THE ROLE OF EMPATHY IN THE RUBBER HAND ILLUSION

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Psychological Science Option

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by

Scott Cannon Lewis

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ABSTRACT

THE ROLE OF EMPATHY IN THE RUBBER HAND ILLUSION

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The relationship between empathy and the rubber hand illusion has yet to be investigated. The current study investigated the relationship between measures of susceptibility to the rubber hand illusion and measures related to empathy and alexithymia. Latency to the illusion was recorded and participants completed a post-illusion questionnaire. Illusion latency, intensity scores, and questions affirming the illusion were compared to scores on the IRI and TAS-20. Significant correlations were found between illusion intensity and illusion latency. Regression analyses indicated the Empathic Concern subscale of the IRI predicted Illusion Latency. Findings indicate an inverse relationship between latency and self-reported strength of the illusion and that empathy may be related to onset of the illusion.

CHAPTER I

INTRODUCTION

The rubber hand illusion is an introspective illusion involving vision and touch. The illusion involves ascribing feedback from physical stimulation of the hand to a location and object not physically connected to the rest of the body (e.g., Botvinick & Cohen, 1998). Generally involving a paradigm in which a participants' hand is stimulated out of view, the illusion involves ascribing the feedback from unseen hand stimulation to arise from an observed artifact (rubber hand). The induction is most likely to occur when the unviewed felt stimulation matches the rate at which the viewed artifact is being stimulated (Costantini & Haggard, 2007). Individuals differ on the ability to ultimately capture the illusion as well as their self-report intensity and how fast it takes them to feel the illusion.

Much of the research on the rubber hand illusion has only been concerned with the mere presence of the illusion as assessed through the self-report questionnaire and to what extent can the illusion set-up can be manipulated and still induce the illusion (Tsakiris & Haggard, 2005; Constantini & Haggard, 2007). A review of the rubber hand illusion literature reveals only a few studies that report illusion onset latency (Peled, Ritsner, Hirschmann, Geva, & Modai, 2000; Peled, Pressman, Geva, & Modai, 2003; Ehrsson, Spence & Passingham, 2004; Ehrsson, Nicholas & Passingham, 2005).

Only one study was found that investigated individual differences in latency to the illusion and it compared schizophrenics to a normal control group (Peled et al., 2003). Interestingly the reported mean time of onset varies widely, from seconds (Ehrsson et al., 2004; Ehrsson et al., 2005) to several minutes (Peled et al., 2000; Peled et al., 2003).

With regard to nonclinical populations, there has been no systematic study of individual differences in susceptibility to the illusion. Studies report that 30% to 50% of people report experiencing the illusion (e.g., .Ehrsson et al., 2005; Ehrsson et al., 2007; Mussap & Salton, 2006). As such, little is known about factors that mediate sensitivity to the rubber hand illusion.

One clue to a possible mediating mechanism comes from a separate area of study investigating so called “heart blindness” and its’ relationship to empathy (Critchley, Wiens, Rotshtein, Ohman & Dolan, 2004). In this research participants are asked across a series of trials to determine whether a series of audible beeps corresponded to their heart rate. Participants were found to vary with respect to accurately identifying when the series of beeps was coincident with their heart rate, with those who performed at or near chance referred to as “heart blind”. Critchley and his team also studied interoceptive awareness and specific brain regions, finding increased activity in the anterior insula for those that were more accurate in matching heart rate to beep temporal patterns. They also found evidence that the size of the right anterior insula is related to interoceptive awareness.

A finding of crucial importance to the current study was the positive relationship between those who were accurate at matching their heart rate to presented beep patterns and their assessed capacity for empathy (Critchley et al., 2004). It was suggested that interoceptive awareness may be an important factor in one's ability or tendency to empathize with others, in a sense, to be able to imagine the internal states of others. If so, this suggests a possible mediating mechanism to help explain individual differences in susceptibility to the rubber hand illusion.

One way to conceptualize the rubber hand illusion is that it involves one's ability to ascribe interoceptive feedback from an actual limb (hand in this case) to a point of origin not physically part of the participants' body (the rubber hand). Given that previous research on individual differences in introspection, interoceptive ability (i.e. heart blindness) and intersubjectivity (i.e. empathy and alexithymia) have identified an overlap of brain regions involved in both personal experience and perception of feeling states and emotions, it stands to reason that capacity for empathy, an intersubjective phenomenon that relies heavily on introspection, may help in explaining individual differences in rubber hand illusion experience, an introspective illusion.

The current study was designed to test the hypothesis that sensitivity to the rubber hand illusion can be predicted by measures of empathy. It is predicted that those who score high on measures of empathy will show greater susceptibility to the rubber hand illusion. While it is not clear the role, if any, alexithymia may play in mediating susceptibility to the illusion in a nonclinical population, the apparent inverse relationship between alexithymia and empathy warranted inclusion of a measure of alexithymia in the current study.

CHAPTER II

LITERATURE REVIEW

Introduction

A unique illusion first introduced by Botvinick and Cohen (1998), the rubber hand illusion involves the perceived location and tactile stimulation of one's actual hand that is hidden from view to arise from a strategically placed and seen 'rubber hand'. This illusion evokes a feeling of ownership of the rubber hand. The illusion is produced by obscuring the hand from view and synchronously brushing it with a seen rubber hand (Botvinick & Cohen, 1998). The synchronicity between the unseen (yet felt) brush strokes and the seen brush strokes on the rubber hand evokes the illusion that the seen rubber hand is the participants' real hand. In a comprehensive study, Tsakiris and Haggard (2005), described it as if, "tactile sensations were projected onto the rubber hand, which eventually felt like part of their own body" (p. 80). After induction of the illusion, strength is commonly measured through a nine item questionnaire originally designed by Botvinick and Cohen (1998). The nine questions of the rubberhand illusion questionnaire are split between affirmation questions and questions targeted towards other illusion-related perceptual phenomena (e.g., hand feeling rubbery).

Similar to empathy, when the rubber hand illusion is induced, actions external to the boundary of one's body (touch of the rubber hand) are "captured" and experienced (tactile sensations arising from one's body). Recent functional magnetic resonance imaging (fMRI) research investigated the integration of the rubber hand into one's own body image and induced feeling of ownership. These studies confirmed that the illusion is more than a high-level perceptual illusion, but includes actual premotor as well as other cortical responses in the brain (Ehrsson, Spence, & Passingham, 2004; Ehrsson et al., 2005) . Ehrsson et al., (2005) even discovered—by blindfolding participants and having them touch the rubber hand with the left hand while an experimenter touched the right hand of participants—that vision is not necessary for the effect of the rubber hand illusion, only tactile and proprioceptive stimulation is necessary.

Further research by Ehrsson, Spence, and Passingham (2004) has confirmed a positive relationship between self reported illusion and neural effects. The team compared data when the brushing was synchronous and the rubber hand aligned with the real hand to data when only the brushing was asynchronous and data when only the rubber hand was not aligned to the real hand. Their findings show fMRI evidence that self-reported stronger illusions coincide with the strongest neural activity in the premotor cortex and additionally that activation in the premotor cortex was enhanced after reported illusion onset (Ehrsson et al., 2004).

