) = 4.30$, $p < .01$, $\eta_p^2 = .13$, P9/P10, $F(4,108) = 12.69$, $p < .001$, $\eta_p^2 = .32$, and PO9/PO10, $F(4,108) = 15.47$, $p < .001$, $\eta_p^2 = .36$. Visual inspection suggests similar N170 amplitudes for SF and AF, and more negative amplitudes for OF (see Figure 21 and 22).

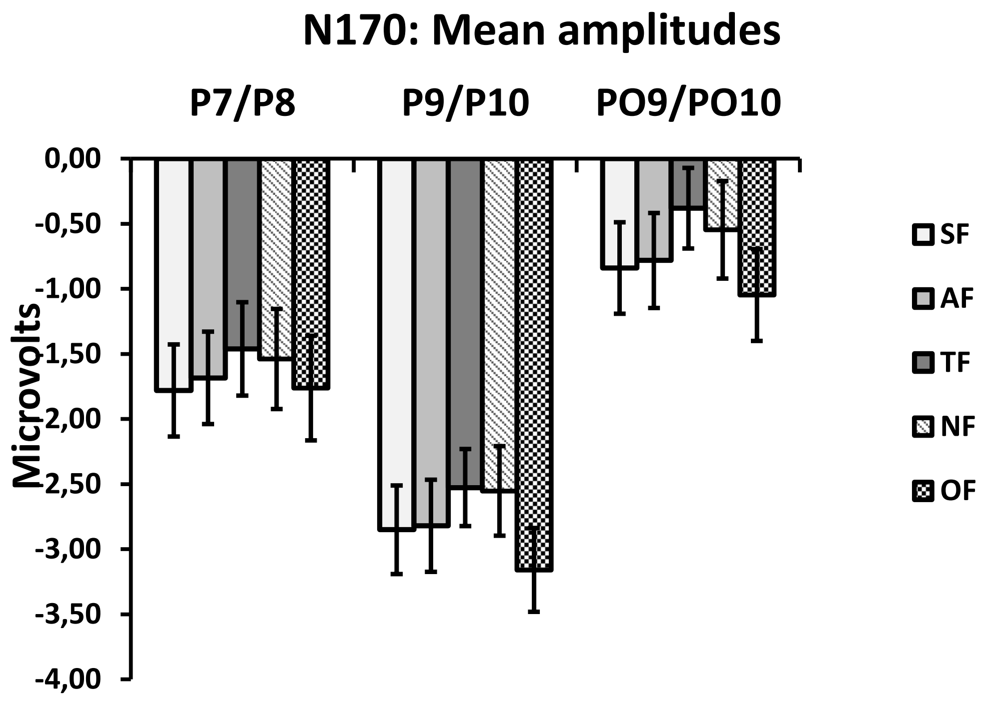

Figure 22. N170 mean amplitudes for each face type in sites P7/P8, P9/P10 and PO9/PO10.

This was confirmed by four planned pair-wise comparisons (LSD) between SF and the other face type conditions at each site. These tests revealed no significant differences between SF and AF at any of the three sites. In contrast, N170 amplitudes for SF were smaller than for OF at P9/P10 and PO9/PO10, both *ps* ≤ .05 Compared to TF and NF, N170 amplitudes for SF faces were also consistently larger at all three sites, all *ps* ≤ .01 (for an overview of these differences, see Table 3).

In sum, these data show no evidence for reliable differences in N170 amplitudes between synchronously and asynchronously stimulated faces. Furthermore, N170 amplitudes were more negative for these two conditions compared to target and novel faces, but less negative compared to own-faces.

	SF vs. AF	SF vs. TF	SF vs. NF	SF vs. OF
Left hemisphere	*p = .94*	*p < .001*	*p < .001*	*p = .31*
Right hemisphere	*p = .34*	*p = .03*	*p = .05*	*p = .07*
P7/P8	*p = .37*	*p = .01*	*p = .02*	*p = .86*
P9/P10	*p = .74*	*p < .01*	*p < .001*	*p < .01*
PO9/PO10	*p = .55*	*p < .001*	*p < .01*	*p = .03*
Overall	*p = .42*	*p < .001*	*p < .01*	*p = .04*

Table 3. Pair-wise Comparisons Between SF and the Other Conditions for the N170 Component

N250

For the N250, ANOVA showed a main effect of face type, $F(4,108) = 34.99$, $p < .001$, $\eta_p^2 = .56$. Visual inspection suggests the most prominent differences were between the OF and all other conditions (see Figure 21 and 23).

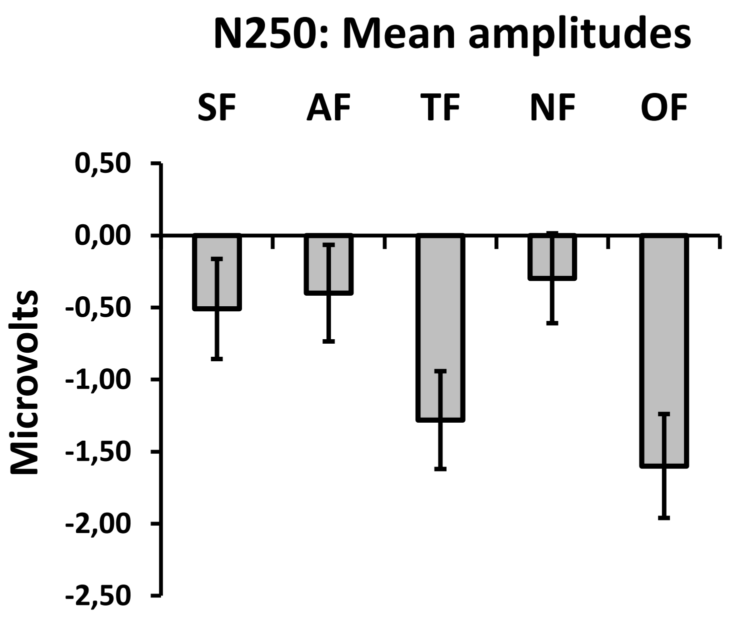

Figure 23. N250 mean amplitudes for each face type.

