Experiencing ownership over a dark-skinned body reduces implicit racial bias

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Abstract

Previous studies have investigated how existing social attitudes towards other races affect the way we 'share' their bodily experiences, for example in empathy for pain, and sensorimotor mapping. Here, we ask whether it is possible to alter implicit racial attitudes by experimentally increasing self-other bodily overlap. Employing a bodily illusion known as the 'Rubber Hand Illusion', we delivered multisensory stimulation to light-skinned Caucasian participants to induce the feeling that a dark-skinned hand belonged to them. We then measured whether this could change their implicit racial biases against people with dark skin. Across two experiments, the more intense the participants' illusion of ownership over the dark-skinned rubber hand, the more positive their implicit racial attitudes became. Importantly, it was not the pattern of multisensory stimulation per se, but rather, it was the change in the subjective experience of body ownership that altered implicit attitudes. These findings suggest that inducing an overlap between the bodies of self and other through illusory ownership is an effective way to change and reduce negative implicit attitudes towards outgroups.

Keywords: *Rubber Hand Illusion, body representation, implicit racial attitudes, social cognition, body ownership, multisensory.*

1. Introduction

Embodied accounts of social cognition argue that body representations play a causal role in sociocognitive processing (e.g. Gallese, Keysers, & Rizzolatti, 2004). Neurocognitive studies into the 'mirror neuron system' have shown that we activate similar brain regions both when we observe a bodily state in others, and when we experience that bodily state ourselves (see Keysers & Gazzola, 2009), reflecting an overlap between self and other bodily representations in the brain. These shared bodily representations for self and other may be particularly important for empathy and other core sociocognitive processes, as they can afford us a unique, first-person understanding of the experiences of others (Gallese, 2001, 2003).

Interestingly, the activation of shared bodily representations for self and other has been shown to be modulated by whether the other person being observed is a member of a racial ingroup or outgroup (Avenanti, Sirigu & Aglioti, 2010; Desy & Theoret, 2007; Gutsell & Inzlicht, 2010; Serino, Giovagnoli & Ladavas, 2009; Xu, Zuo, Wang, & Han, 2009). For example, a recent EEG study (Gutsell & Inzlicht, 2010) showed activation over the motor cortex when participants observed an action performed by a member of their own race, but that this activation was significantly reduced when an action was performed by a member of a racial outgroup. In a single pulse TMS study, Avenanti et al. (2010) measured sensorimotor empathic brain response to the observation of another individual experiencing pain. If participants observed a painful stimulus applied to member of their own race, they showed a typical neural resonance, recruiting the same neural network as when experiencing pain themselves. However, when observing a member of a racial outgroup, this mapping of the other's pain onto the self was absent. Furthermore, the lack of neural resonance with the racial outgroup was significantly

correlated with participants' implicit racial biases, as measured with the Implicit Association Task (IAT: Greenwald, McGhee, & Schwartz, 1998).

This not only suggests that there is a reduced activation of shared bodily representations for self and other for members of racial outgroups, but that our implicit racial attitudes affect this reduction. The more negative our implicit attitudes are towards individuals from a racial outgroup, the less overlap there is between the representation of their bodies and our own. However, no study has yet tested the bidirectionality of this relationship between racial attitudes and self-other bodily representations. Can we alter implicit racial attitudes by experimentally increasing self-other bodily overlap?

This possibility received indirect support from a recent study by Inzlicht, Gutsell and Legault (2012), who showed that the behavioral mimicry of an individual from a racial outgroup reduced implicit racial prejudice towards that outgroup. Mimicry may lead to a blurring of the boundary between self and other (Farmer & Tsakiris, 2012), and has been shown to activate mirror neuron areas responsible for neural resonance with other's actions (Obhi & Hogeveen, 2010). Inzlicht et al. suggested that mimicry reduced implicit prejudice by increasing self-other overlap, thus enhancing neural resonance with the racial outgroup. We endeavored to test this suggestion directly, by experimentally increasing self-other overlap and measuring its effects on racial prejudice.

One of the most viable methods for increasing self-other overlap may be to employ bodily illusions, which utilize synchronous multisensory stimulation to alter the way we represent our bodies. In the Rubber Hand Illusion (RHI: Botvinick & Cohen, 1998), seeing a rubber hand being touched in synchrony with one's unseen hand creates a sense of ownership over the fake hand, allowing its incorporation into our body-representation (see Figure 1A). This blurs the

perceptual boundaries between self and other, increasing the similarity that participants subsequently perceive between the rubber hand and their own (Longo, Schuur, Kammers, Tsakiris & Haggard, 2009). Interestingly, induced ownership occurs despite differences in skin colour. Farmer, Tajadura-Jimenez and Tsakiris (2012) employed the RHI to successfully induce light-skinned Caucasian participants to incorporate a dark-skinned hand from a racial outgroup into their own body-boundaries. Therefore, the RHI is a potentially effective way to increase the overlap between representations of one's own body and that of a member of a racial outgroup, increasing perceived similarity to the self.

