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David Parrick

A report submitted in Partial Fulfilment of the Requirements for the Award of Bachelor of Science (Psychology) Honours, Faculty of Health, Engineering and Science

Edith Cowan University

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Abstract

The purpose of the present study was to examine the effect of depression, mental distress and empathy on the strength of the rubber hand illusion (RHI). The RHI is a perceptual illusion that is thought to occur as a result of visual capture during multimodal sensory stimulation. The RHI was induced in participants by synchronous stroking of their real hand and the visible fake hand for two minutes. Participants were then requested to complete a nine-item questionnaire on the strength of the illusion, the Depression Anxiety Stress Scale (DASS), which was used to screen for depressive symptoms and general mental distress, and the Interpersonal Reactivity Index (IRI) to assess each participant's level of empathy. Results showed that depression and mental distress were positively correlated with embodiment of the RHI, and that the mean score on both the depression and mental distress scales was higher for individuals who experienced the illusion than those who did not. Contrary to the existing literature the correlations found between empathy and strength of the RHI were found for cognitive aspects rather than affective aspects of empathy. The implications of the current study are that individuals who are psychologically less healthy are more likely to experience the illusion. It is possible that diminished interoceptive awareness is responsible for entrainment of the illusion, and this represents a promising avenue for future research.

David Parrick

Dr Ken Robinson

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The Effect of Depressive Symptoms and Empathy on Embodiment of the Rubber Hand Illusion

Certain perceptual illusions are postulated to influence what an individual considers part of themselves, to the extent that objects that are clearly not part of the body become incorporated into the body (Armel & Ramachandran, 2003; Botvinick & Cohen, 1998). Perhaps the most striking of such perceptual illusions is phantom limb syndrome: a person who has had a limb amputated continues to feel "pain" in the severed limb (Ramachandran & Brang, 2009; Ramachandran & Hirstein, 1998). Studies on intact individuals have also demonstrated that the mind can incorporate foreign objects into its body image. The Rubber Rand Illusion (RHI, Tsakiris & Haggard, 2005) occurs when an individual watches a fake hand stroked synchronously with their own unseen hand, resulting in the fake hand becoming attributed to the individuals own body.

The RHI is thought to arise as a result of multimodal sensory conflicts between vision, touch, position sense (proprioception) and how visual capture of proprioceptive information influences perceived body ownership (Botvinick & Cohen, 1998; Schütz-Bosbach, Tausche, & Weiss, 2009; Tsakiris & Haggard, 2005). For this reason research into the RHI has focussed on three broad areas; the nature of body ownership, illusion formation and how individual differences influence experience of the illusion. Body ownership is thought to consist of two major components, body schema which is thought to be a physical representation of the body based on past sensory experience; and body identity or image, which is thought to be a mental representation based on cognitions and emotions (Costantini & Haggard, 2007).

Research into the RHI has focussed on the malleability of representations of body ownership and has examined what factors constitute necessary and sufficient

conditions for the illusion to develop. This has identified factors such as hand posture, texture and how "hand like" the rubber hand appears as critical in the development of the RHI, with large discrepancies in these factors reducing (or eliminating) the effect (Ehrsson, Spence, & Passingham, 2004; Haans, Ijsselsteijn, & de Kort, 2008; Tsakiris, Prabhu, & Haggard, 2006). Individuals with either clinical or sub-clinical mental health issues are more likely to experience the illusion in comparison to healthy controls.

The present paper will begin with a brief overview of the necessary and sufficient conditions for formation of the RHI, focussing on the robustness of the illusion across a range of research paradigms, including how the illusion is measured. A brief review of the nature of body ownership examining body identity, body schema and the neuropsychological research into these constructs in the context of the RHI will then be conducted. This will be followed by consideration of the individual differences research, focussing on a range of mental health issues and their impact on experiencing the illusion. The aim of the present research was to investigate whether depressive symptoms, mental distress and empathy were predictive of strength of the illusion.

Entrainment and Measurement of the RHI

Much of the research into the RHI has focussed on the necessary or sufficient conditions for entrainment and techniques that are appropriate for measuring the degree of entrainment. There are two broad categories of measurement of the strength of the illusion – subjective measures (using behavioural questionnaires), and objective measures (focussing on proprioceptive drift and galvanic skin conductance). There are also temporal, spatial and anatomical constraints on the RHI.