Ehrsson, Wiech, Weiskopf, Dolan, and Passingham (2007) added to these findings by showing similarities between a threatened real hand with and a threatened rubberhand during the rubberhand illusion. Ehrsson et al. (2007) used fMRI to scan the brains of participants as experimenters threatened their hand with a needle, then induced the rubberhand illusion and measured brain activity when an experimenter threatened the rubber hand. Their analyses of these measurements indicated that similar brain regions were activated in both of the threat conditions. They demonstrated that when participants were experiencing the rubber hand illusion they reacted emotionally similar to threats of the rubber hand as when they reacted to threats of their own hand. Additionally, Ehrrson et al. (2007) demonstrated higher activation levels in the anterior cingulate cortex (ACC) for participants that rated the illusion experience stronger. That is to say, those that rated the experience stronger also showed greater activity in the ACC. The fact that ACC activity has been shown to be involved both in the experience of pain and in the *perception of pain in others* provides further support for the idea that susceptibility to the rubber-hand illusion per se is at least in part mediated by mechanisms involved in empathy.

Measuring the Rubber Hand Illusion

To assess the most effective set-up for the rubber hand illusion, the procedures were reviewed in seven studies utilizing the rubber hand illusion (Botvinick & Cohen, 1998; Peled, Ritsner, Hirschmann, Geva, & Modai, 2000; Peled, Pressmen, Geva, & Modai, 2003; Tsakiris & Haggard, 2005; Ehrsson, Holmes, & Pasingham, 2005; Mussap & Salton, 2006; Ehrsson et al., 2007). A few of the studies reported using a screening process to determine experience of the rubber hand illusion. Studies that screened reported a null-illusion rate of 30 to 50 percent of their samples. Many of the studies that prescreened decided to drop participants that did not experience the illusion. Though these studies were interested in factors related to the illusion per se, inclusion of a null-illusion group may have yielded interesting results in the fMRI studies and future research should examine cortical activity between groups of those that do and do not experience the rubber hand illusion. It will be expected that some percentage of participants will not experience the illusion, based on the typical findings across studies that not all participants evidence experiencing the illusion.

Brushing technique and whether the study determined handedness of participants was also examined in these seven studies (see Appendix A). The three studies that used the original design proposed by Botvinick and Cohen (1998)—that of a partition to obstruct the participant's view of their real hand while the rubber hand rests in view next to it—did not report any participants who failed to experience the illusion. This may be due to the fact that the illusion is most vivid when the rubber hand is as close to mimicking the spatial placement of the hand and arm as possible (Tsakiris & Haggard, 2005; Constantini & Haggard, 2007; Lloyd, 2007).

The rubber hand illusion has been traditionally assessed and measured using the questionnaire first designed by Botvinick and Cohen (1998). The questionnaire consists of nine questions; three affirm the presence of the illusion (ex: *I felt as if the rubber hand were my hand*) and the remaining address other physiological and proprioceptive phenomenon not related to potential phenomenal qualities of the illusion (ex: *It felt as if my real hand were turning rubbery;* Botvinick & Cohen, 1998). Much of the research on the rubber hand illusion has only been concerned with the presence of the illusion as assessed through the self-report questionnaire and to what extent can the illusion set-up be manipulated and still induce the illusion (Tsakiris & Haggard, 2005; Constantini & Haggard, 2007). A review of the studies that include the rubber hand illusion reveals only a few studies that report latency of illusion onset (Peled, Ritsner, Hirschmann, Geva, & Modai, 2000; Peled, Pressman, Geva, & Modai, 2003; Ehrsson et al., 2004; Ehrsson, Nicholas & Passingham, 2005). Only one study was found that investigated individual differences in latency to the illusion and it compared schizophrenics to a normal control group (Peled, Ritsner, Hirschmann, Geva, & Modai, 2003). Interestingly the reported mean time of onset varied widely, from seconds (Ehrsson et al., 2004; Ehrsson et al., 2005) to several minutes (Peled et al., 2000; Peled et al., 2003).

Rubber Hand Illusion and Neural Correlates

Ehrsson and colleagues have conducted a number of studies investigating neural correlates to the rubber hand illusion (Ehrsson, Spence & Passingham, 2004; Ehrsson, Holmes & Passingham, 2005; Ehrsson, Wiech, Weiskopf, Dolan & Passingham, 2007). In these studies they used fMRI to investigate areas such as the premotor cortex, the cerebellum, and the intraparietal cortices. In each study the Ehrsson and colleagues were able to show that the strength of self-reported vividness of the illusion correlated with increased activity in specific regions of the brain.

In the first study, Ehrsson, et al. (2004) were able to show that participants who rated the illusion stronger had increased blood oxygen level-dependent (BOLD) signal in the right lateral cerebellum and the bilateral premotor cortex. Participants were scanned using fMRI in a 2 x 2 completely crossed design. The first factor was orientation of the rubber hand; aligned with the hand or rotated 180 degrees. The second factor was synchronous brushstrokes or alternating brushstrokes. Results indicated the strongest condition was the Synchronous Aligned. Comparisons of the fMRI of the Synchronous

Aligned condition to other three conditions indicated a relation between illusion strength and the premotor cortex and the right lateral cerebellum. They concluded from this study that the rubber hand is more likely to be integrated as one's actual hand when the orientation and stimulation matches the rubber hand and only in this matched condition were they able to measure a "felt" response on the neurological level.

In the second study, Ehrsson et al. (2005) introduced a new version of the rubber hand illusion and provided evidence that stronger ratings correlated with higher activation in the brain. In this fMRI study participants were blindfolded and then made to tap a rubber hand with their left hand while an experimenter tapped their real right hand. This was done to produce the illusion that participants were tapping their own hand, even though actual and rubber hands were separated by a distance of 15 cm. Vividness ratings were taken after trials by having participants rate how lifelike they felt they were tapping their own hand on a scale of 0 to 9.

Ehrsson et al. (2005) were able to show that this new paradigm was effective in producing the illusion. Participants reported that they felt they were tapping their own hand. These findings show that vision is not necessary for the illusion. They were also able to show that higher ratings of the illusion correlated with increased activity in specific brain regions. Analysis of the scans of the premotor and cerebellar cortices indicated that greater activation in these regions correlated with greater strength ratings of the illusion.

In a novel fMRI study, Ehrsson et al. (2007) investigated the relationship between the threat of a real hand and the threat of a rubber hand while the illusion was evoked. Using fMRI, Ehrsson et al. (2007) measured participant brain activity while an experimenter threatened their hand with a needle. As a comparison trial, the rubber hand illusion was evoked and then an experimenter threatened the rubber hand. After each trial participants were asked to rate the vividness of the illusion. A third trial where an experimenter threatened the rubber hand when participants were not under the illusion was used as a control comparison. Ehrsson et al. (2007) provided two interesting results; (1) that participants' reactions were the same to threats of the rubber hand as they were to threats of their own hand, but only during the illusion and (2) ratings of vividness correlated with blood-oxygenation-level-dependent (BOLD) response in the anterior insula and the ACC.