Importantly, Farmer et al. (2012) also took pre- and post-RHI measures of implicit racial bias, using the IAT. No significant changes in racial attitudes were found; however, the study had a within-subjects design, in which each participant experienced RHI with both a dark-skinned and light-skinned hand in the same session. Therefore, change elicited by ownership over the dark-skinned hand may have been confounded by subsequent ownership over the light-skinned hand. Interestingly, they did find a significant relationship between the level of ownership the participants reported over both hands, and post-RHI racial attitudes. Again, however, the effect of ownership over the dark-skinned hand cannot be disentangled from the effect of ownership over the light-skinned hand in their experiment.

In the current study, we used the rubber hand illusion to induce light-skinned Caucasian participants to feel that a dark-skinned rubber hand was part of their bodies, and measured whether this could change their implicit racial biases against people with dark skin. Whilst other studies have investigated how existing social distinctions and prejudice affects the way we 'share' the bodily experiences of others, for example in sensorimotor mapping (Desy & Theoret, 2007), and empathy for pain (Avenanti et al., 2010), in this study we aim to experimentally

change the relationship between one's own body and a physically different body, and to quantify its effect on implicit social attitudes. We decided to solely measure implicit racial attitudes, as measuring explicit racial attitudes would leave the study vulnerable to effects of demand characteristics and social desirability. We improved upon Farmer et al.'s (2012) study by employing a methodologically rigorous approach across two experiments, measuring changes in racial attitudes after inducing ownership over either a dark-skinned, or a light-skinned hand. The between-subjects design enabled us to distinguish between the effect of ownership of the dark hand specifically from the overall ownership of both hands, and allowed us to establish the causal direction of any ownership – attitude relationship observed.

We hypothesized that the incorporation of a dark-skinned hand into the body-representation would increase self-other bodily overlap and perceived similarity, and thus reduce implicit negative attitudes towards individuals with dark skin. We tested this hypothesis across two experiments. Experiment 1 was designed to investigate how increased bodily overlap with an outgroup could affect implicit attitudes towards that outgroup. Experiment 2 aimed to further investigate the nature of this effect, elucidating whether the effect was specific to implicit attitudes towards an 'outgroup' skin colour, or whether it was a more general effect also affecting attitudes towards the 'ingroup' skin-colour.

2. Experiment 1

Experiment 1 was specifically designed to investigate the effect of self-other bodily overlap on implicit attitudes towards a racial outgroup characterized by different skin-colour. Using an IAT, we measured implicit attitudes towards people with dark skin in a group of light-skinned Caucasian participants, before and after they experienced the RHI with a dark-skinned rubber hand. One group of participants received synchronous stimulation during the RHI procedure,

and one group received asynchronous stimulation. Synchronous stimulation has been found to elicit higher levels of ownership than asynchronous stimulation, and does so more reliably; consequently, synchronicity is a common experimental manipulation in studies employing bodily illusions. Finally, we also measured participants' trait empathy, which has been shown in previous studies to modulate the extent to which individuals experience ownership in the RHI (e.g. Asai, Mao, Sugimori, & Tanno, 2011; Farmer et al., 2012). This allowed us to ensure that all experimental groups were matched on empathy.

2.1. Materials and Methods

2.1.1. Participants

Thirty-four naïve Caucasian participants performed Experiment 1 (27 females, Mean Age = 20.3 years). Caucasian participants were chosen primarily for their relatively reliable implicit biases against skin-colour outgroups. We had no clear predictions regarding the effects of rubber hand ownership on implicit bias in black participants, as research into implicit attitudes using the IAT has failed to find any clear racial biases against white people in a large black sample (Nosek, Banaji, & Greenwald, 2002a).

2.1.2. Tasks

2.1.2.1. Implicit Association Test

The IAT was chosen as a reliable measure of implicit biases, and importantly it has been shown to be robust against demands characteristics, such as the participants' attempts to 'fake' positive implicit attitudes, regardless of how socially desirable these positive attitudes may be (Banse, Seise, & Zerbes, 2001). The IAT was presented on a 20" LCD-screen positioned 60 cm

away from participants. A keyboard and Presentation® software were used to control stimuli delivery and collect participant's responses

A single-category skin-colour IAT (adapted from Karpinski & Steinman, 2006) was used to specifically assess implicit attitudes towards individuals with dark skin, in isolation from attitudes towards light skin. We chose to focus on skin colour as it is a salient perceptual indicator of racial group membership. Furthermore, the dark-skinned rubber hand employed in the experiment used skin colour, rather than other race-specific morphological features, to indicate racial group membership. In the skin-colour IAT, participants categorized words as either 'good' (e.g. pleasure, peace, joy) or 'bad' (e.g. vomit, torture, filth), and categorized pictures of dark-skinned faces as 'dark', by pressing one of two response keys. For each trial, the word or picture was presented in the centre of the screen. On the left and right sides of the screen, above the central stimulus, two category labels were permanently displayed, informing the participant as to which response key corresponded to which category. The task was comprised of two blocks of 96 trials, of which 24 were practice trials for each block. In one of the blocks, the 'good' word category and the 'dark' face category shared a response key, and in the other block, the 'bad' word category and 'dark' face category shared a response key. Participants used two keys on the keyboard (the 'z' key, pressed with the left hand, and the 'm' key, pressed with the right hand) to categorize each stimulus, and their accuracy and response times were recorded. To avoid the development of response biases, the proportions of good-word trials, bad-word trials, and dark-face trials were not presented at equal frequency; in one of the blocks, 58% of correct responses were assigned to the 'z' response key, and in the other block, 58% of correct responses were assigned to the 'm' response key (according to the method

proposed by Karpinski & Steinman, 2006). Response keys assigned to 'good' and 'bad' word categories were fully counterbalanced within subjects.