Subjective Measures. Experience of the RHI has been measured using a range of different questionnaires, the most common one being that used by Botvinick and Cohen in their original 1998 study. This questionnaire consists of nine items including

two or three statements about the key perceptual effects of the illusion, such as "I felt as if the rubber hand was my hand," "It seemed as if I were feeling the touch of the paintbrush in the location where I saw the rubber hand being touched," and five to seven statements designed to control for task compliance and suggestibility (Botvinick & Cohen, 1998).

In an attempt to gain a greater phenomenological understanding of the illusion Longo, Schüür, Kammers, Tsakiris, and Haggard (2008) undertook detailed interviews with five individuals who experienced the illusion. Based on the information provided from the interviews Longo et al. developed an extended 27-item questionnaire, which was then administered to a new sample of 130 participants. The responses to the questionnaire were then subjected to principal components analysis (PCA) with orthogonal rotation. The PCA revealed four major components of the RHI experience that were interpreted as embodiment of the rubber hand, loss of own hand, movement, and affect (Longo, Schüür, Kammers, Tsakiris, & Haggard, 2008). The longer form questionnaire provided results that were rich in phenomenological information, including identifying experiences of expecting the rubber fingers to move when the participants intended to make a finger movement, that the real hand behind the screen had "disappeared," or that one's own hand was "in the same place" as the rubber hand (Longo, Schüür, et al., 2008). It should be noted that the questions on the factor relating to embodiment were essentially the same as those used by Botvinick and Cohen in their original study.

Objective Measures. Measures such as proprioceptive drift and galvanic skin conductance have been used to provide more objective reports on strength of the RHI (Armel & Ramachandran, 2003; Botvinick & Cohen, 1998; Folegatti, Farnè, Salemme, & de Vignemont, 2012; Guterstam, Petkova, & Ehrsson, 2011). Proprioceptive drift is a

measure of how far the individual's perceived location of their real hand has moved towards the fake hand as a result of entrainment of the illusion. Participant are asked to close their eyes following entrainment the RHI for their right hand and have their error in locating their hand measured using a ruler – with this error being biased towards the location of the fake hand (Botvinick & Cohen, 1998; Ehrsson, 2012; Tsakiris & Haggard, 2005).

The sensitivity of the proprioceptive drift measure was investigated in a series of four experiments by Tsakiris and Haggard (2005). In their study a hidden tape measure was used prior to entrainment of the illusion to measure inherent proprioceptive deficits, following inducement of the illusion participants were requested to verbally report the location of their real hand using the tape measure. To prevent participants using the same number on the tape measure each trial, researchers offset the tape measure throughout the experiment (Tsakiris & Haggard, 2005). In their experiments Tsakiris and Haggard identified that stroking the real and fake hand in synchrony induced a significant level of proprioceptive drift (M = 3cm) in comparison to asynchronous stroking (M < 1 cm; $t(7) = 4.25$, $p = .006$). Similar significant differences were found only when the hand was in an anatomically correct position and when multiple fingers on both the real and fake hands were stroked; however no difference was found for a neutral object or in any condition involving asynchronous stroking (Tsakiris & Haggard, 2005). The range of studies conducted by Tsakiris and Haggard demonstrate the strength of proprioceptive drift as an objective measure of entrainment of the RHI. As might be expected, there were high levels of inter-correlation (Spearman's $r = .56$, $p = .02$) between the subjective and objective measures, with increasing scores on the introspective ownership questionnaire being associated with greater levels of proprioceptive drift (Kalckert & Ehrsson, 2012; Longo, Schüür, et al., 2008).

A second objective measure is arousal responses associated with activation of the autonomic nervous system, which produces increased sweating and thus increases the galvanic skin conductance response (GSR) (Boucsein, 2012). By simulating an injury to the entrained fake hand, such as lifting a finger sharply upwards, it is possible to measure arousal reactions (Armel & Ramachandran, 2003; Guterstam et al., 2011). This may be measured using changes in the conductance of the skin by placing two small electrodes on the index and middle fingers (Guterstam et al., 2011). When the finger of the rubber hand is bent backwards (Armel & Ramachandran, 2003) or it is stabbed with a needle (Ehrsson, 2012; Newport & Preston, 2011), there is a significant GSR in comparison to the control condition (Newport & Preston, 2011; Ocklenburg, Rüther, Peterburs, Pinnow, & Güntürkün, 2011). The strength of this reaction has been shown to correlate with both the behavioural questionnaire responses and the magnitude of the proprioceptive drift in individuals who experience the illusion (Ehrsson, 2012).