Empathy

Empathy can be thought of as affect sharing (Decety & Lamm, 2006; Jackson, Brunet, Meltzoff, & Decety, 2006; Preston & de Waal, 2002; Singer, 2006). When an individual (the subject) perceives another displaying an emotion for a given event, the subject shares that emotion without experience of the event directly. Simply perceiving another in pain activates the sensations and experience in the self, absent of the direct threat. Empathy can also be invoked through imagination (Batson, Sager, Garst, Kang, Rubchinsky & Dawson, 1997; Jackson, Rainville & Decety, 2006). When individuals imagine themselves in painful situations, brain regions associated with the physical experience are activated.

Preston and de Waal (2002) have attempted to unify the empathy construct and debate by offering a model in which empathy is superordinate to other similar constructs (sympathy, emotional contagion, perspective taking) and includes these constructs. Rather than to distinguish empathy from sympathy, emotional contagion and perspective taking, the Perception-Action Model involves all of these by supposing empathy to be as a superordinate concept. Empathy as a superordinate construct is therefore inclusive of all subordinate constructs that involve similar mechanisms. The Perception-Action Model states the: "attended perception of the object's state automatically activates the subject's representations of the state, situation and object, and that activation of these representations automatically primes or generates the associated autonomic and somatic responses, unless inhibited," (Preston & de Waal, 2002, p 4).

Moriguchi et al. (2007) review seven studies in support of this model. What these seven studies share is that they all showcase the neural underpinnings of empathy through functional magnetic resonance imaging (fMRI). With the advent of fMRI these studies have shown that the neural components responsible for the action also function in the *perception* of the action (Moriguchi et al., 2007; Cheng et al., 2007; Ehrsson, Wiech, Weiskopf, Dolan, & Passingham, 2007; Jackson et al., 2006; Ehrsson, Spence, & Passingham, 2004; Ochsner, Bunge, Gross, & Gabrieli, 2002). This evidence stands in support of the cognitive model that human brains have shared neural circuits for our actions and emotions.

These findings have also been extended to other primates and have been supported through electrophysical research on monkeys and fMRI studies in humans (Preston & de Waal, 2002; Decety & Lamm, 2006; Decety & Jackson, 2006; Jackson et al., 2006). Taken as a whole, this research has shown that the neural mechanisms particular to the expression, activation, and physical experience of pain and emotion in the self considerably overlap with those mechanisms that allow us to perceive emotions and pain in others. However, there is not complete overlap between these two mechanisms; each require distinct neural mechanisms as well (Jackon, Rainville, Decety, 2006; Jackson et al., 2006; Decety & Lamm, 2006).

The social neuroscience model of empathy, "includes three primary components: (1) an affective response to another person, which often, but not always entails sharing the person's emotional state; (2) a cognitive capacity to take the perspective of the other person; and (3) emotion regulation" (Decety & Jackson, 2004, p. 54). Moriguchi et al. (2007) refined the third component to read, "some regulatory mechanisms that keep track of the origins of self and other feelings" (p. 2223).

Measuring Empathy

The Interpersonal Reactivity Index (IRI) was created by Mark Davis (1980) to measure empathy under the proposed theory that empathy is multifaceted and comprised of multiple constructs, rather than comprised of a single construct. The IRI consists of twenty-eight questions across four subscales. The four constructs proposed by Davis (1983) are: (1) empathetic concern, sympathy for others; (2) perspective taking, taking the cognitive perspective of others; (3) fantasy, imagining themselves as the characters, or feeling as the characters do, in movies and books; and (4) personal distress, anxiety and unease in social settings.

Recent studies have been conducted to address and assess the issue of validity with self report scales of both empathy and the rubber hand illusion. Decety and Lamm

(2006) reviewed several neuroimaging studies demonstrating the connection between self-report measures of empathy and activity in specific brain regions (Decety & Lamm, 2006, p. 1158, as cited, Davis & Kraus, 1997; Singer et al., 2004; Singer et al., 2006, Lamm, Batson, & Decety, 2006).

Of particular importance is an fMRI study examining differences in empathy and judgments of pain in others between an alexithymic sample and a non-alexithymic sample. Individuals with alexithymia have trouble identifying and expressing their own emotions and were hypothesized to show lower empathy and differences in pain perception (Moriguchi et al., 2006). It may be important to point out that what makes the study by Moriguchi et al. (2006) so relevant is the use of the interpersonal reactivity scale (Davis, 1983), and the stimuli were images of hands and feet in painful situations. Their findings were consistent with previous research indicating neural activation of empathic pain centers in the absence of actual experienced pain (Singer, 2006). Data analysis indicated the Alexithymic group scored higher on the Personal Distress subscale of the IRI (higher scores indicate a higher degree of anxiety and unease in social settings) and lower on the Empathic Concern (sympathy for others) and Perspective Taking (taking cognitive perspective of others) subscales (Davis, 1983).

Empathy and Brain Regions

Recent fMRI studies have indicated a “pain matrix” of interconnected brain regions that are involved in both the experience of pain and the perception of pain in others. This “shared” pain matrix does not involve the entire pain matrix (Singer, Seymour, O’Doherty, Kaube, Dolan & Frith., 2004; Jackon, Rainville, Decety, 2006;

Jackson et al., 2006; Decety & Lamm, 2006). The main regions indicated in this shared pain matrix are the anterior cingulated cortex (ACC) and the anterior insula (AI).

Singer et al. (2004) used fMRI and questionnaire based measures of empathy to explore this shared pain matrix. While in an fMRI scanner, couples were exposed to either a painful stimulus by way of an electrode on their hand (experienced pain) or watched their partner receive a painful stimulus (empathy for pain). Afterwards two empathy questionnaires were administered, the Balanced Emotional Empathy Scale (BEES, Mehrabian & Epstein, 1972) and the Empathic Concern subscale of the IRI (Davis, 1983). Analysis of the fMRI data indicated an overlap of brain regions when participants experience pain and when they perceived pain in their partner; mainly the ACC and AI. Introducing the questionnaire-based measures of empathy to the analyses indicated that both the BEES and EC were correlated with activation in the ACC and AI (Singer et al., 2004). Thus, evidence of a shared pain matrix was found as well as indications that higher activation in these regions correlate with questionnaire-based measures of empathy. Theses findings were later replicated by Singer, Seymour, O'Doherty, Stephan, Dolan and Frith (2006) in a study examining empathy and perceived fairness.

Alexithymia

The concept of alexithymia was first introduced over 30 years ago through observations of clinical patients suffering psychosomatic diseases and is marked by an inability or difficulty with communicating emotional states (Parker, Taylor, & Bagby, 2000). Currently, it most commonly is observed and diagnosed in the clinical population and has been associated with psychosomatic patients, substance dependent patients, those suffering from posttraumatic stress disorder, and eating disorders (Krystal, 1979; Parker, Taylor, & Bagby, 2001). Current research has extended the construct beyond the clinical setting and has validated the measure of alexithymia in non-clinical populations (Kooiman, Spinhoven, & Trijsburg, 2002; Parker, Taylor, & Bagby, 2003; Parker, Keefer, Taylor, & Bagby, 2008).