Results were analyzed with an adapted version of Greenwald, Nosek and Banaji's 'improved algorithm' (2003) utilised by Karpinski and Steinman (2006). First, the overall error rates of each participant were checked to confirm that none exceeded the maximum acceptable error rate of 20% (as defined by Karpinski & Steinman, 2006). All participants satisfied this check and thus were entered into the analysis. The difference between the average reaction times to the two blocks (including incorrect trials, with a 600ms penalty) was presented as a ratio of their standard deviations. This gave us a score for each participant reflecting their implicit bias towards individuals with dark skin, whereby a positive score reflected a positive attitude towards dark skin, as indicated by faster response times to dark-skin stimuli when they were paired with 'good' words than with 'bad' words.

2.1.2.2. Rubber Hand Illusion

Participants sat in front of a table, with their left hand positioned in front of them, palm down. A realistic rubber hand, with dark skin, was situated 15cm to the right of the participant's own hand. The participant's hand and the rubber hand were positioned in a box frame, which hid the participant's own hand from view but allowed the rubber hand to be viewed (Figure 1A: Botvinick & Cohen, 1998). The experimenter sat in front of the participant and manually delivered stimulation to the visible rubber hand and the participant's unseen hand using two identical paintbrushes. Participants were stimulated on their second, third or fourth fingers from the proximal interphalangeal joint to the tip of the finger, with each stroke lasting between 500 and 1500ms. The rubber hand was stimulated in the same manner, either in synchrony or asynchrony with the stimulation of the participant's hand. In the synchronous condition, the

participant's hand and the rubber hand were stroked simultaneously in the same anatomical location. In the asynchronous condition, the stimulation of the participant's hand and the rubber hand were offset; the brushstrokes on the participant's hand and the rubber hand were 180° out of phase. In both conditions, participants were instructed to keep their own hand still and carefully observe the rubber hand for a two-minute period.

To provide a measure of ownership over the rubber hand, participants were asked to complete a 5-item questionnaire, which investigated their subjective experiences of illusory ownership during multisensory stimulation (Figure 1B). Questions were derived from Longo, Schuur, Kammers, Tsakiris, and Haggard (2008) as those which loaded onto the 'ownership' factor of embodiment[1]. Participants were asked to indicate the extent of their agreement or disagreement with five statements, using a 7-point Likert scale. A response of -3 indicated that they "strongly disagreed" with the statement, a response of 0 indicated that they "neither agreed nor disagreed", and a response of +3 indicated that they "strongly agreed" with the statement. Participants could also give a response of any intermediate value between these anchor points. Ratings across all five questions were averaged to provide an 'ownership score' for each participant, as is common practice in other RHI studies (e.g. Kalckert & Ehrsson, 2012; Tsakiris, Carpenter, James & Fotopoulou, 2010; Holle, McLatchie, Maurer & Ward, 2011).

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[1] This factor was chosen as we interested in self-other bodily merging, and felt that the experience of body ownership most closely mapped on to this process. Whilst the 'location' factor of embodiment, and its behavioural proxy proprioceptive drift, have been linked to experienced ownership, there is recent evidence to suggest that changes in hand-location might be independent of experienced ownership in certain experimental contexts (Rohde, Di Luca & Ernst, 2011).

A.

B.

During the experiment there were times when it seemed like…

1. I was looking directly at my own hand, rather than at a rubber hand.

2. the rubber hand was part of my body.

3. the rubber hand was my hand

4. the rubber hand belonged to me

5. the rubber hand began to resemble my real hand.

Figure 1. (**A**) Experimental set-up of the Rubber Hand Illusion. The participant observed a rubber hand being touched with a paintbrush, whilst their own hand was stimulated in the same manner. (**B**) The Ownership Questionnaire, measuring illusory ownership over the rubber hand. Agreement was rated on a 7-point Likert scale.

2.1.2.3. Interpersonal Reactivity Index

The interpersonal reactivity index (IRI: Davis, 1983) taps four separable aspects of empathy using a 28-item questionnaire. Participants indicated the extent to which they agreed or disagreed with statements using a 5-point Likert scale ranging from "strongly disagree" to "strongly agree". Responses to the statements were analyzed to produce separate scores for the four subscales of empathy, namely Perspective Taking, Personal Distress, Fantasy and Empathic Concern. These four aspects of empathy have previously been shown to modulate the extent to which individuals experience ownership during the RHI (e.g. Asai, Mao, Sugimori, & Tanno,

2011), and thus we needed to ensure that the groups our participants were assigned to were matched on this measure.