A third objective measure associated with the illusion is reduction of skin temperature of the real hand. A drop of 0.27°C was observed during the illusion, which correlated with subjective strength of the illusion (Moseley et al., 2008). Moseley et al. (2008) argued that taking ownership of the fake limb engaged the body's homeostatic processes similar to the process for a real limb, suggesting that entrainment of the illusion decreases the weighting given to sensory information from the real limb. Additionally, Moseley et al. stated that the cooling of the real limb provided the first evidence that our conscious sense of self may contribute to homeostatic regulation.

Temporal Constraints. Intermodal matching between vision and touch has been argued as sufficient for self-attribution of the rubber hand (Botvinick & Cohen, 1998). Synchronised visual and tactile stimulation is necessary to induce the RHI, since it does not occur after asynchronous stroking of the real and fake hands (Armel &

Ramachandran, 2003; Botvinick & Cohen, 1998; Ehrsson et al., 2004; Tsakiris & Haggard, 2005). Any object can be experienced as part of one's body if the appropriate intermodal matching is present (Armel & Ramachandran, 2003). Following synchronous visual-tactile stimulation the GSR measured from the participant's real hand were significantly higher compared to the control asynchronous condition (Armel & Ramachandran, 2003). The researchers succeeded in entraining the illusion (measured using GSR), using a bare table top instead of a fake hand, following synchronous stroking of the real hand and the table. Armel and Ramachandran therefore argued that a rubber hand, table, or any other object could be incorporated into one's body schema as synchronous visual-tactile stimulation acts to construct a new body schema.

Contrary to the findings of Armel and Ramachandran (2003) there have been a significant number of research findings indicating that in order for the RHI to be entrained the fake hand must be sufficiently "hand" like (Tsakiris, 2010). For example Haans, Ijsselsteijn and de Kort (2008) used a factorial design to assess the strength of the RHI where the object was either hand shaped or not, with or without a natural skin texture and was stimulated either synchronously or asynchronously with the participants real hand. The study identified that based on behavioural questionnaire responses (rather than GSR), a stronger RHI was entrained in hand shaped objects, than for non-hand shaped objects (Haans et al., 2008). Additional findings suggested that RHI entrainment was not significantly affected by skin texture alone, with the interaction of shape and texture giving greater entrainment for the hand shaped object, but not for the non-hand shaped object (Haans et al., 2008). These results suggested that shape and postural position are important to entrainment of the illusion as synchronous visual-tactile

stroking integrates such objects into a pre-existing body representation, as opposed to creating a new schema (Tsakiris, Carpenter, James, & Fotopoulou, 2010).

Spatial and Anatomical Constraints. Research has shown that the illusion diminishes in strength the further the rubber hand is from the real hand, while remaining in an acceptable postural position (Lloyd, 2007). Spatial and anatomical location is therefore postulated as critical for inducement of the illusion. In this vein, Lloyd (2007) examined how distance between the fake and real hands influenced the illusion, whereas Costantini and Haggard (2007) investigated the effects of postural mismatch.

Lloyd (2007) varied the distance between the participant's real hand and the fake hand to identify over what range the illusion could be generated, and how strength of the illusion varied with distance. Evidence from the behavioural questionnaire indicated that the strongest rating of the illusion occurred when the distance between the real and fake hands was lowest (17.5cm), with perceived strength of the illusion decaying significantly when the distance was greater than 30cm (Lloyd, 2007). Lloyd suggested that when the participants hand is in close proximity to the fake hand, the visual representation of the fake hand is also within the tactile receptive field of the participant's real hand resulting in uncertainty in where the felt sensation occurs. This finding identified that if the real and fake hands are too far apart, then the felt sensation will be clearly outside the tactile reception field eliminating entrainment of the RHI. For this reason spatial proximity is a further necessary condition for entrainment of the RHI (Tsakiris, 2010).

