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Embodying the Other: Effects of Experiencing the Rubber Hand Illusion in Virtual Reality on Implicit Racial Biases

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The Claremont Colleges Library

Undergraduate Research Award

Senior Award Winner

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Reflective Essay

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Undergraduate Research Award essay

For the research award, I would like to propose my senior thesis. To provide some context on my project, my thesis involves a well-known paradigm in cognitive science called the Rubber Hand Illusion (RHI). First studied by Botvonik and Cohen (1998), the paradigm follows that multisensory integration of visuo-tactile stimuli can lead to a perceived sense of body ownership over a non-attached body part. In the original experiment, researchers stroked a rubber hand at the same that they stroked the participant’s human hand, leading participants to report a sense of ownership over the rubber hand. Since the original Botvonik and Cohen experiment, there have been many adaptations and variations of the experiment – all of which have given researchers insight on the malleability of body representation and body ownership. Interestingly, recent studies have begun to look at the potential power of induced body ownership exercises in developing empathy. For my thesis, I was particularly interested in combining the design of a study by Yuan and Steed (2010) which looked at performing induced body ownership exercises with virtual objects and symbols in VR and Maister, Sebanz, Knoblich, & Tsakiris (2013), a study that looked at manipulating the appearance of the rubber hand in the RHI as a way to change implicit racial biases. My research was concerned with studying whether experiencing virtually-induced body ownership of a racial outgroup’s hand could have an effect on one's implicit racial biases towards that race. More information can be found in my submitted research project document.

Background aside, this project has depended tremendously on the support of so many individuals at the Claremont Colleges – many of whom are staffed at the library. In the early stages of brainstorming my thesis topic last September, I met with librarian Jennifer Thompson to discuss the types of search engines available to spark my research question in the first place. At the time, I was entertaining a wide range of vague interests including AI, memory and technology, and racial biases. The idea of studying racial biases and VR eventually came to me after stumbling across a related key-word (“social cognition”) on a psych database (“PsycINFO”) suggested to me by Jennifer. As a first-generation college student, thesis has always been an intimidating and foreign idea to me. In the months leading up to my meeting with Jennifer, I had struggled with finding a research question and often found myself with 20+ tabs open on my web browser with no clue where and how to proceed. In the beginning, simply asking for help on anything related to my thesis seemed scary because I had for so long held the perception of theses as being huge, cumulative, academic achievements that students completed all on their own. In my head, the independence and self-sufficiency in completing one was what made it so monumental; however, my meeting with Jennifer, along with my later meetings with other folks at the library, have taught me otherwise – that is, theses are indeed huge academic achievements but they require the knowledge and support of a community.

I consider my meeting with Jennifer as a precursor to the type of collaboration and support I’d engage in during my research. Aside from Jennifer, I also worked with Eddie Surman and Karthik Basavanahallimanjunath from the Digital Humanities team to figure out what type of equipment and digital resources I could use from the library to oversee my thesis. Prior to my thesis, I hadn’t done anything in VR before so this was completely new territory for me. Not only did working with Eddie and Karthik prove to be incredibly helpful as they were the ones to help me learn how to use the Vive headset, but it also helped me begin to develop confidence in pursuing my research. Because they were so eager and invested in helping me find the tools to oversee my project, I began to feel like what I was doing was important and worth being studied. On a less academic note, I will never forget a post-meeting conversation where Eddie, Karthik and I casually shared our experiences of being in academia with each other. Similar to my meeting with Jennifer, working with these two individuals last semester helped me feel less intimidated to talk about my research and ultimately, helped me overcome my fear of asking for help as a first-gen student.

After finalizing which equipment I'd use for my experiment last semester with Eddie and Karthik, I also worked with Kelly Jackson and Daniel Michon. Kelly helped me coordinate with the library staff for accessing the Vive and Professor Michon connected me to individuals at the 5Cs who assisted me in designing my virtual environment on one of the computers in the Research Studio, as well as helped me figure out how to run my VR environment with the particular software installed for the Vive. In relation to the physical resource that the library is in itself, I ended up testing my participants directly in the graduate study room on the 3rd floor.

To that end, my development as a researcher has changed for the better because of the resources provided to me by the library and the interactions I've had with its community. The names above are only a few of the several contacts I communicated with during the development of my research. Additionally, because I was in contact with so many different individuals at the library, I was constantly giving someone new a spiel about my thesis. These seemingly small conversations played a huge role in changing the way I talk about my work and more importantly, the way I think about my academic worth and confidence. For these reasons, I'm incredibly grateful for the library staff members. To reiterate what was written earlier, this project has taught me that scholarly and academic research requires more than simply constructing sentences on a screen or reading words on a page, but rather they also require the support of a community.

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Research Project
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Embodying the Other: Effects of Experiencing the Rubber Hand Illusion in Virtual Reality on Implicit Racial Biases

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Pitzer College

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Submitted in partial fulfilment for the degree of Bachelor of Arts in Cognitive Science

Abstract

Research on the Rubber Hand Illusion (RHI) has recently begun to explore induced body ownership exercises as a means for experimentally changing implicit social attitudes. Similarly, recent innovations in Virtual Reality (VR) have lead researchers to begin investigating VR as a tool for empathy training and perspective taking. The present study addresses these two fields of research by replicating the RHI in VR, with the goal of inducing body ownership over virtual hands of racial outgroups. A race Implicit Association Test was administered to measure racial biases before and after the illusion. It was predicted that participants who experienced the illusion with the virtual hand of a race different than their own would show greater changes in performance on the post-illusion Implicit Association Test. By and large, results did not show a significant difference between the different hand conditions, though there was a marginally significant effect of racial membership on the strength of ownership during the illusion. Future research should focus on assessing pre-existing implicit attitudes, in order to clarify the question concerning which types of people benefit the most from these body ownership exercises that aim to change social biases.

Introduction

Experiencing ownership over something is a fundamental part of building self-consciousness. Accounts in induced body ownership experiments such as the widely-studied Rubber Hand Illusion (RHI) show that manipulations in visuotactile stimuli can lead the brain to experience body ownership over external body parts. In the original RHI experiment by Botvinick and Cohen (1998), participants observed a rubber hand being stroked while simultaneously receiving the same tactile stimuli on their hidden left hand. The synchronous simulation resulted in reported feelings of ownership over the rubber hand, leading researchers to coin the phenomenon an induced body ownership illusion. Later iterations of this experiment apply a painful “threat” stimulus (e.g. needle, syringe, hammer) to the rubber hand after induction (Armel & Ramachandran, 2003). These studies show that people tend to have automatic visceral reactions to the threat. Other studies that have adopted the RHI include induced ownership over non-corporeal stimuli (e.g. balloons; Ma & Hommel, 2015), using external body parts with different physical markers (e.g. different skin color; Farmer, Tajadura-Jiménez, & Tsakiris, 2012) as stimuli, and performing the simulation through non-real realities (e.g. Virtual Reality; Yuan & Steed, 2010). Findings from studies in the latter two conditions -- specifically in virtual environments, shed light on the utility of using this medium to stimulate a heightened state of body ownership but also, raise questions on the possible applications of induced body ownership illusions in empathy building and altering social attitudes.