The main effect of face type was further qualified by two-way interactions with site, $F(4,108) = 3.35$, $p < .05$, $\eta_p^2 = .11$, hemisphere, $F(4,108) = 3.50$, $p < .05$, $\eta_p^2 = .115$, and time, $F(4,108) = 9.56$, $p < .001$, $\eta_p^2 = .26$. These interactions were tested further with separate ANOVAs with repeated measurements of face type for each site, hemisphere, and time. A main effect of face type was present at P7/P8, $F(4,108) = 19.81$, $p < .001$, $\eta_p^2 = .42$, and P9/P10, $F(4,108) = 32.14$, $p < .001$, $\eta_p^2 = .54$. The main effect of face type was also significant at left, $F(4,108) = 19.86$, $p < .001$, $\eta_p^2 = .42$, and right hemispheric sites, $F(4,108) = 25.76$, $p < .001$, $\eta_p^2 = .48$. Furthermore, a main effect of face type was found in the first half of the experiment, $F(4,108) = 28.30$, $p < .001$, $\eta_p^2 = .51$, and the second half, $F(4,108) = 32.99$, $p < .001$, $\eta_p^2 = .55$. As for the N170, main effects of face type were further tested by planned pair-wise comparisons (LSD), focusing on potential differences between SF and the other face type conditions. As can be seen in Table 4, none of the comparisons showed significant differences between the SF and the AF conditions. N250 amplitudes were overall largest for own-faces, with the TF approaching similar N250 amplitudes.

In summary, these results show that the own face produced a larger N250 compared to all other faces in the first part of the experiment. However, in the second half of the experiment the target faces evoked an N250 component that was similar in magnitude to that of the own face. This finding replicates previous studies (see Pierce et al., 2011; Tanaka et al., 2006). There was no evidence that synchronous and asynchronous multisensory stimulation differentially affected N250 amplitude differences.

	SF vs. AF	SF vs. TF	SF vs. NF	SF vs. OF
P7/P8	*p = .56*	*p < .001*	*p = .16*	*p < .001*
P9/P10	*p = .54*	*p < .01*	*p = .09*	*p < .001*
Left hemisphere	*p = .39*	*p < .001*	*p = .06*	*p < .001*
Right hemisphere	*p = .14*	*p < .01*	*p = .27*	*p < .001*
First half	*p = .71*	*p < .01*	*p = .15*	*p < .001*
Second half	*p = .36*	*p < .001*	*p = .07*	*p < .001*
Overall	*p = .50*	*p < .001*	*p = .09*	*p < .001*

Table 4. Results of Pair-wise Comparisons Between SF and the Other Conditions for the N250 Component.

P300

An ANOVA with repeated measurements on the factors electrode (C3 vs. C4 vs. P3 vs. P4 vs. Cz vs. Pz), time (first half vs. second half), stimulation (synchronously vs. asynchronously) and face type (SF vs. AF vs. TF vs. NF vs. OF) revealed a main effect of face type, $F(4,108) = 56.98$, $p < .001$, $\eta_p^2 = .67$, which was qualified by a two-way interactions between face type and electrode, $F(20,540) = 25.22$, $p < .001$, $\eta_p^2 = .48$, and face type and time, $F(4,108) = 28.99$, $p < .001$, $\eta_p^2 = .51$. Overall, P300 amplitudes appeared to be largest for own and target faces (see Figure 24 and 25).

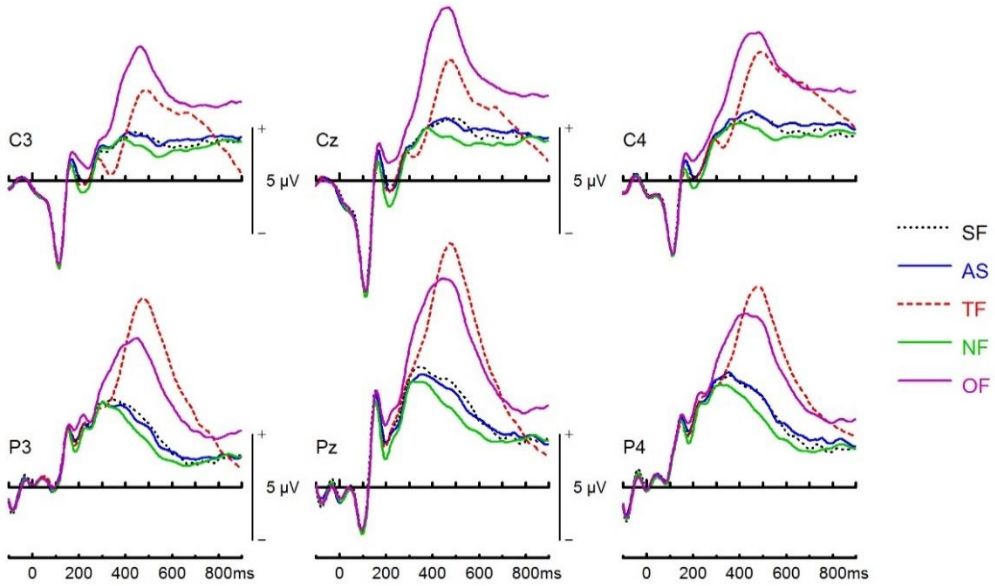

Figure 24. Grand-average ERPs for electrodes C3, P3, CZ, PZ, C4 and P4 illustrating the P300.

The interaction of face type and electrode was followed up by separate ANOVAs for each electrode and, in the case of significant main effects of face type, by pair-wise comparisons (LSD) between SF and the other conditions. These analyses revealed effects of face type for each electrode, all *Fs*(4,108) ≥ 23.78, *ps* < .001, ηs_p^2 ≥ .46, but there was no evidence for significant amplitude differences between SF and AF conditions.