Using a similar approach Costantini and Haggard (2007) examined the effects of postural mismatch with either synchronous or asynchronous stroking, and if the direction of stroking influenced the entrainment of the RHI. This was done by either changing the angle of either the real or fake hand or by changing the angle of the

stroking on the real or fake hand (Costantini & Haggard, 2007). Entrainment of the RHI was measured using proprioceptive drift and found that the strength of illusion was influenced by changes in hand positioning. The illusion was eliminated when the fake hand was misaligned (Costantini & Haggard, 2007). When the direction of stroking was congruent then the illusion was still entrained. Conversely, when the direction of stroking was incongruent between the real and fake hands, it resulted in the strength of the illusion being weakened.

Body Schema and Identity

Botvinick and Cohen (1998) entrained the illusion in a small sample by having participants look at the fake hand, while both the fake and the real hand were stroked in synchrony for 10 minutes. In contrast, when stroking was asynchronous, participants did not experience the illusion. The sense of ownership of the fake hand engendered by the illusion and its implications has been the focus of much of the research into the RHI (Armel & Ramachandran, 2003; Longo, Cardozo, & Haggard, 2008; Longo, Schüür, Kammers, Tsakiris, & Haggard, 2009; Tsakiris et al., 2010; Tsakiris et al., 2006).

Body ownership in psychological and neurological studies is conceptualised in terms of body schema and body image (Costantini & Haggard, 2007; de Vignemont, 2007, 2011; Slatman, 2009). Body schema is a representation of one's body that serves as a standard by which posture and movement are judged and is thought to be driven by past sensory experiences, notably proprioceptive and somatosensory experience (Costantini & Haggard, 2007). By contrast, body identity can be construed as a top down view of body ownership, and is thought to be driven by the mental or conscious representation of one's own body, which comprise attitudes, emotions, beliefs and mental representations (Costantini & Haggard, 2007). In healthy individuals body

schema and identity combine to form a coherent basis for self-consciousness (Costantini & Haggard, 2007).

Body schema represents an unconscious sensorimotor map of the body based on the information necessary for a person to move their own body, suggesting that the focus of the body schema is action (de Vignemont, 2007). In this context, it incorporates factors such as body position, posture and constraints such as size, strength and degree of freedom in joint movement. In contrast body identity is based on a range of differing facets that are necessary to make judgements about bodily properties. It includes a visually driven spatial map of awareness of the body, semantic representations as to what is and is not a body and emotional attitudes towards the individuals own body (de Vignemont, 2011). Both body schema and image are multimodal in nature requiring input from more than one sensory modality to form, although it has been argued that body image places a greater emphasis on vision, while body schema is driven by proprioception (de Vignemont, 2011; Dijkerman & de Haan, 2007).

Neuropsychological Basis of the RHI

Neuropsychological studies have identified that the sense of body ownership is likely to be as a result of multimodal sensory integration. Cognitive neuroscience approaches using PET and fMRI scans have shown that when body ownership is disturbed by adding a fake hand using the RHI, areas of the brain responsible for sensory integration such as the premotor cortex and the frontal operculum are significantly more active, than when the illusion is not present.

Using fMRI studies have examined the locations of the brain that were activated when manipulated perceived body ownership via the RHI, relying on the fact that the illusion tends to be created only in conditions in which stroking of the hands is synchronous. Research by Ehrsson, Spence and Passingham (2004) identified that two

areas showed significantly greater activity the frontal operculum and ventral premotor cortex. A linear regression model indicated that when the RHI was entrained there was a positive, linear, relationship between strength of the illusion and activity in the premotor cortex (Ehrsson et al., 2004). It was argued by Ehrsson et al. (2004) that increased activity in the premotor cortex represents multimodal integration, as the neurons in this area represent both the seen and somatic position of the fake hand. Similarly, using positron emission tomography (PET), Tsakiris et al. (2007) identified that strength of the illusion was positively related to increased activity in the frontal operculum; however no increased activity in the ventral premotor cortex was identified (Tsakiris, Hesse, Boy, Haggard, & Fink, 2007). A potential explanation for the differing results of these two studies is that they examined different aspects of the illusion. In effect, Ehrsson et al. (2004) examined commencement of the illusion, which is likely to involve the premotor cortex, whereas Tsakiris et al. (2007) examined maintenance of the illusion after entrainment (Ehrsson, 2012).