The most popular measurement of the alexithymia construct is the Toronto Alexithymi Scale-short form (TAS-20; Bagby, Taylor, Quilty, & Parker, 2007). The TAS-20 is comprised of three factors: “(1) difficulty identifying feelings and distinguishing them from the bodily sensations of emotion (DIF), (2) difficulty describing feelings to others (DDF), (3) and externally oriented style of thinking (EOT),” (Parker, Bagby, Taylor, Endler, Schmitz, 1993). Originally conceived as a dichotomous variable (i.e. either alexithymic or non-alexithymic) research has provided evidence in support of treating alexithymia as measured by the TAS-20 as a continuous variable, similar to that of a personality variable (Parker, Keefer, Taylor, & Bagby, 2008).

In a study of the latent structure of the alexithymia construct based on data from 4,183 non-clinical participants Parker, Keefer, Taylor, and Bagby (2008) found evidence in support of the theoretical model of alexithymia as a personality dimension. They concluded from this that alexithymia should be considered to be affected by multiple factors throughout cognitive development and not solely heritable. Although the TAS-20 was designed with three intercorrelated factors (Parker et al., 2008), there is some evidence that suggests the three factors lacked discriminate validity (Kooiman, Spinhovenm & Trijsburg, 2002).

It has been brought into question that Alexithymia may not effectively distinguish itself between clinical and nonclinical groups. However, researchers have confirmed the validity in distinguishing from clinical and nonclinical samples (Kooiman, Spinhovenm & Trijsburg, 2002) and Parker et al. (1993) confirmed the previously established three-factor model in a cross-validation study between male and female samples of non-clinical college students from Germany, Canada, and the U.S. To assess the psychometric properties of the TAS-20, Kooiman et al. (2002) compared 519 college students and 212 psychiatric outpatients. Results suggest that the TAS-20 sufficiently discriminates between clinical and nonclinical groups. In their study, post hoc analyses indicated that within the clinical and nonclinical groups, males did not differ from females (Kooiman et al., 2002).

Alexithymia and Empathy

Few studies have looked at the relationship between empathy and alexithymia (Guttman & Laporte, 2002; Moriguchi et al., 2007). It should stand that if empathy requires knowledge of affective states in oneself and to then infer those in others, a lack of that knowledge would hinder one's empathic abilities. Although the studies are few, support for this relationship has been documented (Davies, Stankov, & Roberts, 1998; Guttman & Laporte, 2002; Moriguchi et al., 2007; Parker, Taylor, & Bagby, 2001). Additionally, evidence has emerged that alexithymia is correlated with reduced activation in the pain matrix (Moriguchi et al., 2007; Parker et al., 2008; Taylor, 2000).

In a 1998 study, Davies, Stankov and Roberts sampled one hundred first-year psychology students in a study investigating emotional intelligence. Davies, Stankov and Roberts found negative correlations between a version of the Toronto Alexithymia Scale and two self report measures of empathy, Mehrabian and Epstein's (QMEE; 1970) questionnaire of emotional empathy and Hogan's Empathy Scale (HEA; 1968). The subscale of the TAS, external oriented thinking (EOT), was found to be negatively correlated with both the QMEE and the HEA. Although only merely approaching significance, the subscale Difficulty Identify Feelings also indicated a negative correlation with both empathy measures. The QMEE has been stated as measuring empathy defined as an affective construct (Decety & Jackson, 2006; Mehrabian & Epstein, 1972) and the HEA as more of a measure of cognitive empathy (Decety & Jackson, 2006; Hogan, 1969). These findings indicate that Alexithymia is inversely related to measures of empathy, be they either measures of affective empathy (Mehrabian and Epstein questionnaire) or measures of cognitive empathy (Hogan's HEA questionnaire).

A more recent study investigated alexithymia in a family context (Guttman & Laporte, 2002). Guttman and Laporte investigated the association between alexithymia and empathy and sociodemographic factors across three groups based on family type (those with borderline personality disorder, anorexia nervosa, and a control). Mean scores on the IRI were compared between the alexithymic group and the non-alexithymic group. Significant differences indicated that the alexithymic group scored lower on Perspective Taking (PT), Empathic Concern (EC), and higher on Personal Distress (PD). In addition to these differences, correlations between the TAS-20 and IRI revealed a negative association between alexithymia and the Perspective Taking, Empathic Concern and Fantasy (F) subscales of the IRI and a positive correlation with the Personal Distress subscale. Further regression analyses of the three TAS-20 factors (Difficulty Identifying Feeling, DIF; Difficulty Describing Feelings, DDF; and Externally Oriented Thinking, EOT) indicated that Personal Distress significantly predicted DIF and DDF. The Fantasy, Perspective Taking, and Empathic Concern subscales negatively predicted EOT.

Parker, Talyor and Bagby (2001) found a negative relationship between emotional intelligence (EQ-i) and the TAS-20. Analysis of the correlations between the TAS-20 and the EQ-i revealed that all three of the TAS-20 factors were negatively correlated with total EQ-i score as well as the three factors. Four follow-up factor analyses were performed between the EQ-i and total TAS-20 score and the independent factors; one between the EQ-i and the total TAS-20 score and one each between the EQ-i and the three TAS-20 factors (DIF, DDF, EOT). All four of the factor analyses indicated a two-factor solution as more appropriate than a one-factor solution suggesting that the EQ-i and the TAS-20 measure distinctly different constructs.

In a study comparing participants who scored high on the Alexithymia scale (ALEX group) to a non-ALEX group, Moriguchi et al. (2007) hypothesized that an ALEX group would score lower on measures of empathy and pain-related measures as well as show differences in neural responses under fMRI. Moriguchi et al. (2007) compared 16 alexithymic (as assessed on the TAS-20) college students to 14 non-alexithymica college students, had them view photos of hands and feet in painful and non-painful situations under fMRI, and measured their empathy on the IRI. Mean differences between the ALEX and non-ALEX groups indicated that the 16 alexithymic students scored lower on PT and EC and higher on PD than the 14 non-ALEX students. Along with these differences in self-report measures, Moriguchi et al. also found differences at the neural level. First, they showed a main effect for viewing the painful photos. Activation in the "somatosensory, thalamus, ACC, anterior insula, cerebellum, lateral prefrontal cortex and brain stem" (p. 2230) was associated with viewing the painful photos. Secondly, when the ALEX and non-ALEX groups were compared, the ALEX group had lower activation in the brain regions associated with pain perception.

Conclusion

The rubber hand illusion is an introspective illusion involving vision and touch. Individuals differ on the ability to experience the illusion as well as their self-report of intensity and how fast it takes them to feel the illusion. Previous research on individual differences in introspection, interoceptive ability (i.e. heart blindness) and intersubjectivity (i.e. empathy and alexithymia) have identified an overlap of brain regions involved in both personal experience and perception of feeling states and emotions. It stands that capacity for empathy, an intersubjective construct that relies heavily on introspection, may help in explaining individual differences in rubber hand illusion experience, an introspective illusion.

It is expected that individual differences in empathy and alexithymia will help explain individual differences in the rubber hand illusion. Empathy, a cognitive-affective sharing of personal and private feeling states, is hypothesized to correlate positively to rating of vividness and affirmation of the rubber hand illusion and correlate negatively to latency to the illusion (i.e. a faster illusion onset). Although alexithymia is conceptually inversely related to empathy the research has found that individuals suffering from psychosomatic disorders – who are traditionally low on empathy and high in alexithymia – experience the illusion faster and stronger than controls. Despite this conflicting research, it is hypothesized that alexithymia will be negatively correlated with rubber hand illusion intensity and positively related to latency (i.e. a slower illusion onset).