The interaction between face type and time was further investigated by two separate ANOVAs for the first and the second half of the experiment, respectively. An effect of face type was found for the first and second half of the experiment, $F(4,108) = 56.56$, $p < .001$, $\eta_p^2 = .67$ and $F(4,108) = 51.21$, $p < .001$, $\eta_p^2 = .65$, respectively.

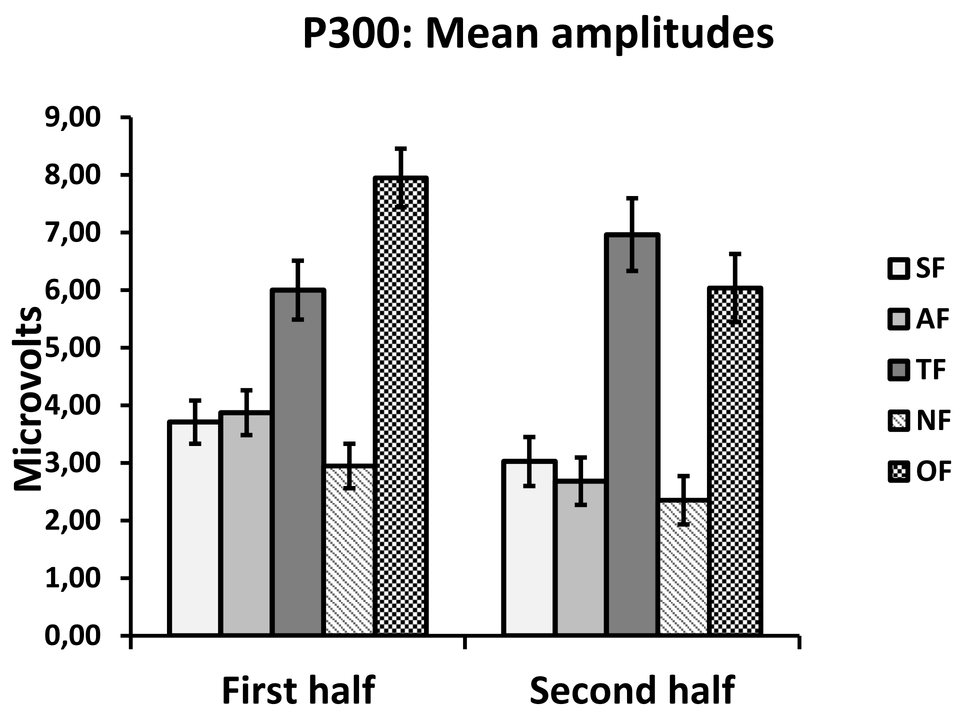

Figure 25. P300 mean amplitudes for each face type in the first and the second half of the experiment.

As with the N170 and N250, main effects of face type were investigated further with planned pair-wise comparisons (LSD), focusing on potential differences between SF and the other face type conditions. As can be seen in Table 5, none of these comparisons reveal significant differences between SF and AF faces. Visual inspection suggests that the interaction mainly stems from an increase of P300 amplitudes for target faces, in particular during the second half of the experiment (see Figure 25). In summary, these data therefore show that both the own face and the target face generally produced an enhanced P300 compared to the other faces.

	SF vs. AF	SF vs. TF	SF vs. NF	SF vs. OF
C3	$p = .86$	$p = .04$	$p = .023$	$p < .001$
C4	$p = .59$	$p < .001$	$p < .01$	$p < .001$
P3	$p = .42$	$p < .001$	$p < .01$	$p < .001$
P4	$p = .98$	$p < .001$	$p < .01$	$p < .001$
CZ	$p = .91$	$p < .010$	$p = .021$	$p < .001$
PZ	$p = .51$	$p < .001$	$p < .01$	$p < .001$
First half	$p = .59$	$p < .001$	$p = .01$	$p < .001$
Second half	$p = .27$	$p < .001$	$p = .014$	$p < .001$
Overall	$p = .75$	$p < .001$	$p < .01$	$p < .001$

Table 5. Results of Pair-wise Comparisons Between SF and the Other Conditions for the P300 Component.

Discussion

This study measured ERPs to investigate whether the enfacement illusion arises during the early structural encoding stage of faces, a recognition stage at which facial stimuli are matched with stored representation, or during the affective evaluation of the face that mediates recognition. To explore these alternatives, the enfacement illusion was induced by stroking observers in synchrony or asynchrony with an unfamiliar onscreen face. After this stimulation stage, observers' subjective experience of enfacement was assessed. Then, ERPs were recorded while observers performed a face target detection task. During this task, a synchronously and an asynchronously stimulated face, observers own face, and two unfamiliar novel faces were intermixed with the presentation of the target.

In line with other studies (see, e.g., Apps et al., 2015; Maister et al., 2013; Tajadura- Jiménez et al., 2012a; Tsakiris, 2008), multisensory stimulation affected observers' subjective experience of the enfacement illusion, such that they were more likely to report that the onscreen face felt like their own face after the synchronous condition. This indicates that enfacement was successfully induced. ERPs were then calculated for the target detection task. The N170 component, which is considered to be a marker of the early perceptual processing of faces (Eimer, 2000; 2011), showed no differences between synchronously and asynchronously stimulated faces. Compared to the target and new faces, N170 amplitudes for synchronously stimulated faces were consistently larger, but smaller than for the own face. This supports previous research in self-recognition, which has also demonstrated that the own face produces a larger N170 component (see Caharel et al., 2002; Keyes et al., 2010).

The N250 component, which is considered to be a marker of the activation of facial identity (see Schweinberger, 2011), was also larger for the own face compared to all other faces. However, after training the target face elicited a comparable N250 to that of the own face. This seems to indicate that the N250 not only reflects the activation of pre-experimentally familiar face activation, such as the own face, but that it is also sensitive to newly acquired facial representation (see Kaufmann et al., 2009; Pierce et al., 2011; Tanaka et al., 2006). This suggests that observers created and consolidated a representation of the target face during the course of the experiment. However, despite these changes, no differences were found between synchronously and asynchronously stimulated faces.