While a study on the RHI in virtual reality (VR) and its impact on biases has yet to be studied (to my knowledge), a review by Maister et al. (2015) investigates the possibility of altering biases through real-world induced body ownership illusions. Specifically, they propose that changes in social biases "occur via a process of self associations, first in the physical, bodily domain as an increase in perceived physical similarity between self and outgroup member, and then in the conceptual domain, leading to a generalization of positive self-like associations to the outgroup" (Maister et al., 2015, p. 6). Thus, experiencing bodily resonance with an outgroup body results in a more positive association given to that outgroup body and more importantly, "bridges the gap between the perceptual, bodily representations involved in body ownership, and the evaluative, conceptual representations involved in implicit social attitudes" (p. 10).

Considering this argument, along with findings from previous induced body ownership studies, the present study is interested in investigating the social cognitive implications of experiencing induced body ownership through a virtual environment. It will examine concepts and studies related to empathy, implicit biases, induced body ownership, and virtual environments, in order to provide the necessary background for the main research question: What effect does one's racial ingroup identification have in inducing ownership of body parts that belong to a racial outgroup -- specifically, when induction is experienced in a virtual environment?

Self Awareness & an Understanding of Others

In order to understand induced body ownership through virtual realities, it is important to consider how one reaches an understanding and perception of oneself as a bodily subject in the first place. Self-awareness has been characterized by some scholars as a state in which one identifies a perceived visual stimulus as belonging to one's own body (Rochat, 2003; Caruthers, 2008). Indeed, this process has been observed in developmental psychology studies -- in particular, with infants and mirror recognition tasks. For instance, in the classic Rouge Test, an infant is marked with a red dot on their face and placed in front of a mirror (Amsterdam, 1972). Depending on the infant's age, along with a few other factors, they may touch their nose after seeing the specular image of their marked red nose. Some developmental psychologists argue that this act of recognition is a sign that the infant has begun to register/process visual stimuli in relation to their own self (Asendorpf & Baudonnière, 1993). The Rouge Test, along with a plethora of other mirror recognition exercises that follow the same light support the idea that self-awareness and self-recognition occur once the brain can identify the observed sensorimotor behavior of the perceptual stimuli as being the same as the experienced proprioceptive signals (Tajadura-Jimenéz et al., 2012). In other words, one integrates the felt with the observed sensorimotor signals. Eventually, as we age and the present cognitive functions further develop and mature, the process of integrating the felt sensorimotor signals with the observed sensorimotor signals is natural and performed unconsciously. While the exact age by which infants learn to self-identify is unclear, developmental psychologists generally agree that this process begins to take form between 18 months to 24 months (Rochat, 2003).

In relation to the present literature review's overall question concerning the perceptions of others in relation to oneself, it is important to then review the following question: At what age, do we learn to develop a perception of those around us? Some child psychologists argue that the expression of embarrassment, a common reaction to seeing one's reflection in the mirror for 2-year old children, is one of the first signs of an emerging understanding of the 'other' (Lewis, 1992; Rochat, 2003). That is, feeling embarrassed by one's own reflection demonstrates that the infant possesses some low-level awareness that they are being watched or judged by another person. Other findings from this field demonstrate that by age 4 or 5, one's awareness of the other develops into the ability to infer details about the other, such as their emotionality and temperament (Callaghan & Rochat, 2003; Rochat, 2003). In fact, the term *Theory of Mind* was first introduced to explain such early developments in social cognition. The term refers to the ability to attribute mental states to others (Wellman, 2017; Goldman, 2012). Not surprisingly, there is evidence that suggests that this ability relates to one's ability to selectively trust and understand the intentionality of others' behaviors and actions (Carlons, Koenig, & Harms, 2013).

The aforementioned question then becomes: how does the ability to acknowledge the mental states of others develop into empathy? Given the focus of the present study, I'd like to narrow this question even further and ask: how does empathy for people who are racially similar to us (i.e. in-group members) differ from people who are racially dissimilar to us (i.e. out-group members)?

Social cognitive research looks to answer this question as it pertains to the larger framework of body representation and self/other processing. Neurocognitive scientists studying mirror neurons and neural empathy would argue that the ability to empathize with someone is related to one's mirror mechanisms (Gallese, 2010; Keysers & Gazzola, 2009). That is, when an individual observes the state, behavior, or action of someone else, similar neurons in the individual's brain are activated as if they too were experiencing that same state, behavior, or action (Rizzolatti & Craighero, 2004). This model of mirror mechanisms and its potential role in empathy building is explored by Gallese (2010) in his theory on embodied simulation. His theory follows that empathy operates through embodied simulation which Gallese defines as the "mapping of others' actions on the present own motor presentations, as well as others' emotions and sensations onto the present own viscero-moto and somatosensory representations" (p. 82). Using findings from mirror neuron studies, he notes that this form of simulation and embodiment is primarily driven by the shared activation of neural substrates.

With that in mind, one could argue that VR is a type of simulated experience that enables us to not only engage in the observational mirror neuron driven empathy, but also perhaps more interestingly, experience a heightened state of embodiment during which we have a much easier time mapping between self-representation and other-representation. By that, I mean VR's immersive features encourage users to map their self-representation via a headset that prevents users from looking elsewhere, onto the representation of the virtual body; thus, manipulating the boundaries between self and other. I will elaborate on this point in a later section of this review on perspective-taking.

As it relates to the aforementioned question of racial outgroup members, the race of the observed other has been shown to modulate one's shared bodily representation with the other in the context of empathizing with their pain (Serino, Giovagnoli, Làdavas, 2009; Xu, Zuo, Wang, & Han, 2009). These results led Cunnington et al. (2013) to conduct an experiment that tested whether an assigned social category would have a similar effect in modulating neural empathic responses to observed pain as race had in previous studies on empathy and racial membership. In their study, Cunnington and his colleagues assigned participants to an "own" group and an "other" group. After being informed of their group assignments, participants were then asked to watch video clips of actors receiving a non-painful touch or a painful touch to their cheek. While this occurred, experimenters measured the participants' neural responses through fMRI scanners. Consistent with previous studies, Cunnington and his colleagues found that the greatest neural activation occurred when participants watched racial ingroup members receive the painful touch. More importantly, they did not find a significant neural response in participants viewing their "own" group assignment. Altogether, these findings suggest that "race may cause an automatic and bottom-up bias in empathic neural activation to pain" and that perhaps, we really are "innately tuned to the perception of people who are 'like us" (p. 9). If this is indeed, true, there is something to be said about the present thesis experiment and its attempt to change racial biases through multisensory simulation. Future studies would benefit from recording participants' implicit racial biases before and after viewing the clips, in order to assess if the racial similarity or dissimilarity of own-group members during the viewing task had an impact on one's racial biases. Incorporating this addition may not seem directly relevant to Cunnington's original research question on empathic responses to pain, but as I will demonstrate in the next section, the ability to understand another's state is deeply tied to one's implicit biases.