Recent research has proposed a third location that may underpin the subjective experience of body ownership, being the posterior insular cortex (Tsakiris, 2010). The posterior insular is the target of afferent input from the body signalling pain, temperature, muscle fatigue and pleasant touch; additionally in conjunction with other areas of the brain (anterior insula and anterior cingulate cortex) it mediates the bodies interoceptive sensations (Ehrsson, 2012; Tsakiris, 2010; Tsakiris, Tajadura-Jiménez, & Costantini, 2011). In addition to their findings on the frontal operculum Tsakiris et al. (2007) also identified a correlation between the magnitude of the proprioceptive drift and activity across this region. Similarly, research has shown that individuals who have a stroke or develop lesions involving the posterior insular cortex can experience denial

of ownership; conversely when owned body parts (that is a real hand) are threatened, these areas of the brain are strongly activated (Ehrsson, 2012).

The neuropsychological studies discussed identified that entrainment of the RHI is associated with activation of areas of the cortex associated with body ownership. Disturbance of body ownership as a result of multimodal sensory integration could be measured using the RHI, with activation of particular areas of the cerebral cortex significantly stronger when the illusion was present. The role of interoceptive awareness as a possible alternative to multisensory integration has recently been proposed by Tsakiris, Tajadura-Jiménez and Costantini (2011).

Role of Interoception

It has been argued that body awareness is dependent on both exteroceptive and interoceptive processes (Tsakiris, 2010; Tsakiris et al., 2011). Exteroceptive signals, such as vision and touch, are a key factor in the development of the RHI in which these signals override the body's proprioceptive sense of location of the individual's own hand (Tsakiris et al., 2011). Additionally, research has also shown that entrainment of the RHI interferes with the homeostatic balance of the real hand, as skin temperature of the real hand decreased when participants experienced the illusion (Moseley, Gallace, & Spence, 2012; Moseley et al., 2008). Tsakiris et al. (2011) contended that the findings from these studies suggest a role for interoceptive awareness (awareness of internal physiological conditions of the body) in modulating external stimuli on the body as well as internal stimuli. Currently there is little research into the role of interoceptive awareness in the formation of the RHI, and it was decided not to pursue this line of research given the necessary limitations imposed by the nature of an honours project.

Individual Differences

Numerous studies using the RHI have examined issues of body ownership

(focusing on body schema and identity) and the necessary and sufficient conditions for entrainment of the illusion (Eshkevari, Rieger, Longo, Haggard, & Treasure, 2012). Less is known about why some people are more susceptible to the illusion than others, with the reported failure rate in entrainment of the illusion varying between five and thirty per cent (although many studies fail to report this) (Asai, Mao, Sugimori, & Tanno, 2011; Botvinick & Cohen, 1998; Christ et al., 2012). The existing individual differences research has focussed on eating disorders, schizophrenia, and schizotypal traits (Asai et al., 2011; Eshkevari et al., 2012; Mussap & Salton, 2006), with these conditions increasing the probability of entrainment the illusion. Alternatively Asai, Mao, Sugimori and Tanno (2011) suggested that empathy may be an important individual difference in entrainment of the RHI.

Eating disorders have been identified as a natural fit for much of the research into the RHI as they are primarily disorders of body image (Eshkevari et al., 2012). Research using non-clinical participants identified that strength of the RHI was correlated with bingeing, purging and the use of dieting supplements (Mussap & Salton, 2006). These findings were supported in a subsequent study by Eshkevari, Rieger, Longo, Haggard and Treasure (2012) where participants had a diagnosed eating disorder, as measured by the Eating Disorders Inventory. Participants who had an eating disorder experienced the RHI significantly more strongly than those who did not, with 22.8% of the variance being explained by an eating disorder psychopathology (Eshkevari et al., 2012).