Statement of Purpose

The purpose of this study was to investigate how capacity for empathy might help explain individual differences in susceptibility to the rubber hand illusion. The study focuses on individual differences with regards to vividness and affirming experience of the illusion and latency to the rubber hand illusion. Very few studies have included latency to the rubber hand illusion and absent are reports of individual differences with regards to illusion latency. Although there are sizable and independent literatures on the rubber hand illusion and empathy, the specific relationship between the two has yet to be explored. Empathy and alexithymia may bring insight into an explanation of individual differences in susceptibility to the rubber hand illusion.

The relationship between empathy and the rubber hand illusion has yet to be explored. Moreover, the correlation between empathy and alexithymia has been moderately explored. Conceptually, it stands that empathy and alexithymia should be inversely related. The focus of this study is on how the capacity for empathy might help explain individual differences in susceptibility to the rubber hand illusion.

The research questions to be answered in this study are:

1. Is there a relationship between measures of susceptibility to the rubber hand illusion and measures related to empathy?
2. Is there a relationship between measures of susceptibility to the rubber hand illusion and measures related to alexithymia?

Hypotheses

It is hypothesized that those who score high on measures of empathy will show greater susceptibility to the rubber hand illusion. It is predicted that assessed empathy will positively correlate with retrospective ratings of illusion intensity and negatively correlate with latency to the illusion (e.g., higher empathy will be associated with shorter illusion latency). While it is not clear the role, if any, alexithymia may play in mediating susceptibility to the illusion in a nonclinical population, the apparent inverse relationship between alexithymia and empathy warranted inclusion of a measure of alexithymia in the current study. As such it is predicted that assessed alexithymia will negatively correlate with retrospective ratings of illusion intensity and positively correlate with latency to the illusion (higher alexithymia will be associated with longer illusion latency).

Limitations of the Study

Self-report have their limitations and may not always be ideal. The self-report measures used in this study are no different. In this study participants were asked to rate the vividness of any experienced illusion, and to report when they first begin feeling "something funny" as a measure of illusion latency. Both of these measures are likely sensitive to variations in response criteria across participants; as such findings based on participants verbal responses to perceived experience of the illusion must be interpreted with caution.

Additionally, empathy can be measured in many ways, from self-report to interview to picture viewing tasks where people are asked to comment on the meaning of an ambiguous setting. Questionnaires differ on how empathy is defined and measured. Some define empathy as merely affective, some as distinctly cognitive, and yet others measure empathy as both an affective and cognitive construct. These components of empathy may thus play different roles in the degree to which empathy per se is involved in mediating susceptibility to the rubber hand illusion.

The rubber hand illusion questionnaire is designed to include questions that both affirm and deny the presence of the illusion. Because of this, the illusion was not described to the participants prior to their participation. To control for participants probing the experimenter for illusion descriptions, only vague descriptions were provided and subjective interpretations of when to report having experienced the illusion were encouraged. Participants were not provided detailed description of the illusion and merely asked to report when they felt something "funny" or felt "something odd". Though participant queries about the illusion occurred in two separate trials, with the first trial intended to familiarize the participant with the procedures and any resulting illusion experience, providing participants little prior explanation of the illusion could have had unintended consequences.

Individual differences may be present with regard to latency to the illusion. To account for these differences two trials were used. Two trials of the illusion were used in this study to (1) account for a learning component and compare the number of participants that reported the illusion in trial one to trial two and (2) to increase the reliability of participants responses by exposing them to separate illusion-induction trials. It is assumed that data from the second trial would be more reliable than from the first learning trial, hence assessments of the hypotheses were to be based primarily on data from the second trial.

The methods used to induce the rubber hand illusion have generally involved brushing the bare hand. Few studies have extended the methodology beyond this type of stimulation. It is assumed that the stimulation provided by tapping does not differ in any significant way to either cause for participants to not experience the illusion or change the experience in any fundamentally important way. It is understood that any tactile stimulation is generally sufficient to induce the illusion as long as the felt stimulation matches that of the seen stimulation. Also, it is assumed that the inclusion of rubber gloves will not have any negative effects on the induction of the illusion. Reports of allergies to latex have started to become commonplace; precautions to latex allergies have been observed in settings that routinely use latex products. To account for those with latex allergies all rubber gloves were made of a non-latex rubber.

CHAPTER III

METHODOLOGY

Participants

Participants were 130 students from a California State University psychology department who volunteered for the study. The sample consisted of 63.8% females (*n* = 83) and 33.8% males (*n* = 44); three did not indicate sex. Ages ranged from 18-56 years, with a mean age of 22.72 years (*SD* = 5.16). The majority of respondents reported being right-handed (*n* = 119), followed by left-handed (*n* = 10); none reported being ambidextrous, and one failed to report their handedness.

Materials

One rubber glove (right handed), stopwatch to record onset of illusion, metronome for the timing of taps, a small cardboard partition, a post-illusion questionnaire consisting of demographic information (age & gender; see Appendix B), handedness and the self-report rubber hand illusion questionnaire (RHIQ; Botvinick & Cohen, 1998), Interpersonal Reactivity Index (IRI; Davis 1983), and twenty-item Toronto Alexithymia Scale (TAS-20; Taylor, 1992). Written Informed Consent and Debriefing forms were also used (see Appendix C). Appendix D includes a picture of the experimental setup.

The IRI consists of twenty-eight questions across four subscales. The four subscales are: (1) empathetic concern, sympathy for others; (2) perspective taking, taking the cognitive perspective of others; (3) fantasy, imagining themselves as the characters, or feeling as the characters do, in movies and books; and (4) personal distress, anxiety and unease in social settings. Cronbach's alpha was used to determine internal consistency. Scale reliabilities were found to be good for Personal Distress (.802) and Fantasy Scale (.839) and were found to be acceptable for Empathic Concern (.756) and Perspective Taking (.722).

The TAS-20 is comprised of three factors: "(1) difficulty identifying feelings and distinguishing them from the bodily sensations of emotion (DIF), (2) difficulty describing feelings to others (DDF), (3) and externally oriented style of thinking (EOT)," (Parker, Bagby, Taylor, Endler, Schmitz, 1993). Originally conceived as a dichotomous variable (i.e. either alexithymic or non-alexithymic) research has provided evidence in support of treating alexithymia as measured by the TAS-20 as a continuous variable, similar to that of a personality variable (Parker, Keefer, Taylor, & Bagby, 2008). Scores on the TAS-20 ranged from 23 to 71. Although the alexithymic construct was treated as a continuous variable for analyses cutoff points were used to identify populations within the construct. A cutoff point of >= 61 was used to identify high alexithymia and a cutoff of <= 51 was identified as low alexithymia. These cut-off points are similar to those used by Parker, Taylor, and Bagby (2003). With these cutoffs 9% (n = 12) were considered high alexithymia and 77% (n = 100) were considered nonalexithymic.