Detecting Racial Biases

The development of the Implicit Association Test (IAT) by Greenwald, McGhee, and Schwartz (1998) introduced social psychologists to quantitative metrics for capturing an individual's "thoughts and feelings outside of conscious awareness and control" (Project Implicit, n.d.). Termed *implicit biases*, these thoughts and feelings are typically characterized as being challenging to consciously detect due to the near impossibility of self-reporting them. That being said, research has shown how important these invisible biases are in the present day-to-day interactions -- namely in predicting discriminatory behavior (Mcconnell & Leibold, 2001; Gonsalkorale et al., 2008; McConnell & Leibold, 2001, Greenwald, 2009).

Today, the IAT is one of the most commonly used methods for measuring implicit biases. During the test, participants complete rapid categorization tasks that involve matching concepts and attributes to categories. In the case of the IAT for racial biases, test takers undergo 7 blocks of categorizing words (attributes) and pictures of faces (concepts). In the first block, they are asked to categorize faces as either belonging to a Black or White-identifying individual. The second block repeats the same categorizing instructions; however, instead of photographs as stimuli, participants are presented with adjectives and must attribute the adjectives to either the positive or negative word list which participants are introduced to at the beginning of the test. Each category corresponds to either a left or right response key on the keyboard. The third block combines the Black/White concept categorization with the positive/negative attribute categorization so that participants are presented with pairs of categories that share the same response key as another category (e.g. Black and negative mapped to the left key, White and positive mapped to the right key). Participants are again instructed to categorize the stimuli -- either a photograph or an adjective as fast as possible.

To provide an example, a participant is currently in a block wherein Black and negative are both assigned to the left response key. They are presented with a photograph of a Black face. In order to give a correct response and proceed to the next trial, they would need to press the left key since that is the corresponding response key for the category Black during that block. In the next trial, they are then presented with an adjective from the negative word list. Again, they would need to press the left key in this trial since negative words are also mapped to that key.

The fourth block is identical to the third block, though only the scores from the fourth block are used for calculating the racial bias score, unlike the first, second, and third block -- all of which are considered practice blocks and are not included in the analysis. Scores are determined by response times, with the argument being that the time that someone takes to categorize the stimuli reflects the strength of their association between the concept and the attribute. For example, someone with an implicit racial bias in favor of White people would respond quicker to categorizing White or positive word stimuli when these two categories share the same response key. The remaining blocks replicate the first two blocks; albeit, slight changes are made to reverse the category pairs (e.g. Black/negative becomes Black/positive, White/positive becomes White/negative). The same reversal applies to the sixth and seventh block so that the initial categories that shared the same key in the third and fourth block are swapped with the other categories.

Previous studies have shown that there is a discrepancy between self-reported measurements and implicit measurements (Cunningham et al., 2001; Hofmann et al., 2005). So even if we think we aren't consciously exercising prejudice, what happens in the present brains to trigger these biases? Simply put, it isn't necessarily a question of a trigger, more so a question of an inhibition. Continuing the previous example, when the White-preferred participant encounters a White face during a trial in which White people share the same key response as bad words, the participant will most likely take longer to respond than in trials in which White people share the same response key as good words. This is largely in part due to the fact that they inhibit their automatic associations of White faces and good words, in order to give the correct response. The inhibition, therefore, results in a latency and more importantly, reflects the existing strength of association between certain concepts and attributes in one's brain. Similar to affective priming tasks wherein participants must inhibit responses to incongruent target words, test takers must inhibit their implicit, automatic attitudes to particular concept-attribute pairings.

On that note, there's an ongoing debate about whether the IAT is a truly reliable measurement for assessing the strength of one's implicit biases. While some of the above references have concluded that there exists a correlation between one's IAT score and one's social behavior, some critics of the IAT who are more wary of these findings, argue that there several other variables that can influence one's performance and that the score alone should not be the only thing to directly determine one's level of prejudice or racism. Some examples include: whether participants have completed a version of the IAT before (see test-retest reliability; Cunningham et al., 2001), whether participants can simply recognize the tested concepts and attributes (Rothermund and Wentura, 2001; see review by Greenwald & Nosek, 2001), and whether participants are a part of the majority or minority group being tested (Rudmore & Ashmore, 2001). The IAT is a promising tool for uncovering implicit attitudes under a wide umbrella of social concepts, such as race, skin color, gender, and religion; however, as critics of the IAT have pointed out, findings should be taken fairly lightly in terms of assessing the discriminatory tendencies of an individual (Greenwald & Nosek, 2001).

In response to the discovery of implicit biases and the subsequent tests made to detect such attitudes, there has been a sudden growth in research specifically dedicated to investigating techniques for reducing implicit biases. One study by Inzlicht, Gutsell, and Legault (2011) found that mimicking outgroup members lead participants to score lower on an implicit anti-Black prejudice test. This study is relevant to the present experiment because its findings delineate some of the mechanisms involved in changing implicit attitudes. In their discussion, Inzlicht and his colleagues, point to the phenomenon of self-other overlap as one possible explanation behind these changes. According to Inzlicht, the notion of self-other overlap refers to “the overlap between one’s mental representation of the self and the mental representations of another person or group” (2011, p. 364). Considering this definition, Inzlicht and his colleagues call attention to studies that have looked at prejudice reduction -- specifically, at how prejudice reduction exercises (e.g. mimicry, manipulations to perspective-taking, increased intergroup interactions) manipulate the overlap between one’s understanding of oneself and understanding of others (Galinsky & Moskowitz, 2000; Phills et al., 2011). One particular study that Inzlicht cites found that perspective-taking exercises reduced stereotyping, as well as they lead to an increase in self-other overlap (Galinsky & Moskowitz, 2000; Inzlicht, Gutsell, & Legault, 2011).