Finally, the P300 component, which seems to mediate the emotional response for familiar faces (Bobes et al., 2004; Ninomiya et al., 1998), also demonstrated an enhanced response for the own faces compared to all other faces. Again, however, the amplitude of this component became more similar for the target and the own faces in the second half of the experiment. In addition, synchronously and asynchronously stimulated faces also evoked a larger P300 than novel faces. However, as with previous components, no differences were found between the synchronously and asynchronously stimulated faces. Altogether, these results suggest that enfacement does not affect early perceptual ERP markers of face processing (N170), subsequent recognition stages (N250), or later affective evaluations of the face (P300). This is a striking finding considering that observers were more likely to report that the enfaced face was, in fact, their own after synchronous multisensory stimulation.

Several reasons might explain the absence of ERP modulations between synchronously and asynchronously stimulated faces. Firstly, it is possible that the brief multisensory stimulation period in the current experiment modulates observers' phenomenological illusion of *owning* the enfaced face but is unable to modulate perceptual, identity or emotional representations that have been built up over years. However, this contrast with extensive evidence showing that a short period (usually less than two minutes) of synchronous stimulation with other face is enough to modulate not only the representation of one's own face (see, e.g., Apps et al., 2015, Tajadura- Jiménez et al., 2012a; Tsakiris, 2008), but also social cognition processes (see e.g., Maister et al., 2013; Paladino et al., 2010). For example, when observers' own face is stroked in synchrony with other face, they show a bias in self-recognition tasks whereby they tend to accept more aspects of that face as own (Tajadura- Jiménez et al., 2012a). This effect is such that it also affects more private aspect of the self (see Morin, 2006), such as emotion recognition (Maister et al., 2013) and conformity behaviour (Paladino et al., 2010).

Alternatively, it is possible that synchronous stimulation can affect the representation of the own face, but this effect is short-lived and dependent on constant *online* stimulation. As a consequence, as no further stimulation was administered during the recording of EEG in the current experiments, any changes to the representation of observers' own faces might have decayed before these could have been measured. This would support previous research that has shown that body ownership depends on the concurrent detection of self-specifying intersensory correlations (see, e.g., Ehrsson, Holmes, & Passingham, 2005; Tsakiris, 2010). Accordingly, the role of synchronous multisensory stimulation is not simply to update the representation of the own face but also to keep it active (Tsakiris, 2010).

In summary, in the current study observers consistently experienced a phenomenological enfacement illusion, but this did not modulate ERP components reflecting the early perceptual processing of faces (N170), the activation of facial identity (N250), or the emotional response to these stimuli (P300).

Chapter 5:

Summary, Conclusions and Future Research

5.1 Summary and conclusions

This thesis investigated the effect of multisensory stimulation of the face on physical and psychological aspects of the self. It has been classically assumed that the visual representation of the own face is stable (Miyakoshi et al., 2008; Porciello et al., 2014). This implies that people recognize their own face by matching the visual input with a stable and view-invariant representation that they have stored of their own face (Bruce, 1982; Bruce & Young, 1986). This position has been challenged by recent research, which suggests that the representation of the own face is not static but flexible and constantly updated. This research shows, for example, that when an observer's own face is stroked on the cheek in synchrony with another face, they tend to see that face as more similar to their own (see e.g., Paladino et al., 2010; Tajadura-Jiménez et al., 2012a; Tsakiris, 2008; Sforza et al., 2010). This perceptual effect is accompanied by a phenomenological experience that the other face *belongs* to the observer, and is absent when this stimulation is administered in asynchrony (i.e., with a short delay). This indicates that synchronous, but not asynchronous, multisensory stimulation supports the updating of the cognitive representations of the own face.

The enfacement illusion is not only informative about the characteristics of cognitive representations of the own face, but also provides insight into social cognition. For example, after SMS of the own-face with the face of an unfamiliar other, observers report more positive affective reactions and more conformity behaviour toward the unfamiliar person, than after asynchronous stimulation (Paladino et al., 2010). This modulation of socio-cognitive processes is also seen toward outgroup members. For example, after the enfacement of a black face, observers show an increase of the *visual remapping of touch* effect (i.e. the increased tactile sensitivity in observers when viewing another face being touched; see Cardini et al., 2012; Marcoux et al., 2013). This effect seems to be bigger in observers who initially have a stronger implicit bias against the outgroup members (Fini et al., 2013). Altogether, these findings suggests that SMS blurs self-other boundaries not only with regard to physical appearance but also in a more social sense, by reducing the differences between the self and an enfaced face. In turn, the enfaced face appears to become incorporated into the self-space (Paladino et al., 2010; Schubert, & Otten, 2002), thus producing an overlapping of the mental representation of both faces (see Tsakiris, 2010).

Interestingly, other tasks, such as behavioural mimicry, intergroup contact and shared attributes generation, are also based on self-other boundaries blurring and have been employed to decrease prejudice toward outgroup members (see Crips & Turner, 2009; Davis et al., 1996; Gaertner & Dovidio, 2000; Hall et al., 2009; Inzlicht et al., 2006; Turner et al., 2007). Chapter 2 therefore investigated whether SMS of the face, similar to these tasks, also modulates racial prejudice. For this purpose, Caucasian observers were stroked on the cheek with a cotton bud in synchrony with a black face in Experiment 1. This was compared with a neutral condition, in which no tactile stimulation was administered during exposure to a black face. The impact of these manipulations on observers' phenomenological experience of the onscreen face was then assessed with an established enfacement questionnaire (see Tajadura-Jiménez et al., 2012a; Maister et al., 2013b). In addition, racial prejudice was measured implicitly with the name-race IAT (see Hall et al., 2009), and explicitly with Lepore and Brown's (1997) subtle racial prejudice scale. In this experiment, observers experienced a consistent enfacement illusion after synchronous stimulation, whereby they reported to embody the black face. However, these changes in their phenomenological experience were not accompanied by a modulation of racial prejudice.