Research has identified that individuals with schizophrenia have deficits in their sense of self and in their self-processing (American Psychiatric Association, 2000; Thakkar, Nichols, McIntosh, & Park, 2011). In a study of clinically diagnosed schizophrenics, Thakkar, Nichols, McIntosh and Park (2011) identified that participants

experienced the RHI more strongly than healthy controls when measured using both the behavioural questionnaire ($t(43) = 2.0$, $p = .05$; $d = .60$) proprioceptive drift ($t(43) = 2.8$, $p = .009$; $d = .48$). One concern with these findings, as identified by Thakkar et al., is that they may have been confounded by the anti-psychotic medication that many of the individuals in the schizophrenia group were taking. Alternatively Asai et al. (2011) investigated the effect of schizotypal personality traits on the RHI, and found a significant correlation with Positive Schizotypy. The schizotypal personality disorders were measured by the Schizotypal Personality Questionnaire Brief (SPQB; Raine, 1991), with Positive Schizotypy correlated with entrainment of the RHI ($r = .37$, $p < .01$; $d = .86$). Positive Schizotypy referred to those factors in the SPQB associated with active perceptual experiences (hearing sounds) and suspiciousness (identifying threats in conversation). Additionally, Asai et al. also examined empathy and found significant correlations between responses on the SPQB and an individual's level of empathy.

The ability to empathically map between the fake and real hand has also been reported to be associated with the formation of the illusion (Asai et al., 2011). Empathy was measured using the Interpersonal Reactivity Index (IRI; Davis, 1980), which measures empathy across four dimensions (Emotional Concern, Personal Distress, Fantasy and Perspective Taking) (Asai et al., 2011; Wang et al., 2013). Sensitivity to the RHI was significantly correlated with the IRI total score ($r = .27$, $p < .05$; $d = .58$) and the Emotional Concern sub-score ($r = .31$, $p < .01$; $d = .69$) (Asai et al., 2011). The findings by Asai et al. (2011) suggested that as an individual's affective empathy (Emotional Concern and Personal Distress) increased, the strength of the RHI also increased; indicating that the ability to empathise with the rubber hand may be associated with susceptibility to the RHI.

Empathy has also been shown to be related to depression, with individuals who suffer from major depression having significantly lower levels of empathy than healthy controls (Cusi, MacQueen, Spreng, & McKinnon, 2011; Sloan & Sandt, 2010; Wilbertz, Brakemeier, Zobel, Härter, & Schramm, 2010). Major depression is defined in the Diagnostic and Statistics Manual of Mental Disorders (DSM-IV-TR) by the presence of either one of; depressed mood or diminished ability to experience pleasure (anhedonia) over a period of at least two weeks, combined with at least four additional symptoms such as psychomotor dysfunction or sleep disturbance (hypersomnia or insomnia) (American Psychiatric Association, 2000). Cusi and colleagues (2011) examined the responses of individuals who had suffered at least one depressive episode (n = 20) to matched healthy controls to the IRI and Toronto Empathic Questionnaire (TEQ; Spreng, McKinnon, Mar, & Levine, 2009). Individuals with major depression scored significantly lower than healthy controls on the Perspective Taking scale ($F(1, 38) = 7.65$, $p = 0.009$; $d = .90$) and the Emotional Concern scale ($F(1, 38) = 4.86$, $p = 0.03$; $d = .72$) (Cusi et al., 2011). Cusi et al. suggested that the finding of lower emotional concern in individuals with major depression provided preliminary evidence that these individuals experience fewer feelings of care and concern in response to someone else's emotional experiences. It should be noted that Cusi et al. did not directly examine if individuals did experience lower concern, such as for a fake hand, rather this was inferred from the findings based on the shortfalls in various aspects of empathic responding.

While the existing research examining the relationship between the RHI and schizophrenia or eating disorders is important, the clinical nature of these disorders is outside the scope of the current study. Conversely depressive symptoms can be measured at sub-clinical levels, and it is suggested that individuals with major

depressive disorders have lower levels of empathy, than healthy individuals (Cusi et al., 2011). This suggests that individuals with depression or depressive symptoms would be likely to experience the RHI differently to healthy individuals.

The current research examined the ability of depression, mental distress and empathy to predict the strength of the RHI measured by self-report with three hypotheses:

1. It was predicted that depression scores, as measured by the depression sub scale of the DASS, would be predictive of embodiment scores on the RHI.
2. As an extension of hypothesis one, it was predicted that mental distress as measured by the total DASS score (combined depression, anxiety and stress scales) would also be predictive of embodiment scores on the RHI.
3. That empathy as measured by the IRI would be predictive of embodiment of the RHI.

Method

Design

The study utilised a linear regression design with three predictor variables and one criterion variable. The predictor variables were depression, overall mental distress and empathy and the criterion variable was the self-reported strength of the RHI. Depression and mental distress were measured on the Depression, Anxiety and Stress Scale (DASS) and empathy was measured by the Interpersonal Reactivity Index (IRI). Self-reported strength (embodiment) of the RHI was measured using Botvinivk and Cohens (1998) nine item questionnaire that assesses the strength of embodiment of the fake hand.