The idea of perspective-taking or as Inzlicht characterizes it in their paper, "putting oneself in the shoes of another" as a method to promote self-other associations and more importantly, reduce racial biases has been studied by other members in social psychology. For instance, a study by Fini et al. (2013) indirectly builds upon this idea by researching a process that they've identified as *somatosensory resonance*. According to Fini et al., this process refers to the re-mapping of observed bodily states onto one's own sensorimotor system. In their study, Fini et al. delivered tactile stimuli to participants as they observed clips of either racial ingroup or outgroup faces receiving the same tactile stimuli. Researchers adopted the Visual Remapping of Touch[1] (VRT) effect from Ladavas and Serino (2010) to quantify feelings of somatosensory resonance. Similar to previous findings on the racial modulation of bodily resonance, participants' VRT effects were found to be modulated by one's existing implicit biases towards racial outgroup faces. Specifically, White participants were able to experience higher somatosensory resonance (i.e. stronger VRT effects) with Black faces after undergoing an interpersonal multisensory stimulation (i.e. the Enfacement Illusion[2]; Tajadura-Jiménez et al., 2013, p. 7). This change in somatosensory resonance suggests that interactions between "low-level multisensory integration processes," such as the interpersonal multisensory stimulation and "higher-

[1] This effect refers to the enhancement of one's perception of near-threshold tactile stimuli (i.e. touch) to one's face when observing someone else's face being touched (Serino & Ladavas, 2010).

[2] The Enfacement Illusion is another form of induced body ownership illusion that involves experimenters touching participants' faces while they watch someone else's face being touched. Similar to the RHI paradigm, synchronous touching leads participants to develop a sense of self-identification with the other face (Tajadura-Jiménez et al., 2013)

level representations of self and other" (e.g. racial membership) can result in the blurring of boundaries between self and other and ingroup and outgroup membership.

Induced Body Ownership

To that end, what characteristics facilitate a successful body induction? As highlighted in the original RHI experiment (Botvonick & Cohen, 1998), the simulation must be administered synchronously in order for the illusion to work. The reasoning behind this follows that the correlated visual and tactile stimuli influence the brain to match the visual stimulation (i.e. stroking the rubber hand) with the tactile stimulation (i.e. stroking the participant's real hand). Thus, the multisensory integration of visuotactile stimuli develops into a perceived sense of body ownership. Some scholars view this requirement of synchronous visuotactile stimuli as evidence that bottom-up mechanisms drive the present feelings of body ownership (Armel & Ramachandran, 2003).

On the other hand, other studies have challenged this notion by examining the limitations of induction. For instance, in Tsakiris and Haggard's study (2005), their findings showed that the rubber hand must be positioned in the same angle as the real hand, as well as it must possess some representational similarity with the real hand, in order for the RHI to have an effect on participants. That is, Tsakiris and Haggard found that the RHI did not have an effect when they replaced the rubber hand with a wooden stick. A later review by Tsakiris (2010) developed this point further, by proposing a neurocognitive model in which Tsakiris identified three main criteria of a successful induction: 1. The participant has an existing association stored in the brain between the visual appearance of an object and their physical human body, 2. the object's postural and anatomical features are congruent with that of a real effector; and 3. visual stimuli and tactile stimuli match

(Tsakiris, 2010; for review see Ma & Hommell, 2015). This model, along with Tsakiris and Haggard's findings (2005) supports the argument that there are top-down limitations that interfere with induction. Interestingly, in a recent study by Ma and Hommell (2015), researchers were able to successfully induct participants' body ownership over virtual balloons. As they point out in their discussion, these findings do not support Tsakiris' first and second proposed criterions. Rather, they support the aforementioned view of bottom-up processes.

In light of these findings, I hope that reviewing these two studies demonstrates to the reader that present knowledge on the mechanisms involved in the RHI paradigm is still very much unknown. That being said, it is an important phenomenon to study because it gives us insight into the malleability of one's body representation, as made apparent in the above studies.

To that end, I would like to redirect the focus of this literature review back to studies that have specifically researched induced body ownership and its effect on implicit biases. The study that perhaps provides the most insight on this topic was conducted by Farmer, Tajadura-Jiménez, and Tsakiris (2012). In the first part of their study, Farmer and his colleagues manipulated the skin color of the rubber hand used in the classic RHI paradigm, to see whether skin color of the rubber hand (i.e. white vs. black) would have an effect on the strength of induced body ownership. They employed skin conductance response measures, a questionnaire, and a proprioceptive drift test to assess each participant's strength of inducement. Additionally, they administered the race IAT on participants before and after the simulation task to measure participants' pre- and post-racial biases. Collecting these metrics led them to the remarkable finding that participants who experienced a stronger sense of ownership over outgroup hands during the RHI ended up scoring lower on the post-simulation IAT.

The second part of their experiment refined the design from the first experiment, in order to ensure that the observed changes in the introspective, behavioral, and physiological responses from the first experiment were caused specifically by the feeling of body ownership, rather than the effect of synchronous stimulation alone. They did this by adding a condition in which the position of the rubber hand was set up to imply either a first-person perspective (i.e. in front of the participant) or a third-person perspective (i.e. rotated 180° away from the participant's real hand). Findings from this portion of the study confirmed that the changes were being influenced by body ownership, such that participants reported lower introspective ownership scores during the third-person condition. Overall, this study highlights the implications of induced body ownership illusions and hints at the potential role that strengthening ownership has in changing one's perception of racial outgroups.

In a nearly identical study, Maister, Sebanz, Knoblich, and Tsakiris (2013) discovered that "inducing an overlap between the bodies of self and other through illusory ownership" leads to a reduction of negative implicit attitudes towards outgroup bodies (p. 170). The most significant difference between the two studies was that the study conducted by Farmer et al. (2012) had a within-subjects design whereas Maister's study used a between-subjects design. Maister and her colleagues purposely chose a between-subjects design because they speculated that in the previous study, participant's ownership over both the White and Black rubber hands between pre- and post-RHI measurements lead to an indistinguishable effect on IAT changes. They argued that using a between-subjects design and more importantly, separating the induction experiences would allow the experimenters to "separately quantify changes in attitudes towards dark skin and changes in attitudes towards light skin" (p. 9). As demonstrated in their data, participants did in fact show a change in implicit attitudes towards dark skin after they experienced ownership of the dark-skinned hand, but not ownership over the light-skinned hand. That being said, Maister and Farmer's findings both highlight the potential implications that come from experimentally changing self-other overlap.

Virtual Reality and Virtual Body Ownership

The use of VR technologies in empathic training has received significant attention in the last decade. From medical trainings (Seymour et al., 2002; Stansfield et al., 2000) to educational applications (Bailenson et al., 2008), VR has proven to be a powerful tool for simulating immersive experiences. With the growing number of VR tools made available on the market, researchers have been able to conduct experiments specifically looking at induced body ownership via virtual environments. One of the first studies to do this was by Yuan and Steed (2010). In their study, Yuan and Steed tested to see if IVR induced arm ownership illusion existed and whether a virtual arm versus an abstract arrow cursor would make a difference in the induction. They instructed participants to complete a memory game adapted from Burns et al. (2005) wherein participants had to memorize color sequences on a virtual monitor and a ball game wherein participants had to pick up a ball from a table and drop it into a hole on the same table. During the ball game, participants experienced a threat to their virtual arm in the form of a table lamp falling upon their virtual hand. Lastly, they collected participants' GSR immediately after the threat, as well as administered a questionnaire that involved participants ranking statements regarding their feelings of ownership over the virtual arm after the two games. Results indicated that the IVR induced arm ownership illusion was stronger in the virtual arm condition (i.e. stronger subjective responses on the questionnaire and higher SCR to the threat) than in the abstract cursor. This is consistent with some of the aforementioned studies that suggest the importance of similarity in the visual appearance of the artificial object and one's self (see the Induced Body Ownership section).