Recent research has questioned the validity of the name-race IAT that was employed to measure racial prejudice in Experiment 1, as the preference toward white names in this test could reflect a simple familiarity effect (see van Ravenzwaaij, et al., 2011). To rule out this possibility, Experiment 2 used a face-race IAT (Dasgupta et al., 2000), in which the black- and white-associated names from Experiment 1 were replaced with black and white faces. This IAT therefore cannot be undermined by a lack of familiarity with the race stimuli (van Ravenzwaaij et al., 2011). As in Experiment 1, observers experienced a stronger enfacement illusion after the synchronous condition in Experiment 2. However, despite the changes to the IAT, SMS did not produce concurrent changes in racial prejudice.

Experiment 3 modified the stimulation paradigm and the IAT in a further attempt to increase the sensitivity. In the stimulation task, the neutral condition was replaced with an asynchronous stimulation condition, which is the classical comparison condition in the enfacement paradigm (see, e.g., Tajadura-Jiménez, et al., 2012a; Tsakiris & Haggard, 2005). In this condition, observers receive the same tactile stimulation as in the synchronous condition, but this is administered with a one-second delay to the observed stimulation of the onscreen face. This asynchronous condition therefore imposes a temporal incongruence between what observers feel when they are touched and the touch that they see applied to the onscreen model. In addition, the IAT was also replaced with a single-category version, which does not contrast attitudes to an ingroup with an outgroup, but measures attitudes toward the outgroup only (Karpinski & Steinman, 2006). For this reason, the single-category IAT is considered a more direct measure of observers' attitudes toward black people (see Karpinski & Steinman, 2006; Maister et al., 2013a). In a further change to the preceding experiments, observers were only exposed to one of the stimulation conditions (i.e., synchronous or asynchronous). To determine whether any change in racial prejudice occurred as a consequence of SMS of the face, they therefore performed the single-category IAT twice, prior to and after stimulation stage. As in previous experiments, observers reported a stronger subjective enfacement illusion in the synchronous condition. Once again, however, SMS did not modulate racial prejudice.

In summary, the experiments reported in Chapter 2 show that it is possible to embody a face, even when it belongs to a difference ethnic group. However, this change in the onscreen face ownership experience was not accompanied by a modulation of racial prejudice. These findings converge with previous research, by showing that it is possible to embody physical features of an outgroup member, such as a black hand (Maister et al., 2013a) or black faces (Fini et al., 2013; Bufalari et al., 2014). In contrast to previous work, however, a positive effect of SMS of the face on prejudice reduction was not found. For example, recent research has shown that the intensity level of observers' illusion of ownership over a black hand relates to their racial prejudice (see Maister et al., 2013a). These differences could be explained by faces being more difficult to embody than hands. In support of this notion, phenomenological evidence suggests that the enfacement illusion is less vivid than both the rubber hand and the full-body illusion (Botvinick & Cohen, 1998; Lenggenhager et al., 2007; Sforza et al., 2010; Tsakiris & Haggard, 2005).

Despite the absence of an effect of SMS on racial prejudice, a clear enfacement effect was obtained in all experiments in Chapter 2. This converges with previous research to suggest that SMS of the face is a remarkably robust effect in self-face recognition (e.g., Sforza et al., 2010; Tajadura-Jiménez et al., 2012a; Tsakiris, 2008). However, the enfacement paradigm relies on observing the tactile stimulation of another person, which is a scenario that is not encountered outside of the laboratory.

Chapter 3 therefore examined whether a similar updating of observers' facial representations occurs with a stimulation method that is more similar to the experience of studying one's own reflection in a mirror. For this purpose, a novel gaze-contingent paradigm was developed. In this paradigm, the eye movements of a face on a computer screen directly mimic the looking behaviour of the observer. To measure the effect of this mirror-like stimulation in self-recognition, established measures of the enfacement illusion from multi-sensory stimulation paradigms were adopted (see, e.g., Keenan et al., 1999; Maister et al., 2013b; Tajadura-Jiménez et al., 2012a; Tsakiris, 2008). This comprised a self-other discrimination task, in which observers were shown a morphing sequence between the face viewed in the stimulation stage and observers' own face. In this task, observers were asked to determine at which point they could perceive their own face in the sequence. This measure was complemented with an adapted version of the enfacement questionnaire from the previous Chapter.

In Experiment 4, observers were exposed to congruent stimulation, in which the movement of the onscreen face was synchronized with their own gaze behaviour, and an incongruent condition, in which the eyes of the onscreen face moved in a different direction to their own eyes. This experiment did not reveal an effect of gaze stimulation on the self-other discrimination task or observers' subjective reports. The verification items of the questionnaire suggest that observers were sensitive to the onscreen eye-gaze in the congruent condition only. By contrast, however, they did not report a clear directionality for the onscreen face's eye movements in the incongruent condition. This suggests that observers misperceived the direction of the onscreen face's eye movements, which might have undermined any stimulation effects of the gaze-contingent task.

Subsequent experiments explored whether the gaze-contingent paradigm can be modified to elicit such effects. Experiment 5 replaced the incongruent condition with neutral displays, in which the onscreen eye-gaze was static and unresponsive, to provide a stronger contrast with congruent displays (see Burton et al., 2009; Yokoyama et al., 2014). Observers' self-reports showed that they were sensitive to the difference in eye movements between conditions, and also the mimicry that these eye-movements exerted in the congruent condition. In addition, observers experienced a consistent enfacement-like illusion after the stimulation of the congruent condition, whereby they reported to embody the onscreen face. Once again, however, these changes were not accompanied by a corresponding effect in the self-other discrimination task. This indicates that the gaze-contingent task did not modify observers' perceptual representations of the own face.