Procedure

Participants underwent two trials of two minutes each. Each trial included one participant and two experimenters. Participants were seated with both arms resting upon a small table and a kitchen glove worn on the right hand. A small cardboard partition was used to obstruct the gloved hand from participant's view. A stuffed rubber kitchen glove was placed to the right of midline, in view of the participant, and a small blanket was draped over the shoulder and partition to hide the end of the stuffed glove from view. The distance between the index finger of the participant's gloved hand and the index finger of the stuffed rubber glove was approximately 15cm (6 in). Synchronous tapping was applied to the middle finger of both gloves at a rate of 2Hz (two taps per second). A metronome was used to help keep the taps synchronized.

After completing an informed consent, participants donned a rubber kitchen glove on their right hand and were seated at a table. One experimenter was designated as lead and gave all instructions to the participant and administered the tapping; the second experimenter recorded the time when participants verbally expressed experiencing the illusion. Both arms rested on the table, shoulder width apart, palms down. Participants were told of the procedure and instructed to verbally inform experimenter when they believed themselves to be experiencing the illusion. Description of the illusion was vague and if participants asked what it was they should feel, they were told it "would feel funny" and "that they would know." Additionally, participants were instructed to remain focused on the stuffed glove for the duration of each two-minute trial. If participants verbally reported experiencing the illusion the second experimenter recorded the time using a digital stopwatch. Participants underwent two two-minute trials of synchronous tapping; each two-minute trial began with synchronous tapping and the second experimenter started the stopwatch. After each trial participants rated the strength of the illusion on a scale of 1 to 7 (not at all – vivid, respectively). An inter-trial period of thirty seconds was used to allow time for the illusion to dissipate. After the second of two trials participants completed the post-illusion questionnaire (RHIQ; Botvinick & Cohen 1998), IRI, and TAS-20.

CHAPTER IV

RESULTS AND DISCUSSION

Rubber Hand Illusion

Out of the 130 participants, 46 (35.4%) failed to report experiencing the illusion at all, 27 (20.8%) reported the illusion in only one of the two test trials, and 57 (43.8%) reported the illusion in both test trials. Hence, 64.6% of participants experienced the illusion at least once, compared to 35.4% who never reported experiencing the illusion. Mean latency for reporting the illusion in trial one (latency 1) was 49.40 seconds (SD = 33.50; n = 60) and for trial two (latency 2) was 36.93 seconds (SD = 32.13; n = 81). Differences between trial one and trial two were analyzed using a *t-test* for only participants that reported the illusion in both trials (n = 57). A paired samples *t-test* indicated that reports in trial one (M = 48.95 seconds, SD = 33.10) were significantly slower than in trial two (M = 26.85 seconds, SD = 27.79), $t(56) = 4.06$, $p < .001$.

For participants reporting intensities for both trials, self-report intensity after trial one (Intensity 1) ranged from 3 to 7 (M = 5.88, SD = 1.1) and intensity ratings after trial two (Intensity 2) ranged from 2 to 7 (M = 5.95, SD = 1.27). A paired samples *t*-test indicated no significant difference between intensity ratings. These findings indicate that although self-report intensity between trial one and trial two was no different, participants were identifying and verbally reporting the illusion faster in trial two.

A one-way ANOVA was used to compare scores on the IRI subscales between those who did not report experiencing the illusion (n = 46) and those who reported the illusion in both trials (n = 57). No significant differences emerged.

Correlations

The relationships between Latency 1, Latency 2, Intensity 1 and Intensity 2 were analyzed using Pearson product-moment correlations. Significant correlations were found between Intensity 2 and Latency 2 (r = -.490, n = 58, p < .001), and between Intensity 2 and Intensity 1 (r = .383, n = 41, p = .013), indicating that higher intensity ratings at trial two were associated with shorter latency times in the second trial and higher intensity ratings at trial one were related to higher intensity ratings at trial two. No other correlations were significant (see Table 1). These findings suggest that when participants reported the illusion experience early in the second trial, their intensity ratings for the second trial were also higher. Additionally, if they rated the intensity high the first time they continued to rate it high the second time.

Table 1

Correlations Between Latency and Intensity Ratings for Each Trial

	Intensity 1	Latency 2	Intensity 2
Latency 1	-.119	.099	-.007
Intensity 1	.	-.269	.383*
Latency 2		.	-.490**

Note. *. Correlation is significant at the .05 level.
**. Correlation is significant at the .01 level.

Regression Analyses

Two separate multivariate regression analyses were performed to determine the relationship between latency on each trial and each of six predictors: sex, total TAS-20 score, and scores for each of the IRI subscales (Perspective Taking, Empathic Concern, Fantasy Scale, and Personal distress). The first regression using Latency 1 as the dependant variable revealed no significant effects among the predictors. However, the stepwise regression analysis revealed a significant effect for Latency 2, $R = .279$, $F(1, 75) = 6.31$, $p = .014$, adjusted $R^2 = .065$. The sole significant predictor was the Empathic Concern subscale, ($\beta = -.279$, $p = .014$), accounting for 7.8% of the variance. This finding suggests that as Empathic Concern increased, latency to the illusion during trial two decreased.

Two separate regression analyses were also performed for self-reported intensity for each of the two trials using the same six predictors: sex, total TAS-20 score, Perspective Taking, Empathic Concern, Fantasy Scale, and Personal distress. No predictors emerged as significant.

Five exploratory multivariate regression analyses were also conducted using sex (*Male* = 1, *Female* = 2) and six of the questions from the rubber hand questionnaire as predictors for each of the four IRI subscales and total Alexithymia score (see Table 2). Empathic concern was significantly related to sex ($\beta = .465$, $p < .001$) and Question 3 ($\beta = .300$, $p = .021$), $R = .501$, $F(7, 93) = 4.45$, $p < .001$, adjusted $R^2 = .195$. Personal Distress was significantly related to sex, $R = .385$, $F(7, 92) = 2.28$, $p = .034$, adjusted $R^2 = .083$. Fantasy scale was significantly related to sex ($\beta = .197$, $p = .048$) and Question 5

(*It felt as if my real hand were drifting towards the gloved hand*; β = .273, p = .015), R = .413, F(7, 93) = 2.73, p = .013, adjusted R^2 = .108. TAS-20 score was significantly related to Question 2, R = .413, F(7, 93) = 2.73, p = .014, β = -.321, p = .004, adjusted R^2 = .106. No significant relationship was found between Perspective Taking and any of the predictors.

Table 2

Regressions Predicting IRI and Alex from Rubber Hand Questionnaire and Sex

Variable	β	Sig. (p)	R^2
Empathic Concern			.25
Sex	.47	.001	
Question 3	.30	.021	
Personal Distress			.15
Sex	.31	.003	
Fantasy Scale			.17
Sex	.20	.048	
Question 5	.27	.015	
TAS-20			.17
Question 2	-.32	.004	

Note. Question 2: “It seemed as if I were feeling the touch in the location where I saw the gloved hand touched”
Question 3: “It seemed as though the touch I felt was caused by the tapping on the gloved hand (false hand)”
Question 5: “It felt as if my real hand were drifting towards the gloved hand (false hand)”

Follow-up Exploratory Regressions

To explore the relationship between illusion latency and self-report based measures of the rubber hand illusion, four follow-up exploratory regression analyses were conducted using six of the questions from the rubber hand questionnaire (see Appendix B) and sex as predictors for each of the separate measures of the illusion (Latency 1, Latency 2, Intensity 1, Intensity 2; see Table 3).