On that note, the question of self-representation and virtual bodies has certainly been reviewed by an extensive body of research. Perhaps most pertinent to my experiment is a study by Peck et al. (2013). In this study, Peck et al. discovered that light-skinned participants who experienced a virtual environment in a dark-skinned virtual body had lower scores on their post-VR race IAT. As I briefly described above, VR technologies pose the possibility for a heightened state of embodiment of the other. In Peck et al.'s study, the embodied condition which comprised of synchronous body movements between the virtual body and the participants' body and a first-person perspective (e.g. participants could look down with the headset on and see their virtual body as if they were looking down at their own body) lead to stronger feelings of ownership in participants than in the non-embodied condition which involved simply seeing a virtual body in the mirror. Interestingly, Peck et al. suggest that future studies measure the length in which the lower IAT score lasts. That aside, the study's overall findings illustrate the empathic benefits of simply moving in a virtual body that is different from one's own.

The Present Study

Given these bodies of evidence, the main question that the present study seeks to address is whether experiencing virtually-induced body ownership of a racial outgroup's hands has an effect on one's implicit biases towards that racial outgroup. I hypothesize that the use of the VR in the RHI will not only induce a sense of body ownership, as made evident in Yuan and Steed's study (2010), but will more crucially, result in lower scores on the race IAT, as demonstrated in Peck et al. (2013).

In order to test this hypothesis, I will compare the pre- and post-illusion IAT scores of participants. Since previous studies on induced body ownership and implicit racial biases have only used White participants, I hope to test this illusion on participants from a wider range of racial backgrounds. As Maister et al. (2013) point out in the design of their study, skin color is "a salient perceptual indicator of racial group membership"; therefore, I have chosen to implement a similar design of testing with a Black and White virtual hand as other skin colors may result in vaguer racial group memberships. To account for these vague racial group memberships, I will also dedicate two questions on the post-illusion questionnaire that will ask participants to rate their feelings of similarity or difference with photographs of a White hand and a Black hand. These responses will help determine the racial ingroup and outgroup status of the participant in relation to the race of the virtual hand they saw. Based off of findings from Maister et al. (2013), I suspect that participants will demonstrate the greatest change in post-illusion IAT performance after they've been induced with a virtual hand of a different race.

Methods

Participants

Thirty-two participants (26 females, 5 male, 1 non-binary) were recruited from the undergraduate student population at the Claremont Colleges. The average age was 20.6

years. The self-identified racial backgrounds of the participants were as follows: Asian/Pacific Islander (14), Latino/a (4), Black (3), White (9), and Multiracial (3). They were compensated $10 for their participation.

Apparatus and Materials

Participants were tested in a private room at the Honnold Mudd Library. The equipment used to perform the simulation was an HTC Vive headset, run on a Dell Precision T5500 desktop. The simulation itself was designed and implemented in a 3D-graphics software called Unity. In the virtual environment, there was a small room with light blue walls and brown carpet. The room was furnished with a chair, desk, and lamp. On the desk, there was a pair of hands and a paintbrush floating above the right hand (see Figure 1). All of the objects in the room (with the exception of the paintbrush which was built by Sonia Grunwald), were downloaded from Unity's online 'Assets' store.

For measuring participants' implicit racial biases, an open-source tool called IATgen (Carpenter et al., 2018) was used to design a single-category race Implicit Association Test (IAT), compatible with Qualtrics software. The features of the IAT were identical to the traditional IAT by Greenwald, McGhee, and Schwartz (1998). Participants were first presented with instructions, asking them to complete categorization tasks as quickly as possible. The first two blocks were "practice" blocks that involved categorizing words as having a "positive" (e.g. excitement, friend, spectacular) or "negative" (e.g. horrible, hurtful, angry) association or categorizing images of faces as belonging to either Black or White race. In order to make a categorization, they were required to press either the 'E' key for the the left category and the 'J' key for the right category. The word or image was displayed in the center of the screen and stayed there until the participant entered a response. If the participant entered an incorrect response, they were presented with a red 'X' and forced to correct their error before they could proceed to the next trial.

Following these single category practice blocks, was a test block made up of 20 practice trials and 40 critical trials. In the stereotype-compatible test block, positive words and White images were assigned to one key and Black images and negative words were assigned to the other key; this forced participants to sort the image or word stimuli based off of the stereotype that White faces elicit more positive associations and Black faces elicit more negative associations. The stereotype-incompatible block was the reverse of this so that Black images and positive words were assigned to one key and White images and negative words were assigned to the other key. The order in which participants saw either test block was randomized, thus counterbalancing the categories of words and images. After the first test block, participants completed another sequence of two single-category practice blocks, followed by the other test block. The test was administered through Qualtrics on a MacBook Air 2014 laptop.

In addition to the race IAT, there was also a questionnaire administered through Qualtrics and run on the same MacBook laptop. The first portion of the questionnaire asked participants to rate their level of agreement towards 5 statements on a 5-point Likert scale. The values ranged from -2 (=strongly disagree) to +2 (=strongly agree). These statements were taken from Maister, Sebanz, Knoblich, & Tsakiris (2010) and were used to measure participants' introspective responses to the RHI (see Appendix A). Similar to other RHI studies (Yuan & Steed, 2010; Kalckert & Ehrsson, 2012; Tsakiris, Carpenter, James & Fotopoulou, 2010), responses from the 5 questions were averaged to provide an 'ownership score' for each participant which was later used to assess the strength of the induction. The second part of the survey involved rating the similarity and difference between the participant's hand and images of a Black and White hand on another 5-point Likert scale. The values for similarity and difference ranged from -2 (=very different) to +2 (=very similar). Following these questions were three demographic questions whereby participants reported their self-identified race, gender, and age.

Procedure

Participants were instructed to sit at a table and complete the race IAT on a laptop. They were given instructions on navigating the physical space with the VR headset, as well as given general instructions on how to operate the VR headset. They were then fitted with the HTC Vive headset. Once on, participants were given a 2 minute adjustment period in which they were asked to look around the environment and verbally confirm to the experimenter what they saw in the room. Afterwards, participants were asked to place their arms on the table similar to the posture that they saw in the virtual environment (see Figure 2). The experimenter then informed participants that they would be watching a clip of the virtual right hand being stroked in the VR headset while the experimenter applied strokes to their right hand with a paintbrush. Half of the participants saw a Black hand while the other half saw a White hand. The experimenter timed the strokes to the participant's right hand so that tactile stimuli was synchronised as close as possible to visual stimuli. The stimulation lasted for 2 minutes. Immediately afterwards, participants were instructed to take off the VR headset and complete the same version of the previous race IAT. After completing the race IAT, they were then presented with the questionnaire that measured feelings of ownership and identification with the virtual hand, along with their demographics. Lastly, they were debriefed and compensated by the experimenter.