It is possible that the encoding of the onscreen face was limited in these experiments because observers were drawn from its location to the peripheral object-triggers during the stimulation phase. To avoid this, Experiment 6 replaced these peripheral objects with further photos of the onscreen face to promote further encoding of this identity. These additional face images also responded to observers' gaze in an attempt to further enhance this manipulation. In contrast to Experiment 4, observers were now clearly sensitive to gaze direction in both the congruent and the incongruent condition. This was accompanied by stronger reports of an enfacement-like illusion in the congruent condition than with incongruent displays. Once again, however, the stimulation conditions did not affect the perceptual discrimination task.

Taken together, the results of Chapter 3 indicate that the gaze-contingent mirror-experience paradigm can alter observers' subjective reports about their own face, by creating a 'felt' resemblance between the self and an onscreen target. This, stimulation was not effective in altering observers' perceptual self-representations, as measured with the self-other discrimination task. A possible explanation for the difference between observers' subjective reports and their perceptual performance could be that these reflect independent pathways in the cognitive face recognition system. One of these might be responsible for the perceptual recognition of a face, whereas the other provides an accompanying arousal response (see Ellis & Young, 1990; Schweinberger & Burton, 2003). This idea derives from the study of Capgras patients, who can identify familiar faces but do not exhibit the appropriate corresponding feelings of familiarity. As a consequence, these patients believe that familiar people are replaced by impostors or aliens (Ellis, 1997). It is possible that the gaze-contingent paradigm of Chapter 3 exerts the reverse effect, by manipulating affective evaluations of the own face but not perceptual representations.

The final experimental chapter investigated the locus of the enfacement illusion. Previous research suggests that the locus of this effect could be in early processing perceptual stages, such as the structural encoding of a face (see Bruce & Young, 1986). This is borne out of the finding that the inferior occipital gyrus, which has been linked to the structural encoding of faces (see Haxby et al., 2000), is activated during the enfacement illusion (Apps et al., 2015). Experimental evidence has also shown that the lateral part of this structure (i.e., the occipital face area) is involved in the processing of individual facial features but not in the representation of identity (see Barton, 2008; Kanwisher, & Barton, 2011).

Alternatively, the enfacement effect could also arise during later processing stages, such as the pre-semantic matching of visual stimuli to a stored representation of identity (e.g., an FRU, see, e.g., Breen et al., 2001; Schweinberger & Burton, 2003). Some evidence also supports this view. For example, psychometric approaches have shown that the main component of the enfacement illusion reflects the identification of the other face as the own (Tajadura-Jiménez et al., 2012b). In addition, the fact that the enfacement illusion affects performance in self-recognition tasks also suggest an identity locus, based on the process of updating representations of the own face (e.g., Tajadura-Jiménez et al., 2012a; Tsakiris, 2008).

Lastly, the enfacement effect could arise during the affective evaluation of the face (i.e., arousal response) that mediates recognition (see, e.g., Breen et al., 2001; Schweinberger & Burton, 2003). Some research also supports this hypothesis. For example, Tajadura-Jiménez et al. (2012) showed that electrodermal activity toward the enfaced face is higher during synchronous than asynchronous stimulation. This electrodermal activity seems to reflect the mediation of an arousal emotional response to faces (see Schweinberger & Burton, 2003). Additionally, Bufalari et al. (2014) found that the more positively perceived the enfaced face was, the stronger the enfacement illusion was, which suggests that this illusion might be dependent on positive emotions toward the enfaced face (see also Paladino et al., 2010; Sforza et al., 2010).

The fact that the own face modulates ERP components in the early perceptual stages of face processing (i.e., the N170 component; Keyes et al., 2010), during the activation of facial identity (i.e., the N250 component; Tanaka et al., 2006), and the emotional response to stimuli (i.e., the P300 component; Ninomiya et al., 1998) suggests that these components can be used to explore the cognitive locus of the enfacement illusion. This issue was investigated in Experiment 7 in Chapter 4. In an initial stimulation stage, observers were exposed to blocks of synchronous and asynchronous stimulation. After each stimulation block, ERPs were recorded while observers performed a face target detection task in which they were presented with pictures of their own face, the synchronously stimulated face, the asynchronously stimulated face, new faces, or a target face. Observers were instructed to respond only to the target face.

As in previous experiments, observers reported that they felt like they were looking at their own face during synchronous stimulation, which indicates that the enfacement illusion was successfully induced. In the analysis of the ERPs, the N170, which is considered to be a marker of early perceptual processing stages (Eimer, 2000; 2011), was more negative for the own face compared to all other faces, which supports previous research in self-recognition (see Caharel et al., 2002; Keyes et al., 2010). Additionally, N170 amplitudes were more negative for the synchronously and asynchronously stimulated faces compared to the new and the target faces. Taken together, these results suggest that the early perceptual processing of the own face is enhanced, whereas enfacement does not affect this processing stage.

The ERPs also showed a larger N250 for the own face compared with all other faces. However, after extensive training, the target face also elicited a N250 response that was identical to that of the own face. This indicates that observers created and consolidated a representation of the target face during the course of the experiment. This suggests that the N250 not only reflects the activation of pre-experimentally familiar faces, such as the own face, but also that it is sensitive to newly acquired facial representations. However, despite these effects, no differences were found between the synchronously and asynchronously stimulated face in this component. Similarly, the P300 component, which seems to mediate the emotional response to familiar faces (Bobes et al., 2004; Ninomiya et al., 1998), showed a stronger effect to both the own face and the target face than all other faces. However, no difference was found between the synchronously and asynchronously stimulated faces for this component.

Altogether, the results of Experiment 7 suggest that enfacement does not affect the early perceptual processing of faces (i.e., the N170 component), later recognition stages (i.e., the N250 component) or the affective evaluation of the face that mediates the recognition (i.e. the P300 component).