2.1.3. Procedure

Participants first completed the single-category IAT, to provide us with a baseline measure of their implicit attitudes. In a different session, they repeated the IAT, but experienced two 2-minute sessions of RHI before each of the 'critical' IAT-blocks. After they had finished the IAT, participants rated their subjective experiences of the RHI in the Ownership questionnaire, and then completed the IRI. They finally were asked to state their understanding of the purpose of the study, to allow us to assess participant naivety. The experimenter for this study was Caucasian.

As the aim of the experiment was to investigate whether the experience of RHI over a dark-skinned hand could significantly predict change in IAT score, we planned to enter factors reflecting Ownership, Synchronicity, and their interaction, into a hierarchical linear regression with IAT-change as the dependent variable. As our experiments involved both categorical (Synchronicity) and continuous (Ownership) variables, regression was chosen as more suitable than the more limited ANOVA as it allowed us to avoid dichotomization of our Ownership variable. As we had clear *a priori* predictions and a relatively small set of predictor variables, we did not further correct for multiple comparisons in the regression.

2.2. Results

No participants in this experiment appeared to have understood the true purpose of the study, as measured with the naivety question at the end of the final session, and thus all were entered into the analysis. First, baseline (pre-RHI) IAT scores were analyzed to investigate any

initial differences in implicit racial attitudes between the group of participants receiving

synchronous stimulation, and the group receiving asynchronous stimulation. There was no

significant difference in baseline IAT scores between synchronous and asynchronous groups,

$F(1,32) = 0.38$, $p = .539$, $\eta^2_p = .012$. Baseline IAT scores were not correlated with reported

illusory ownership in either of the stimulation conditions, $r_{SYNCH} = -.32$, $p = .20$, $r_{ASYNCH} = -.36$,

$p = .16$. We then compared IRI scores between the participants who received asynchronous

stimulation vs. those who received synchronous stimulation, to ensure that there were no

significant differences in trait empathy between experimental groups. A MANOVA including all

four sub-scales of the IRI revealed no main effect of Group, $F(1,32) = 0.24$, $p = .915$.

Furthermore, the four subscales of the IRI were not significantly associated with Ownership

(Pearson's correlational analysis, all p-values > .05), and so IRI scores were not analyzed

further.

Next, we analyzed ownership scores to investigate whether they were affected by

experimental condition. There was a significant difference in ownership scores between

synchronous and asynchronous conditions, $F(1,32) = 18.64$, $p < .0005$, $\eta^2_p = .368$, with the

synchronous condition yielding higher ownership scores, $M = 1.26$ ($SD = 1.70$), than the

asynchronous condition, $M = -1.35$ ($SD = 1.81$).

For the main analysis, a two-step hierarchical linear regression was employed on IAT-

change scores (post- minus pre-IAT). The hierarchical approach was chosen to enable us to test

the simplest model containing our main effects, before analyzing whether inclusion of

moderator effects (our interaction term) contributed significantly more to the predictive power

of the model. As Ownership and Synchronicity were significantly correlated, r = .610, p < .001,

we mean-centered the Ownership variable for each level of Synchronicity before adding into the

regression to avoid problems of collinearity. The full model and results from the regression can be seen in Table 1.

Table 1. Summary of two-step hierarchical regression analysis for variables predicting dark-skin IAT-change, for Experiment 1 ($N = 34$).

Variable	β	p
Step 1		
Ownership	.574	.008**
Synchronicity	.012	.941
Step 2		
Ownership*Synchronicity	.137	.542

Note. $r^2_{adjusted}$ = .154 for Step 1; Δr^2 = .010 for Step 2, (p = .542). **p < .01.