Results

IAT scores were analyzed through a web application that accompanied the same open-source tool used to run the IAT. The web application automatically excluded individual trials over 10,000 ms, as is common practice in the IAT (Greenwald et al., 2003). One participant was also excluded from the analysis because more than 10% of their response times lasted less than 300 ms. Two *D*-scores (pre and post induction) were automatically calculated for each participant by the web application. The *D*-score is a common effect size measure for implicit bias that involves computing the difference in mean latency between the stereotype-compatible (White/positive, Black/negative) and stereotype-incompatible block (Black/positive, White/negative) and dividing this difference by the standard deviation of the latencies from both of the two blocks (Greenwald, Nosek, & Banaji, 2003). The resulting values were scored such that more positive *D*-scores (> 0) indicated a stronger preference for White faces.

First, an independent samples t-test was used to check if participants had significantly different pre-existing racial biases. There were no significant differences in pre-illusion IAT scores between participants in either condition of Black or White virtual hand, $t(30) = .690$, $p = .496$. Of the pre-illusion IAT scores, 31% of participants had *D*-scores below zero (i.e. a stronger preference for Black faces).

For the main analysis of hand color on the participants' pre- and post-illusion implicit bias scores (see Table 1), a 2 (Hand color: black vs. white) x 2 (Condition: pre-illusion vs. post-illusion) repeated measures ANOVA was run. The main effect of hand color on induction scores was not significant, $F(1, 30) = 0.02$, $p = .884$. Additionally, results did not show a main effect of condition, $F(1, 30) = 1.12$, $p = .299$ nor did it show a significant interaction between condition and hand color $F(1, 30) = 1.47$, $p = .235$.

Next, ownership scores were analyzed to determine whether hand color had an effect on the strength of ownership that participants experienced during the induction. In order to measure the strength of ownership, participants' responses to the five "I" statements were averaged, similar to what had been done in Yuan & Steed (2010). These averages made up the participant's ownership score and ranged between -2 (a weak sense of ownership) and +2 (a strong sense of ownership) (see Table 2).

An independent samples t-test revealed that there was not a significant difference in ownership scores between the two hand color conditions, $t(30) = 0.72$, $p = .479$. Additionally, a correlation test found that ownership scores and the difference in pre- and post-illusion IAT scores were not strongly correlated $r(30) = 0.21$, p = .244.

To examine whether racial congruency (i.e. identifying with the presented race of the virtual hand or not identifying with it) might have affected the strength of ownership, a 2 (Hand color: black vs. white) x 3 (Racial identification: racially congruent, incongruent, and equal) ANOVA was run. Racial congruency or membership was determined by the condition that participants were in (Black or White hand) and their responses to the two questions asking them to rate their hand's similarity to a White hand and a Black hand. Participants who reported feeling a greater similarity to a hand that was of the same race of the virtual hand that they saw during their induction were grouped as "racially congruent." On the other hand, participants who reported feeling a greater similarity to a hand of a different race than what they saw during their induction were grouped as "racially incongruent." Participants who reported finding both the images of the White hand and

Black hand as being neither similar nor different to their hand were grouped as "equal" (see Figure 3). Results from the ANOVA found a marginally significant effect of racial identification, $F(2, 26) = 3.24$, $p = .055$, with those in the racially congruent group reporting, on average, the strongest ownership scores ($M = -0.23$, $SD = 0.27$). There was no significant effect of hand color, $F(1, 26) = 2.00$, $p = .169$ nor was there an interaction between hand color and racial identification, $F(2, 26) = .634$, $p = .538$.

Discussion

In the present study, the Rubber Hand Illusion was performed on participants through Virtual Reality to test whether induced body ownership of a virtual hand belonging to a different race could change an individual's implicit racial biases. Although findings from previous studies have confirmed similar predictions (i.e. changes in implicit biases can be motivated by induced body ownership exercises), the present study did not find a significant effect of racially dissimilar body parts on changes in one's implicit racial biases. Considering these results, it is important to then discuss the design of this experiment and how it differs from previous studies, in order to explain what might have led to these findings.

To date, there have only been a handful of other studies to investigate induced body ownership and changes in implicit biases. Specific to implicit racial biases and VR, there has been one other study to look at these two things; albeit utilizing a full-virtual body embodiment exercise that differed from the mechanisms of the traditional RHI (Yuan & Steed, 2010). Interestingly, this study along with the few other studies dealing with the RHI and racial biases had all White-identifying participants. In contrast, the present study had a more racially diverse sample with White participants making up only 28% of the sample.

Similar to what Maister et. al. (2013) point out in the discussion of their RHI study with all-White participants, the effect of the IAT is generally found to be more apparent in white-majority environments (Ashburn-Nardo & Johnson, 2008; Livingston, 2002; Richeson, Trawalter & Shelton, 2005). Taking into consideration this effect, along with the racial makeup of the present sample, one might speculate that the present participants may have started with weaker racial biases than what is generally reported by other RHI studies, dealing with implicit racial biases. To further support this speculation, a study by Farmer, Maister, and Tsakiris (2014), found that changes between pre- and post-illusion IAT were only significant when participants did not have an initial bias in favor of Black people. In their study, implicit racial biases were measured through a single category variant of the IAT, slightly different from the one used in the present sample. Additionally, scores were counterbalanced so that scores greater than 0 indicated a more positive association of Black people and scores less than 0 indicated a more negative association. The changes in post-illusion scores were found to be significant only when participants' pre-illusion IAT scores were less than 0.07. If we assume the same trend in the present data, albeit through an inverse scale (i.e. scores less than 0 indicate a more positive association of Black people and scores greater than 0 indicate a more negative association of Black people) that means only 69% of participants had an initial bias that Farmer, Maister, and Tsakiris would consider to be strong enough to elicit a change in IAT scores. That being said, due to the potential variability in *D*-score measuring algorithms between the two studies, this comparison should be taken fairly lightly.

Something else to note about the present findings is that participants, regardless of which condition they were in, reported weaker levels of ownership than what participants reported in previous non-VR RHI studies (Maister, Sebanz, Knoblich, & Tsakiris, 2013). Because induced body ownership in VR is still very new and unknown, there is a chance that the novelty of the virtual environment may have interfered with participants' inductions, leading them to feel less ownership over the virtual hand than what participants typically report feeling when experiencing induction over a real life hand. In the future, it would be useful to implement a non-VR condition wherein researchers perform the RHI without the virtual reality; this would help us assess whether the virtual environment leads to a weaker or greater sense of induction.