5.2 Theoretical implications

The findings of this thesis have clear theoretical implications for accounts of identity and self-face recognition. Foremost, these studies show that the representation of the own face is malleable as a consequence of sensory input. This is such that when observers are stroked in synchrony with other face, they have the feeling that the other face is, in fact, their own. Interestingly, as shown in Chapter 2, this effect occurs even when the observer and the model belong to different ethnic groups. These findings suggests that SMS of the face blurs self-other boundaries by reducing the differences between the self and an enfaced face (Paladino et al., 2010; Schubert, & Otten, 2002; Tsakiris, 2010).

This phenomenon is striking as the race does not only play an important role in self-identity (Lepore & Brown, 1997) but also people belonging to different ethnic groups (i.e., white Caucasian and Black people) have distinctive facial features. However, the phenomenological experience of embodying a black face did not produce concurrent modulation of racial prejudice. This contrasts with other tasks, such as behavioural mimicry and intergroup contact, which are also based on the reduction of self-other differences but have been employed to decrease prejudice toward outgroup members (see Crips & Turner, 2009; Davis et al., 1996; Gaertner & Dovidio, 2000; Inzlicht et al., 2012; Pettigrew & Tropp, 2006; Turner et al., 2007). It is possible that the mechanism involved in these tasks is different to that involved in the enfacement illusion. In the enfacement illusion, observers tend to perceive the onscreen face as more similar to their own, but not the opposite (see Tajadura-Jiménez et al., 2012a). In contrast, in other manipulations, such as behavioural mimicry (Inzlicht et al., 2012), shared attribute generation (Hall et al., 2009), or intergroup contact (Tuner & Crisp, 2010), observers must take the model's perspective and should therefore "look" more like the model. The findings of Chapter 2 also suggest that such perspective-taking might be important for prejudice reduction.

The classical enfacement paradigm relies on observing the tactile stimulation of another person, which is a scenario that is not encountered outside of the laboratory. Interestingly, a similar phenomenological experience of embodying was obtained in Chapter 3, with a new paradigm which is more similar to the experience of studying one's own reflection in a mirror. This gaze contingent paradigm simulates the mirror reflection experience by mimicking observers' eye-gaze behaviour with an onscreen face. However, and despite that this stimulation altered observers' subjective reports about their own face, it was not effective in altering observers' perceptual self-representations.

A possible explanation for these differences between observers' subjective reports and their perceptual performance could be that these reflect independent pathways in the cognitive face recognition system. One of these might be responsible for the perceptual recognition of a face, whereas the other provides an accompanying arousal response (see Ellis & Young, 1990; Schweinberger & Burton, 2003). This idea derives from the study of Capgras patients, who can identify familiar faces but do not exhibit the appropriate corresponding feelings of familiarity. As a consequence, these patients believe that familiar people are replaced by impostors or aliens (Ellis, 1997). It is possible that the gaze-contingent paradigm of Chapter 3 exerts the reverse effect, by manipulating affective evaluations of the own face but not perceptual representations.

Chapter 4 investigated this issue in detail using ERPs. In spite of the clear phenomenological effect of embodying the other face when comparing the synchronous and the asynchronous condition, the enfacement did not affect the early perceptual processing of faces (i.e., the N170 component), later recognition stages (i.e., the N250 component) or the affective evaluation of the face that mediates the recognition (i.e. the P300 component). This contrasts with previous evidence showing that the enfacement effect might have a perceptual (Apps et al., 2015), identity (Tajadura-Jiménez et al., 2012a; Tajadura-Jiménez et al., 2012b; Tsakiris, 2008) or emotional (Bufalari et al, 2014; Paladino et al., 2010; Tajadura-Jiménez et al., 2012a) locus

It is possible that synchronous stimulation can affect the representation of the own face, but this effect is short-lived and dependent of constant *online* stimulation. To avoid noise distortion in ERPs, EEG recording requires long test periods (Luck, 2014), so as no further stimulation was administered during this recording stage, any changes to the representation of observers' own faces might have decayed before these could have been measured. This would support previous research that has shown that body ownership depends on the concurrent detection of self-specifying intersensory correlations (see, e.g., Ehrsson et al., 2005; Tsakiris, 2010). Accordingly, the role of SMS is not simply to update the representation of the own face but also to keep it active (Tsakiris, 2010).

This last point would have important consequences when models of face learning (e.g., Burton et al., 2005) are extended to self-face learning. The own face, like other faces, can exhibit considerable variability in appearance due to changes of the pose, grooming, aging, and so forth. Our cognitive system has to deal with these changes in order to maintain recognition accuracy. Recent models of face learning suggest that one way to deal with such changes is through facial averages (e.g., Burton et al., 2005). According to these models, different instances of the own face might be integrated into a single representation, which would contain the information that is relevant exclusively for recognition. By contrast, variable visual information that is not relevant for this task would be eliminated during averaging because the effect of this "noise" is cancelled out across different instances (Burton et al., 2005). However, these theories stop short of explaining the self-referential process of knowing that a particular face is, in fact, one's own (e.g., Devue & Bredart, 2011; Morin, 2006). Understanding the effect of SMS of the face could fill this gap in current theorizing, as the representations of our face are held to be created and updated through the interaction and integration of different senses, such as visual, tactile and proprioceptive information (Blanke et al., 2004; Tsakiris & Haggard, 2005). While the current experiments begin to explore this process, the results stop short of providing a convincing explanation.

Despite a persistent phenomenological enfacement illusion after synchronous (Chapters 2 and 4) and congruent gaze stimulation (Chapter 3) in relative terms (i.e., when compared with their respective control conditions), this effect was small in absolute terms (i.e., observers' responses for the synchronous or congruent conditions were below the mid-point of the questionnaire). This is consistent with other face embodiment studies (e.g., Sforza et al., 2010; Tajadura-Jiménez et al., 2012a; Tajadura-Jiménez et al., 2012b) and contrasts with the phenomenological experience reported in the rubber hand illusion (e.g., Longo et al., 2008), which is greater not only in relative terms, but also in absolute terms. It has been proposed that these differences show that the enfacement illusion is less vivid than other body illusions (see Sforza et al., 2010).