At the first step, the first-order terms of Condition and Ownership were entered as potential predictor variables. At the second step, the second-order interaction term of Condition*Ownership was added. The overall model fit was significant at the first step, $F(2,33)$ = 4.08, p = .027, η^2_p = .208. Ownership positively predicted IAT-change, β = .574, p = .008, with higher ownership associated with IAT scores becoming more positive towards individuals with dark skin (see Figure 2). Adding the interaction term to the model in Step 2 of the regression did not significantly improve the model fit, Δr^2 = .010, p = .542.
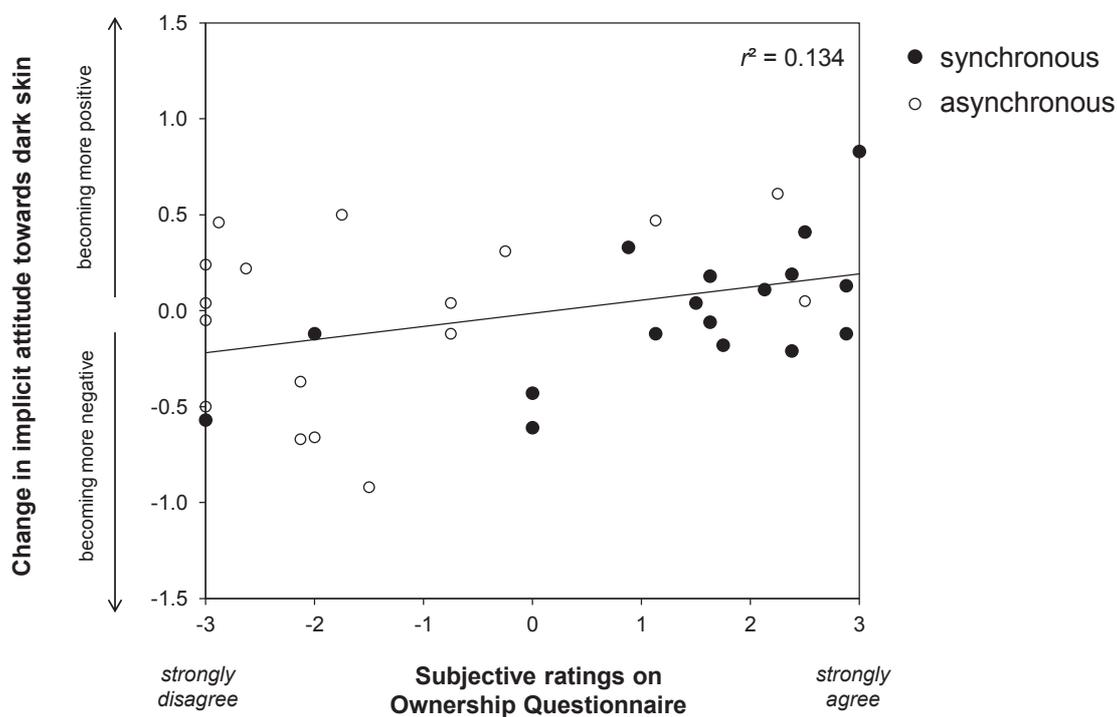
Figure 2. In Experiment 1 ($N = 34$), intensity of illusory ownership over a dark-skin rubber hand (as measured by mean subjective rating on Ownership Questionnaire, across all items), predicted change in implicit attitudes towards dark skin, measured with single-category IAT (Pearson's correlation coefficient on raw data, r = .366, p = .033). Positive attitude-change values reflect an increase in positive attitude towards dark-skin individuals.

3. Experiment 2

A second experiment was conducted to investigate whether the effect of illusory ownership is specific to implicit attitudes towards an 'outgroup' skin colour, or whether it might be a more general effect. In a between-subjects experimental design using a new sample of participants, RHI was induced over either a dark- or light-skinned rubber hands, and implicit attitude-change towards both dark- and light-skinned individuals was measured.

3.1. Method

3.1.1. Participants

Seventy-three naïve Caucasian participants (53 females, Mean Age = 19.8 years) performed Experiment 2.

3.1.2. Tasks

3.1.2.1. Implicit Association Test

A two-category skin-colour IAT (Greenwald, McGhee, & Schwartz, 1998) assessed attitudes towards both light and dark skin-colours. Participants categorized faces as light- or dark-skinned, and words as being 'good' or 'bad'. Participants used two keys on the keyboard (the 'z' key, pressed with the left hand, and the 'm' key, pressed with the right hand) to categorize each stimulus, and their accuracy and response times were recorded. The task involved seven blocks of trials, five of which were 'practice' blocks, and the remaining two (blocks 4 and 7) were 'critical' blocks. The critical blocks contained both face categorization trials and word categorization trials, and, as in the single-category IAT, the skin-colour categories and the word categories share the same two response keys. These category pairings are reversed between the first and second critical block. Each practice block contained 24 trials, and each critical block contained 48 trials. An equal proportion of good-word, bad-word, dark-skinned face and light-skinned face trials were presented within each block. Response keys assigned to 'good' and 'bad' word categories were fully counterbalanced within subjects. We used the improved algorithm (see Section 2.1.2.1) to separately analyze relative reaction times between Blocks 4 and 7 to dark-skin stimuli only, and to light-skin stimuli only, to provide both a dark- and a light-skin attitude score for each participant. Separate analysis of responses to dark- and light-skin stimuli was chosen as a more suitable approach than a using a composite analysis calculated from all responses. This is because the aim of Experiment 2 was to elucidate

whether the effect of RHI on IAT-change was specific to dark skin, or whether it was a more general effect also affecting light skin. The IAT score generated from a composite analysis is ambiguous regarding this aim, as it gives a relative measure of implicit attitudes to dark skin compared to light skin, and thus instead two separate IAT scores were calculated.

3.1.2.2. Rubber Hand Illusion

Participants were randomly assigned to one of four conditions, in which they experienced either synchronous or asynchronous visuotactile stimulation whilst viewing either a dark-skinned or light-skinned rubber hand. The experimental procedure for the RHI was identical to that of Experiment 1 (see Section 2.1.2.2).

3.1.3. Procedure

The experimental procedure was very similar to that of Experiment 1. Participants first completed the two-category IAT, to provide us with a baseline measure of their implicit attitudes. In a different session, they repeated the IAT, but experienced two 2-minute sessions of RHI before each of the 'critical' IAT-blocks. After they had finished the IAT, participants rated their subjective experiences of the RHI in the Ownership questionnaire. They finally were asked to state their understanding of the purpose of the study, to allow us to assess participant naivety. The experimenter for this study was Caucasian.