Table 3

Regressions Predicting Latency and Intensity from Rubber Hand Questionnaire and Sex

Variable	β	Sig. (*p*)	R^2
Latency 1			.281
Question 2	-.29	.030	
Latency 2			.274
Question 4	-.27	.015	
Intensity 1			.440
Question 3	.44	.004	
Intensity 2			.548
Question 4	.55	.001	

Note. Question 2: “It seemed as if I were feeling the touch in the location where I saw the gloved hand touched”
Question 3: “It seemed as though the touch I felt was caused by the tapping on the gloved hand (false hand)”
Question 4: “I felt as if the gloved hand were my hand”

A significant relationship was found between Latency 1 and Question 2 (*It seemed as if I were feeling the touch in the location where I saw the gloved hand touched)*, R = -.288, F(1, 57) = 5.165, p =.027, adjusted R^2 = .067, Latency 2 and Question 4 (*I felt as if the gloved hand were my hand)*, R = -.274, F(1, 76) = 6.17, p = .015, adjusted R^2 = .063, Intensity 1 and Question 3 (*It seemed as though the touch I felt was caused by the tapping on the gloved hand*), R = .440, F(1, 38) = 9.15, p = .004, adjusted R^2 = .173; and Intensity 2 and Question 4, R = .548, F(1, 55) = 23.59, $p < .001$, adjusted R^2 = .287.

CHAPTER V

SUMMARY

There has been much interest exploring, separately, the constructs of empathy and alexithymia and the phenomenon of the rubber hand illusion. An overarching goal of this study was to bridge the three and initiate an exploration of how the three might be related.

This study examined two key questions:

1. Is there a relationship between measures of susceptibility to the rubber hand illusion and measures related to empathy?
2. Is there a relationship between measures of susceptibility to the rubber hand illusion and measures related to alexithymia?

Traditionally, the rubber hand illusion has been induced using a method of brushing the hand and affirmation measured using a questionnaire (e.g., Botvinick & Cohen, 1998; Constantini & Haggard, 2007). In this study the paradigm utilized was tapping instead of brushing. This tapping paradigm has been reportedly used once before (Pavani, Spence & Driver, 2000). Additionally, including two separate illusion-induction trials provided evidence of a learning component involved in the experience of the illusion. This latter finding points to the importance of providing subjects a warm up phase before target measures of the illusion are gathered.

It should be noted that tapping is a more fleeting tactile stimulation technique compared to brushing. Previous studies have reported that the brushing technique applies stimulation for about one second. Comparatively, the stimulation provided by tapping is extremely brief and fleeting. Because of this, tapping may provide a more sensitive measure of sensitivity to the illusion. By having less tactile stimulation to override one's proprioceptive information, it would require the participant to be more susceptible to-- or be more capable of capturing the illusion.

In order to reduce expectancy effects, all participants were naïve to the illusion in the first trial; the description of possible experience was intentionally vague. If the illusion was experienced during the first trial, then this experience was the subject's basis for what to look for in the second trial. As such, the first trial should be considered a practice trial. As it turned out, participants were in fact faster to report the illusion in the second trial and more participants reported the illusion in trial two.

Hypotheses

Rubber Hand Illusion

As hypothesized, those who reported the illusion sooner also reported the illusion to be stronger compared to those whose illusion latency was slower. Correlations between latency to the illusion and intensity were negative, indicating that those who experienced a shorter latency to the illusion also higher vividness ratings. In addition to this, both latency and vividness ratings in the second trial were correlated with the question most directly affirming experience of the illusion (Q4; *I felt as if the gloved* *hand were my hand).* These findings suggest that latency is an important component to the rubber hand illusion and should be included in measures of the illusion.

Empathy and RHI

With respect to the hypothesis that motivated the currently study, empathy and the rubber hand illusion were found to be inversely related thus supporting the hypothesis that level of expressed empathy moderates susceptibility to the rubber hand illusion. Those scoring higher on the Empathic Concern subscale reported shorter latency in the second trial, and to the rated question *It seemed as though the touch I felt was caused by the tapping on the gloved hand*. Although, accounting for just under 8% of the overall variance, the current study provides evidence of a statistically significant relationship between capacity for empathy and susceptibility to the rubber hand illusion. This finding provides a significant contribution to understanding why individuals vary with respect to their susceptibility to the illusion. A follow up comparison between those who never reported experiencing the illusion and those who reported experiencing the illusion on both trials showed no difference on any of the IRI subscales. This implies that other factors must be involved in individual differences in susceptibility to the illusion.

Alexithymia

Interestingly, total alexithymia score was positively related to a question affirming the illusion (Q2, *It seemed as if I were feeling the touch in the location where I saw the gloved hand touched*). This may suggest that those who are more alexithymic are more susceptible to the illusion or it may suggest that those scoring higher in alexithymia are more apt to social desirability when asked questions about a phenomenon they struggle to explain. If not due to a social desirability bias, then because alexithymia is defined as a difficulty identifying and describing feelings, those scoring higher on the TAS-20 simply may not have been able to accurately describe the illusion until asked concrete questions about the experience. Those having difficulty describing the illusion at the time they experienced it could then describe it *post hoc* after being fed descriptions form the rubber hand questionnaire. Whatever the explanation, these results were unexpected and an explanation for the positive relationship between alexithymia and experiencing the illusion remains an open question.

Conclusions

It remains unclear if a shorter latency *causes* one to experience the illusion more strongly; that is, a short latency may cause a shift in subject response criteria per se. The results of this study only indicate that those who reported shorter latencies rated the vividness higher; alternatively stated, those who rated the vividness higher also reported shorter latencies. Another explanation could be those who experience the illusion earlier have more time for the illusion intensity to increase. It may be that high vividness ratings and higher ratings affirming the illusion are dependent on the amount of time in which participants experience the illusion. If this were the case, then it would stand that individuals who report shorter latencies also rate vividness and illusion affirmations higher, but would not differ in empathy or any other way from individuals who took longer to experience and report the illusion. In other words, empathy may be related to onset of the illusion but not to the capacity for the illusion per se. Future research should focus on controlling for the time that participants experience the illusion by assessing intensity ratings at various time intervals once the illusion is induced.

Limitations of the Study

The current study used self-report measures for all constructs. As is understood in the field, there are typical problems with self-report that may have contributed to the findings (e.g., social desirability, response criterion biases, etc). Although more direct measures might have increased the reliability of the findings (e.g., fMRI), the current study was consistent with respect to the percentage of participants typically reporting the illusion.

Although superficially the tapping paradigm and the brushing technique are very similar it may stand that the nature of the touch stimulation might cause differences in how the illusion is experienced or whether it is experienced at all. The current study used tapping mostly because it was easier to ensure simultaneous real and rubber hand touching. While some other studies used the brushing method, there is no empirical or theoretical reason to suppose that one method is superior to the other in inducing the illusion.