5.3 Limitations and future research

Body ownership has been investigated mainly with the rubber hand paradigm (Botvinick & Cohen, 1998). In general, this research has shown that a hand is embodied with relative ease (for review, see Tsakiris & Haggard, 2005). Although faces are also susceptible to rubber-hand like illusions, this effect seems to be subtler (see Sforza et al., 2010). This is not surprising as the face is our most distinctive feature and is strongly tied to our identity (McNeill, 1988). However, these differences between the rubber-hand and the enfacement illusion have only been addressed indirectly, by comparing different published studies (see Sforza et al., 2010). Future research should, therefore, directly compare the differences between the embodiment of a hand and a face in a within-subjects design.

The effect of each illusion could be measured at a phenomenological level by using questionnaires. However, as such information is based on explicit verbal report, it can be limited and biased. On the other hand, it could be difficult to compare the effect of these illusions at a behavioural level, as this would require the adaptation of behavioural rubber-hand effect measures for the measurement of enfacement paradigm, and vice versa. One objective and useful measure to compare the effects of the rubber hand and the enfacement illusion could be the use of physiological responses, such as electrodermal activity (EDA). For example, recent research has shown that EDA is an index of the strength of the rubber hand illusion (see Braithwaite, Broglia, & Watson, 2014). Comparing the EDA activity of the rubber hand illusion and the enfacement would help to elucidate not only which illusion produces a stronger sense of ownership, but also which has an earlier onset. Answering these questions would help to further understand the importance of different body parts in the representation of the self.

The enfacement illusion has been obtained by the combination of vision and touch. Another interesting question that arises is whether it is possible to obtain an enfacement illusion with alternative sensory modalities. Research in the rubber hand illusion has shown that it is possible to embody a hand with no tactile stimulation, when only the movement of the rubber hand and the own hand are congruent (e.g., Dummer et al., 2009; Riemer et al., 2014). This seems to indicate that the sense of body ownership is not specific to the multisensory integration of vision and *tactile* information, but to the detection of self-specifying intersensory correlations (see Ehrsson et al., 2005; Dummer et al., 2009; Tsakiris & Haggard, 2005).

Chapter 2 tried to extend these results by trying to obtain an enfacement-like effect with a completely novel paradigm in which no tactile stimulation is involved. Instead, in this gaze-contingent paradigm the eye-gaze direction of an unfamiliar face on a computer screen follows observers' eye-gaze, in a mirror-like way. However, in contrast with the classical enfacement paradigm, this manipulation did not alter observers' perceptual self-representations. One possible explanation is that to get an enfacement effect it is necessary to reach a minimum sensory threshold level (see Stein & Meredith, 1993). In contrast with the classical enfacement paradigm, the gaze-contingent paradigm therefore might not provide sufficient sensory input to reach such a minimum threshold level. This situation could occur because eye-gaze direction cannot be perceived easily outside the focus of attention (Burton et al., 2009). If the enfacement illusion, and other bodily illusions, depend on the amount of sensory stimulation received, then increasing the amount of sensory input would produce a stronger sense of ownership. This issue could be investigated by increasing the amount of input delivered into the same sensory modality (e.g., one cotton bud stroking each side of the face) or by combining different paradigms that tap into different sensory modalities (e.g., the classical enfacement paradigm with a gaze-contingent mirror paradigm).

Finally, one of the aims of science is, of course, to extent laboratory findings to applied contexts. In the case of psychological sciences, one of these contexts is the clinical and mental health practice. Neuropsychological therapy based on SMS has already been applied successfully to phantom limb disorders after amputations (see, e.g., Ramachandran & Hauser, 2010). In addition, some recent evidence suggests that this kind of therapy can be used to treat somatotopagnosia, which is the inability to recognize a part of one's body as one's own (see, e.g., Buxbaum & Branch-Coslett, 2001). It is also possible that mirrored self-misidentification, which is a neuropsychiatric disorder that consists of the belief that one’s own mirror image reflects another person (Breen et al., 2000, 2001; Feinberg & Keenan, 2005; Van den Stock et al., 2012), could benefit from SMS of the face. The extra stimulation that this method provides could help to make patients aware that the face reflected in the mirror is, in fact, their own. Research programmes in the field of neuropsychology of mirrored self-misidentification should consider the application of SMS to treat this disorder.

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Appendix

The subtle prejudice questionnaire (Lepore & Brown, 1997).

1. It makes sense for minority groups to live in their own neighbourhood because they share more and get along better than when mixing with whites.
2. I consider our society to be unfair to black people.
3. It should be easier to acquire British citizenship.
4. The number of black members of parliament is too low and political parties should take active steps to increase it.
5. Minority groups are more likely to make progress in future by being patient and not pushing so hard for change.
6. Given the present high level of unemployment, foreigners should go back to their countries.
7. The right of the immigrants should be restricted (1), left as they are (4), extended (7).
8. If many black persons moved to my neighbourhood in a short period of time, thus changing its ethnic composition, it would not bother me.
9. If people move to another country, they should be allowed to maintain their own traditions.
10. Once minority groups start getting jobs because of their colour, the result is bound to be fewer jobs for whites.
11. Those immigrants who do not have immigration documents should be sent back to their countries.
12. Some black people living here who receive support from the state could get along without it if they tried.

13. Suppose that a child of yours had a child with a person of very different colour and physical characteristics than your own. If your grandchildren did not physically resemble the people on your side of the family, you would be very bothered (1), not bothered at all (7).
14. It is unfair to the people of one country if the immigrants take jobs and resources.
15. I would not be concerned if most of my peers at the university were black.