That being said, there have been a few studies that have researched induced body ownership (although not in relation to implicit racial bias) in a virtual environment (Yuan & Steed, 2010; Ma & Hommel, 2013) and have been relatively successful in inducing ownership in their participants; however, these studies utilized exercises that were far more complex than the traditional RHI. In Yuan & Steed (2010), for example, they used two game-like tasks and applied a threat stimuli to the virtual hand. Additionally, in the aforementioned study by Peck et al. (2013), they had access to a full-body suit and had instructed participants to stay in the virtual environment for at least 11.5 minutes. In line with what was brought up in the previous paragraph, there is a possibility that the participants in my sample may have needed a more interactive induction, as well as may have needed a longer time to adjust to the virtual environment.

Another possible explanation for why participants may have reported such low ownership scores is that this study's race IAT enforced a binary of White and Black racial membership that may have felt too limiting for participants of other races. the present findings may have turned out differently had we tested on participants exclusively from either racial group, rather than from other racial groups. As described earlier, the highest percentage of participants self-identified as Asian American/Pacific Islander (44%). In relation to the present stimuli, participants from this background were presented with faces that were from two racial outgroups (White and Black) during the IAT. Though some of these participants reported finding the Black or White hand similar to their own hand, perhaps that similarity measurement wasn't sufficient enough to conclude a racial identification with a skin color. That being said, we suspect that this may have also been the reason why we ended up with a fairly high number of participants who reported feeling as equally similar and different to the images of Black and White hands. It is possible that these individuals could not choose one over the other; thus, opting for the equal response. Future research on this topic would benefit from tailoring the IAT to include both a racial ingroup and racial outgroup, depending on the reported racial identity of the participant.

Perhaps the most promising findings are those of the marginally significant effect that was found between participants' ownership scores and their level of similarity with a hand of either White or Black race. This suggests that the more one identifies with the physical appearance of a hand, the stronger they report feeling ownership over a virtual version of it. More related to the aforementioned marginally significant effect, having a more racialized body part such as a virtual face as stimuli could lead to stronger findings, in that it could clarify what the parameters of similarity (i.e. do individuals find the shape of a body part the biggest indicator of similarity or do they find skin color?) are in the interaction between similarity and strength of ownership.

While the data is not significant enough to neither confirm nor deny the hypothesis, the present study opens up several lines of future research and raise deeper questions on the role that one's pre-existing identity has in experiencing induced body ownership exercises. It is important that future studies recruit participants from a wide range of racial groups such as what has been done in this study. Though there are previous studies who have successfully altered IAT scores through the RHI, their all-White samples defeat the purpose of using induced body ownership exercises outside of the laboratory. That is, outside of the laboratory, populations are much more racially diverse and race is not as easily quantified nor salient. In the future, analyzing the IAT scores of previous RHI studies -- namely the studies who have recruited all-White samples, may also shed light on the potential differences that exist between each race's performance on the race IAT. Further research should be done on the topic of manipulating implicit biases for non-White individuals as this still appears to be a fairly unknown topic.

Tables

Table 1

Means and Standard Deviations for IAT D-scores in Each Condition

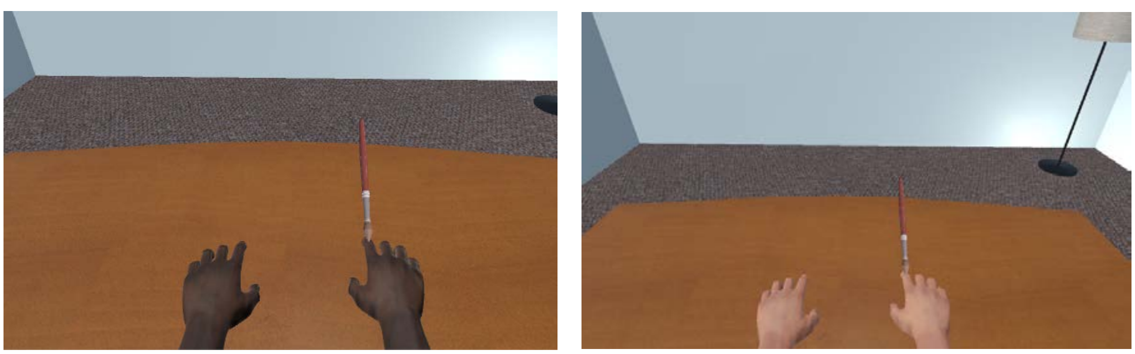
Condition	Pre-induction		Post-induction	
	M	SD	*M*	SD
White hand	0.228	0.521	0.049	0.578
Black hand	0.108	0.461	0.121	0.487

Table 2

Means and Standard Deviations for Ownership Scores in Each Condition

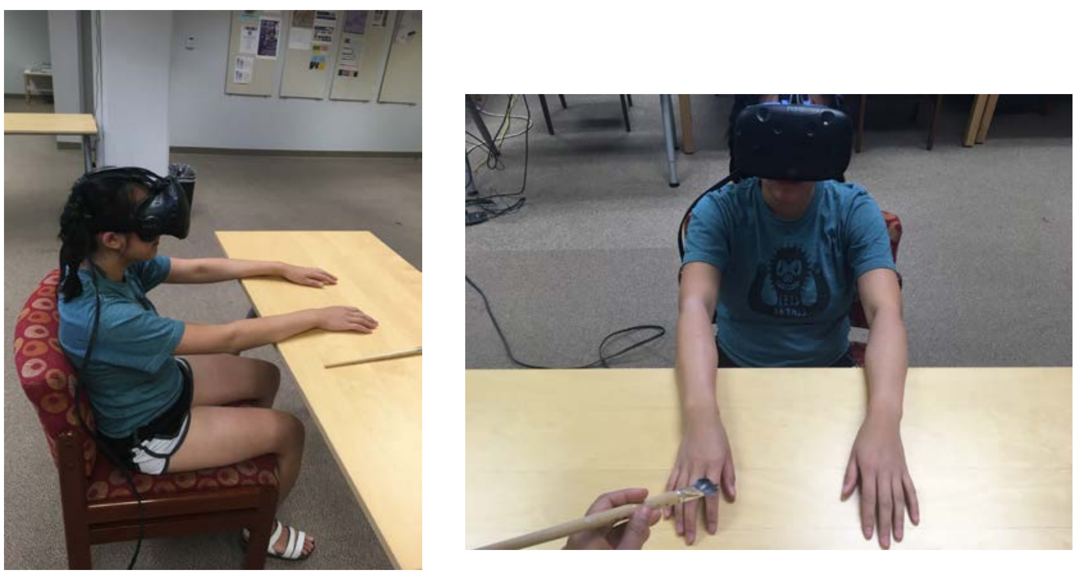
Condition	*M*	SD
White hand	-0.938	0.973
Black hand	-0.688	1.001

Figures



A **B**

Figure 1. Experimental set-up of the virtual rubber hand illusion. Participants saw either the Black (A) or White (B) pair of hands.