The overall statistical approach was identical to that of Experiment 1, in which we employed a hierarchical linear regression analysis to investigate the effects of RHI on attitude change. However, for the current analysis, attitude change towards light skin and attitude change towards dark skin were analyzed in two separate regressions, and the additional factor of Hand-Colour was included in both to enable us to test the specificity of our effect to dark skin. As in

Experiment 1, we again mean-centered the Ownership variable for each level of Synchronicity before adding into the regressions to avoid problems of collinearity.

3.2. Results

Analysis of the responses to the naivety question at the end of the final session revealed that four participants had some understanding of the specific purpose of the study. These participants were excluded from analysis, resulting in a total of 69 participants (50 females) in the final sample. First, baseline (pre-RHI) IAT scores were analyzed to investigate any initial differences in implicit racial attitudes. In a 2(Condition: SYNCH vs. ASYNCH) x 2(Hand-Colour: dark vs. light) ANOVA, there was no significant main effect of Condition, $F(1,65) = 0.06$, $p = .798$, $\eta^2_p = .001$, nor Hand-Colour, $F(1,65) = 1.15$, $p = .289$, $\eta^2_p = .017$, nor any interaction, $F(1,65) = 0.20$, $p = .652$, $\eta^2_p = .003$. As in Experiment 1, baseline IAT scores were not correlated with reported illusory ownership in any of the conditions, all p-values>.24.

Next, we analyzed ownership scores to investigate any effects of experimental condition. Ownership scores were entered into a 2(Condition: SYNCH vs. ASYNCH) x 2(Hand-Colour: dark vs. light) ANOVA, which revealed a main effect of Condition, $F(1,65) = 49.62$, $p < .0005$, $\eta^2_p = .433$, with the SYNCH condition eliciting significantly higher ownership ratings than the ASYNCH condition, $M_{SYNCH} = 0.99$ ($SD = 1.58$), $M_{ASYNCH} = -1.67$ ($SD = 1.54$). There was no main effect of Hand-Colour, $F(1,65) = 1.18$, $p = .281$, $\eta^2_p = .018$, nor any interaction, $F(1.65) = 0.06$, $p = .812$, $\eta^2_p = .001$.

Dark- and light-skin IAT-change scores were then analyzed separately in linear regressions with Synchronicity, Ownership, and Hand-Colour entered as predictor variables in the first step, and, all two-way interaction terms entered in the second step. This yielded a significant model for dark-skin IAT change at the second step, $F(6,68) = 2.33$, $p = .043$, $\eta^2_p = .184$. Full details of

this model are displayed in Table 2. In contrast, the model for light-skin IAT change was not

significant at either step, $p > .05$.

Table 2. Summary of two-step hierarchical regression analysis for variables predicting dark-skin IAT-change, for Experiment 2 ($N = 69$).

Variable	β	p
Step 1		
Ownership	.038	.763
Synchronicity	-.071	.568
Hand-Colour	.028	.822
Step 2		
Ownership*Hand-Colour	-.384	.013*
Ownership*Synchronicity	-.283	.129
Synchronicity*Hand-Colour	-.135	.522

Note. $r^2_{adjusted} = -.039$ for Step 1; $\Delta r^2 = .178$ for Step 2 ($p = .006$). *$p < .05$.

The significant Ownership*Hand-Colour term in the model was investigated using simple slopes

analysis. Simple linear regressions on dark-skin IAT change, with Ownership entered as a

predictor variable, were carried out for the light-skin Hand-Colour group and the dark-skin

Hand-Colour group separately. Replicating Experiment 1, Ownership significantly predicted

dark-skin IAT-change in those participants who saw the dark-skinned hand, β = .385, p = .030.

The more intense the experienced ownership over the dark-skinned rubber hand, the more

positive implicit attitudes towards dark skin became. In contrast, Ownership was not a

significant predictor of dark-skin IAT change for the light-skin Hand-Colour group, β = -.247, p

= .140. These findings are illustrated in Figure 3.