There are many types of ways to measure empathy and many individual measures within those separate types. The present study only focused on a single self-report measure of empathy. Other self-report measures were not included and may have provided more insight in the role that empathy play in susceptibility to the illusion (e.g., BEES, Mehrabian Epstein, Hogan’s Empathy Scale, PANAS). The present study was also limited in that it only focused on self-report and no other form of empathy measurement (e.g., interview, emotion recognition).

Reports in the literature support gender differences in both empathy and alexithymia. These gender differences may complicate analyses of the relations between the two constructs and between the constructs and the rubber hand illusion. Steps were taken to separate sex from its covariates but it remains a convoluted picture. Sex was found to be related to three of the IRI subscales (Empathic Concern, Personal Distress, and Fantasy) but did not stand out in regression analyses of latency and vividness.

Recommendations

Future research should include other measures of empathy and other types of measurement. It will be important to find if the relationships extend through all measurements of empathy. Due to the construct debate over empathy, it may be of critical importance to cross-validate findings with many different measures of empathy.

It will be important for future research to question the link between latency and vividness and control for latency. It will be important to compare individuals of similar latency and investigate to what extent other variables are related. As noted earlier, empathy may not be directly related to susceptibility to the illusion directly but rather to onset of the illusion. Future research should ask participants to provide an intensity rating when they first report experiencing the illusion, and then again at the end of the trail period.

Future research that includes the rubber hand illusion should also use one or more warm-up/learning trials given that the illusion is not commonly experienced, and often described as “weird”. Many participants were able to report the illusion after approximately one minute of stimulation in the first trial. This was nearly halved in the second trial, presumably after participants knew what to respond to. Also, more participants responded in the second trial, this may be due to requiring a period of stimulation longer than two minutes. It may be important to identify a time after which a majority of participants experience the illusion.

Yet another suggestion for future research is to include an analysis of the relationship between heart-blindness and susceptibility to the rubber hand illusion. The heart blindness research conducted by Critchley et al. (2004) was the basis of speculation that empathy may also moderate illusion susceptibility. It would be a logical step to investigate if there exists a relationship between those who can accurately match their own heartbeats to a tone and their susceptibility to the illusion.

The hand has many receptors and in general a smaller two-point threshold than many other parts of the body. Studies may find it useful to investigate if other body parts are susceptible to the illusion. The general question to investigate is the degree to which body part sensitivity is related to illusion induction. It is not clear, for instance, whether body parts that are less sensitive to touch are more or less likely to have their stimulation induce the illusion.

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APPENDIX A

Review of Rubber Hand Illusion Methods

Study	Methods	Duration of stimulation	Handedness tested	Hand used in illusion	n	Excluded due to no illusion
Botvinick & Cohen, 1998	Hand behind screen	10 min	No	L	10	0
Ehrsson et al., 2007	fMRI, supine, rubber hand over abdomen upper parts index finger	88 sec 3 trials	Yes, righties	R	19 (11 males)	9
Tsakiris & Haggard, 2005	Hand in frame (box) Index finger – knuckle to tip	4 min	Yes, righties	L	8 (4 females)	0
Mussap & Salton, 2006	Hand in box, Brushed back of hand	1 min	Yes, righties	L & R	101 (55% females)	29
Ehrsson et al., 2005	Blindfolded Arms on table, left finger touched right index knuckle	60s or 30s	Yes, righties	L touch R feel	32 (15 females)	7
Peled et al., 2003	Hand behind screen	15 min	Yes, righties	L	38	0
Peled et al., 2000	Hand behind screen	10 min	Yes, righties	L	49	0

APPENDIX B

Age: _______ *(Latency 1:* *) Trial 1:*

Gender (circle one): **M** **F** *(Latency 2:* *)Trial 2:*

Handedness (check one): Primarily Right Handed ____ Primarily Left Handed ____ Ambidextrous ____

Please answer the following questions as they pertain to your experience of the illusion.

1. I never felt like the gloved hand was my hand. In other words, I never felt the illusion. (If you never experienced the illusion skip the remaining questions and proceed to the next questionnaire)
   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

2. It seemed as if I were feeling the touch in the location where I saw the gloved hand touched.
   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

3. It seemed as though the touch I felt was caused by the tapping on the gloved hand.
   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

4. I felt as if the gloved hand were my hand.
   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

5. It felt as if my real hand were drifting towards the gloved hand.
   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

6. It felt as if the gloved hand were drifting towards my real hand.
   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

7. It seems as if the touch I was feeling came from somewhere between my own hand and the gloved hand.
   Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

8. During the period in which you felt the illusion *in Trial 2*, select which of the following best describes your experience (circle one):

   Steadily increased in intensity *Steadily decreased in intensity*

   Fluctuated in intensity *Intensity remained constant*

APPENDIX C

INFORMED CONSENT FORM

AGREEMENT TO PARTICIPATE

This study investigates the relationship between your susceptibility to a well known illusion called the "rubber hand illusion" and various aspect of your personality. Your right hand will be gloved and placed behind a screen where it will be repeatedly tapped but you will not be able to see your hand. However, a gloved rubber hand will be in view and you will be able to observe it being tapped. You will also be asked to complete three personality-related questionnaires.

Your answers are strictly confidential. No one will be able to associate your data with you personally. You will be identified only by an ID code, and that code will not be linked to your name. However, if at any time you choose to not complete the study you are free to do so without penalty. We have taken steps to ensure your confidentiality so we appreciate your honest responses.

The total time necessary to complete the study will vary from 15 to 30 minutes.

The study is supervised by Dr. Edward Vela and will be conducted by Scott Lewis, a graduate student in the department of psychology collecting data for his master's thesis.

I certify that I have read the foregoing and understand that I am free to discontinue participation in the project at any time. I hereby give my consent to participate in this project.

____
Name (please print)

____________________________ ___________________________
Signature Date

APPENDIX D

DEBRIEFING

Thank you for participating in this study. We are interested in the relationship between susceptibility to the rubber hand illusion and both your capacity for empathy and your ability to monitor your own internal states.

This research is based on prior research which shows that one's ability to know their own internal state (e.g., being able to know your own heart rate) is related to one's empathy ability. That research has shown that the better you are at monitoring your internal states the better you are able to empathize with others. This research looks at the possible relationship between these two abilities and susceptibility to the rubber hand illusion. The rubber hand illusion refers to an interesting phenomenon where people sometimes feel as if a fake rubber hand is actually their own hand. Not all people experience this illusion and our hypothesis is that those who do experience the illusion are those with higher empathy abilities.

We believe the results of this study will add to our understanding of human interpersonal skills and help resolve the issue of why only a subset of people experience the rubber hand illusion. If you are interested in the results of this study, please contact Scott Lewis at crazeenca@sbcglobal.net or Dr. Vela at: evela@csuchico.edu anytime after May of 2009.

We thank you again for your willingness to participate. Be assured that your answers are confidential and that your data will not be associated with you personally in any way.

APPENDIX E

EXPERIMENTAL SETUP

Note: Participant seated, viewing stuffed glove. Real hand is obstructed from view. Experimenter applying synchronous taps to middle fingers.