A B

Figure 2. Participant wearing the HTC Vive headset before undergoing the RHI simulation (A) and position of experimenter and participant during the RHI simulation (B).

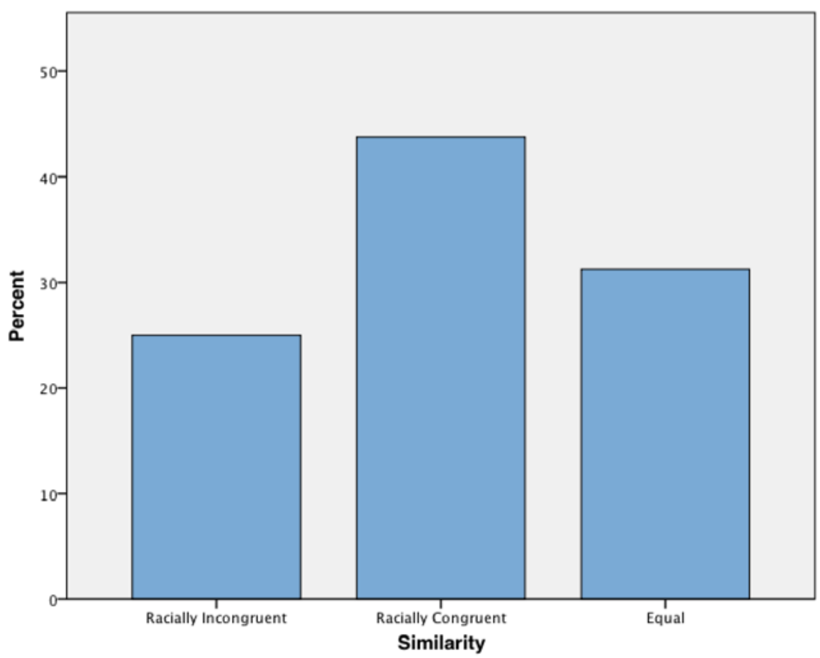


Figure 3. Percentage of participants in each of the racial membership categories.

Appendix A

The 5 statements from the 'Ownership' portion of the Qualtrics questionnaire, adapted from Maister, Sebanz, Knoblich, & Tsakiris (2013). Participants' were asked to rate their level of agreement towards the statements. Responses were then rated on a 5-point Likert scale (+2 = 'Strongly agree', -2 = 'Strongly disagree').

During the experiment there were times when it seemed like…

1. I was looking directly at my own hand, rather than at a virtual hand.
2. The virtual hand was part of my body
3. The virtual hand was my band
4. The virtual hand belonged to me
5. The virtual hand began to resemble my real hand.

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Other resources:
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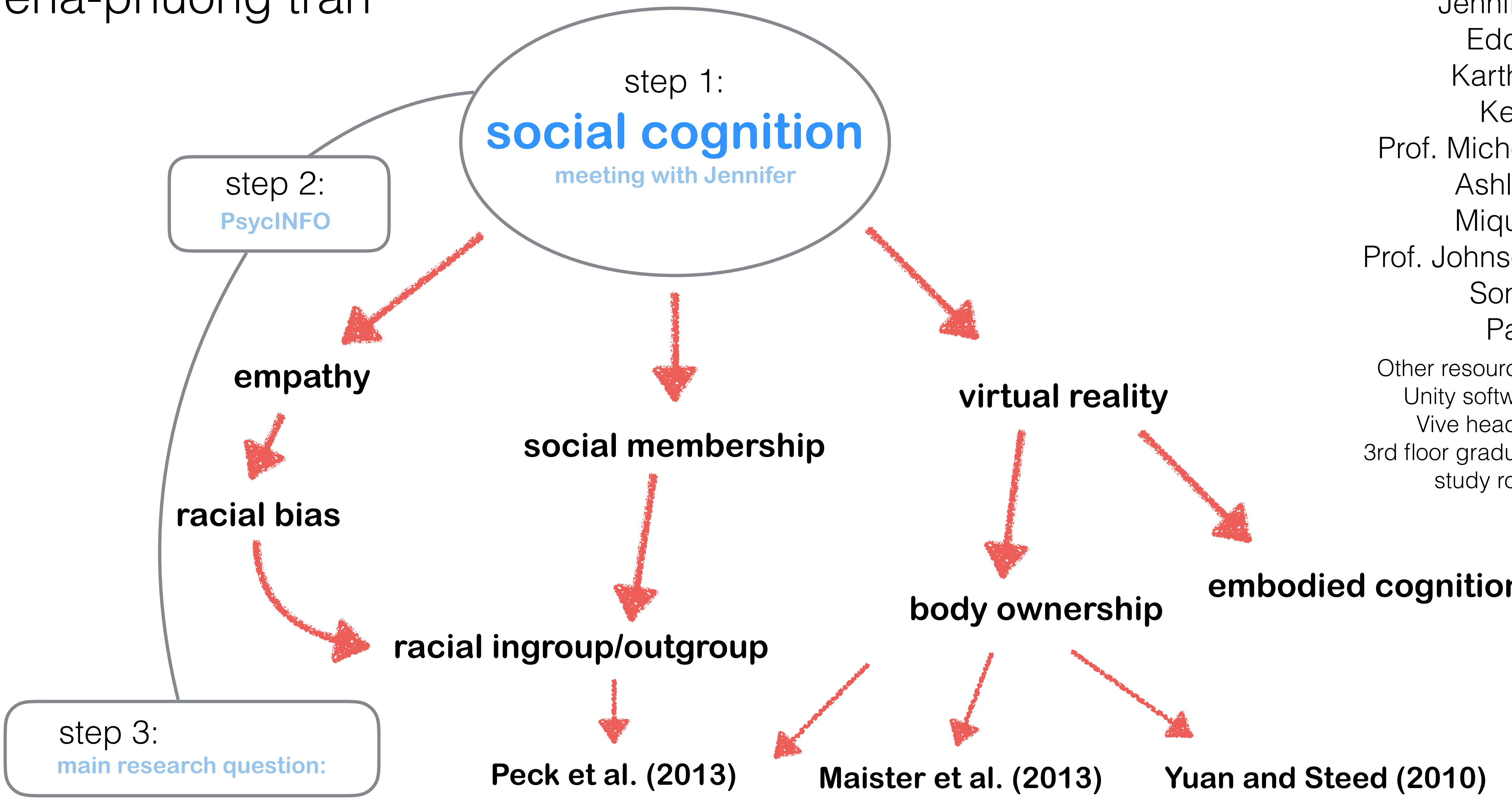

Does experiencing virtually-induced body ownership of a racial outgroup's hand have an effect on one's implicit racial biases?