Figure 3. Experiment 2 (N = 69) replicated the positive relationship between ownership over a dark-skinned rubber hand (as measured by mean subjective rating on Ownership Questionnaire, across all items) and dark-skin attitude change (Pearson's correlation coefficient on raw data, r = .385, p = .030, Left Panel). No relationship existed between light-skinned hand ownership and dark-skin attitude-change (Pearson's correlation on raw data, r = -.247, p = .14, Right Panel).
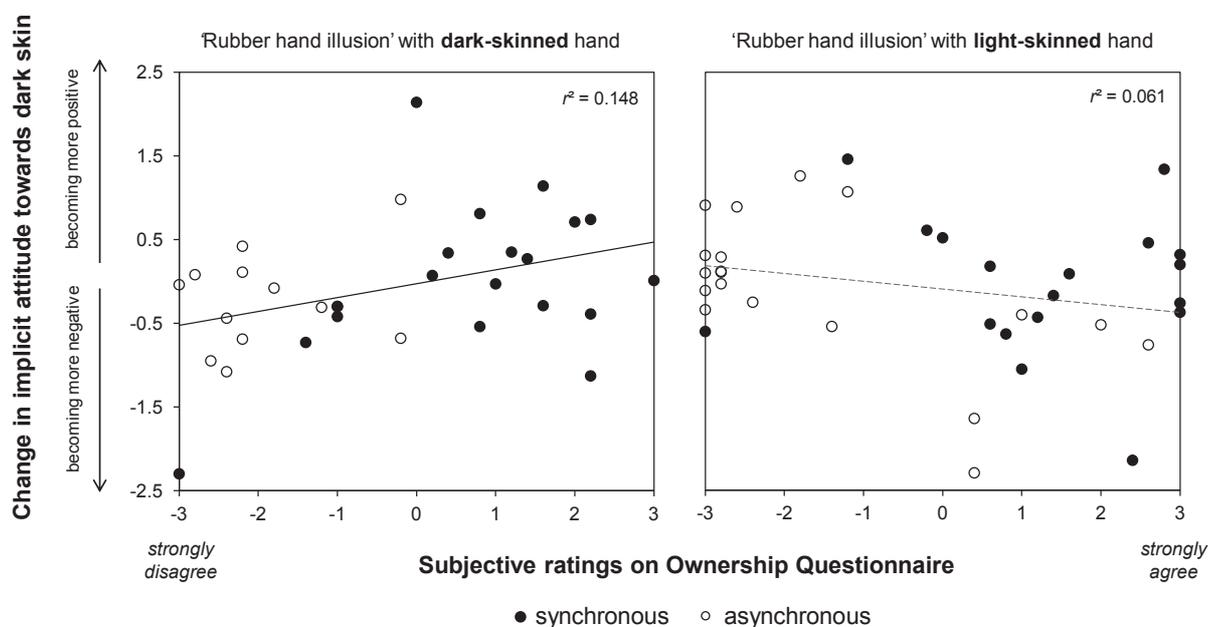
4. Discussion

Using the Rubber Hand Illusion, we induced light-skinned Caucasian participants to feel that a dark-skinned rubber hand was part of their bodies, and measured whether this could change their implicit biases against people with dark skin. We found that the more intense the participants' illusion of ownership over the dark-skinned rubber hand, the more positive their

implicit attitudes became, and that this effect was specific to the 'outgroup'. These findings suggest that an increase in overlap between self and other, induced by a change in body-representation, was able to alter the perceived boundaries between ingroup and outgroup to modulate high-level social attitudes. Changes in body-representation may therefore constitute a core, previously unexplored, dimension that in turn changes social cognition processes.

Although the effect of ownership on attitude-change was highly significant, there was no effect of synchronicity alone. This was due to the fact that both synchronous and asynchronous stimulation elicited a range of ownership scores. Although on average the ownership elicited by asynchronous stimulation was weaker than that elicited by synchronous stimulation, it did induce a subjective experience of ownership in some individuals (see Longo et al. 2008; Moseley et al., 2008; Farmer et al., 2012, for similar findings), and this was able to drive attitude change. This may be due to the fact that the asynchronous condition, although not providing synchronous pairing of another's experience and one's own, does provide a predictable contingency between the observation of touch experienced by another, and the touch subsequently experienced on oneself. This contingency is very similar to that elicited by behavioral mimicry, in which one observes an action performed by another, and subsequently performs that action oneself. Interestingly, it has been suggested that such mimicry may elicit a self-other merging (Farmer & Tsakiris, 2012; Inzlicht et al., 2012), akin to aspects of ownership experienced in the RHI. This may therefore explain our finding that both synchronous and asynchronous stimulation were able to elicit experiences of self-other overlap in some individuals, as measured by reported ownership over the hand. Furthermore, we showed that this overlap between self and other bodily representations was able to modulate racial bias, regardless of the synchronicity of the stimulation eliciting it. This is consistent with the study by

Inzlicht et al. (2012), who demonstrated that mimicry of an individual of another race is able to reduce implicit negative racial attitudes, and suggest that this effect was driven by an increase in self-other overlap. Our study supports and extends these findings, by providing more direct evidence on the processes that might lead to reduction in negative racial attitudes.

To date, one other study has investigated self-other bodily merging in Caucasian participants using RHI with a dark-skinned hand. Farmer and colleagues (2012) carried out a study in which participants experienced ownership over both a light- and dark-skinned hand, and found that the level of ownership the participants reported over both hands positively correlated with a subsequent measure of implicit racial attitudes. However, neither ownership over the light- nor the dark-skinned hand significantly predicted racial attitude change from pre- to post-RHI. This conflict in findings with those presented in the current study is likely to be due to differences in experimental design between the two studies. The primary focus of the Farmer et al. study was not to measure changes in implicit racial attitudes as a result of RHI, but to investigate in a more systematic way whether participants could experience ownership over a rubber hand of a different skin colour, and whether existing racial attitudes could affect this experience. The study had a within-subjects design, in which all participants experienced RHI with both a dark-skinned and light-skinned hand between pre- and post-RHI measurement of IAT. Therefore, the effect of ownership specifically for the dark hand on IAT change may have been confounded by subsequent ownership over the light hand, and was indistinguishable from the effect of overall ownership for both hands. The current study therefore represents a significant improvement, as we measured the effect of ownership over a light- and dark-skinned hand separately between subjects. This enabled us to demonstrate that ownership specifically over the dark-skinned hand, and not over the light-skinned hand, could predict a change in

implicit attitudes. Furthermore, our design utilized a single category IAT method (in Experiment 1) and separate analysis of dark-skin and light-skin trials (in Experiment 2), which allowed us to separately quantify changes in attitudes towards dark skin, and changes in attitudes towards light skin. This revealed that Ownership over a dark-skinned hand only predicted a change in implicit attitudes towards dark skin, and not towards light skin.

Our study opens up several lines of future research. First, it will be interesting to replicate the effect with different social groups and stereotypes. In the current study, only white participants took part, as research into implicit racial attitudes using the IAT has failed to find any clear racial biases against white people in a large black sample (Nosek et al., 2002a), and this effect is particularly apparent in a white-majority environment (Ashburn-Nardo & Johnson, 2008; Livingston, 2002; Richeson, Trawalter & Shelton, 2005). However, for future studies it would be important to identify and employ other implicit measures that might be appropriate for different racial groups. Second, our findings would be strengthened by replication using alternative measures of ownership. We employed a subjective report measure, but it would be important to replicate this finding in future studies with more implicit alternatives, such as the measurement of autonomic responses (Ehrsson, Wiech, Weiskopf, Dolan & Passingham, 2007; Moseley et al., 2008).

Further research is also needed to investigate in more depth the nature of the implicit attitudes modulated by self-other bodily merging. We employed a measure of implicit racial attitudes that was based on skin colour, because it corresponded with the skin-colour information used to indicate racial group membership in our RHI procedure. Thus, we measured social attitudes towards people with dark or light skin. Our positive results using this measure are encouraging, and it is now important to investigate this effect using more race-specific

stimuli, such as photographs of White and Black faces. To observe a similar effect with these stimuli, the self-other bodily merging must be abstracted beyond simple skin-colour, to change representations of a specific racial group. It is important to note that we are solely focusing on implicit measures of racial attitudes in this line of research; explicit measures are likely to be unsuitable for these studies, due to confounding effects of demand characteristics and social desirability.

In conclusion, our results demonstrate that illusory ownership over a dark-skinned body part reduces implicit negative attitudes towards people with dark skin, regardless of individual differences in initial racial attitudes or empathy. Synchronous multisensory stimulation in itself is not sufficient to elicit the effect; rather, it is the magnitude of change in the subjective experience of body-ownership that predicts the reduction in negative implicit racial attitudes. We suggest that sharing bodily experiences, such as touch, may increase neural resonance with others, reflecting an activation of shared self-other bodily representations. This may induce both a subjective experience of bodily merging, or 'ownership', and an increase in perceived similarity between self and other (Longo et al., 2009). Perceived similarity plays an important role in implicit cognition; several studies have demonstrated an increased implicit 'liking' of individuals who are more physically similar to the self (Dasgupta, Banaji, & Abelson, 1999; DeBruine, Jones, Little & Perrett, 2008). Therefore, the self-other overlap induced by bodily illusions may reduce implicit negative attitudes towards individuals with dark skin by increasing their perceived similarity to ourselves. Perceived self-similarity has been associated with increased neural activity in the right inferior frontal gyrus and right inferior parietal lobe, thought to be part of the mirror neuron system (Uddin, Kaplan, Molnar-Szakacs, Zaidel & Iacoboni, 2005; Uddin, Molnar-Szakacs, Zaidel, & Iacoboni, 2006; Verosky & Todorov, 2010);

therefore, it may be possible to observe an increase in neural 'resonance' with members of the racial outgroup after RHI, which correlates both with reports of increased self-similarity and with change in racial attitudes.

Although other studies have shown that existing social attitudes affect the overlap between bodily representations of self and other, ours is the first study to investigate whether it is possible to change implicit social attitudes by experimentally increasing this bodily overlap. Negative implicit attitudes towards racial outgroups are formed from an early age, and remain relatively stable throughout adulthood (Baron & Banaji, 2006). We have shown that inducing a sense of ownership over a body of a different skin colour may attenuate these persistent implicit social biases, altering the perceived boundaries between ingroup and outgroup. We did not address the persistence of the reported effect over time, and therefore future studies should test this to give us a deeper understanding of the temporal qualities of the effect. Nevertheless, our results begin to 'bridge the gap' between the basic, perceptual representation of the body, and the complex social mechanisms underlying much of our everyday social interaction. These findings suggest that inducing an overlap between self and other through illusory ownership is an effective way to reduce negative implicit attitudes towards outgroups. Further research is needed to investigate how interventions in multisensory embodiment may be employed outside the laboratory setting to reduce implicit racial bias.

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