Participants and Recruitment

All participants received an information letter that provided a brief synopsis of the proposed research and were asked to sign a consent form prior to participation (See Appendix A for information letter and Appendix B for consent form). A total of 69 participants were recruited from Edith Cowan University and associates of the researcher, following ethics approval from the Edith Cowan University Human Research Ethics Committee.

Power Analysis

Existing research into the strength of the RHI has reported effect sizes using Cohen's *d* ranging from .63 (Guterstam et al., 2011) to.69 (Asai et al., 2011), while the relationship between empathy and depression has a reported effect size of.72 (Cusi et al., 2011). Based on the effect sizes a statistical power of 0.8 could be achieved with a minimum of 40 participants, although for multiple regression purposes a minimum sample of 60 participants is required (Field, 2009; Lipsey, 1990).

Materials

Participants completed three questionnaires sourcing information on their embodiment of the illusion, and their levels of depression, mental distress and empathy. The strength of the illusion questionnaire was completed immediately after the experimental manipulation; the remaining questionnaires were not completed in any particular order.

RHI Strength Questionnaire. The self-report questionnaire on the strength of the illusion was initially used by Botvinick and Cohen (1998) (See Appendix C for the questionnaire items). The questionnaire consists of nine items measured on a seven point Likert scale from -3 (strongly disagree) to +3 (strongly agree); where experiencing the illusion is consistent with positive scores. The questionnaire has a unitary dimension

and while there are no studies on the validity and reliability of these questions, Cronbach's alpha for this sample was .91. Additionally research by Asai et al. (2011) has shown the sum of the scores on the questionnaire correlate (Spearman's $r = .56$, $p = .02$) with objective measures of the illusion such as proprioceptive drift.

Depression Anxiety Stress Scale (DASS). The short form of the DASS, the DASS – 21, is a tool used to screen individuals for depression, anxiety and stress (See Appendix D for the questionnaire items). The depression scale measures dysphoria and sadness, the anxiety scale focuses on physiological arousal and fear while the stress scale examines states of tension and stress (Sinclair et al., 2012). Each question is based on experiences in the preceding seven days and measured on a Likert scale ranging from 0 (not at all) to 3 (all or most of the time). Questions on the DASS – 21 are representative of the full scale, however for scoring purposes each result is multiplied by two to enable interpretation across the measure (S. Lovibond & P. Lovibond, 1995). The DASS - 21 has been shown to be stable and internally consistent with Cronbach's alpha = .85 (Henry & Crawford, 2005; Osman et al., 2012) and has shown reasonable levels of validity, in comparison to similar self-report tools, with a correlation of above 0.70 to the Beck Depression Inventory (P. Lovibond & S. Lovibond, 1995; Sahebi, Asghari, & Salari, 2004) and 0.49 for the Hospital Anxiety and Depression Scale (Musa, Ramli, Abdullah, & Sarkarsi, 2011).

The individual sub-scales of the DASS have been shown to have reasonable discrimination and validity, however a significant body of research has also identified the possibility of an overarching "distress" factor (Osman et al., 2012; Sinclair et al., 2012). These studies found that the total DASS score (obtained by summing the individual scale scores) is a strong predictor of overall mental distress in the individual with high correlations to the Beck Depression Inventory II ($r = .80$) and the Mood and

Anxiety System Questionnaire (MASQ – 90) (r = .73) (Osman et al., 2012). For this reason the total DASS score was also considered to be a variable within the analysis.

Interpersonal Reactivity Index (IRI). Participant's empathy was assessed using the IRI (See Appendix E for the questionnaire items). The IRI is based on the two-component model of empathy and measures both cognitive and affective components of empathy using four 7-item subscales. Fantasy (FS) and Perspective Taking (PT) are thought to represent cognitive aspects of empathy whereas Personal Distress (PD) and Empathic Concern (EC) are identified as affective aspects. Fantasy refers to people's ability to identify with situations and with characters in books, movies, plays and other fictional situations. The Perspective Taking scale contains items that assess spontaneous attempts to adopt the perspectives of other people and see things from their point of view. The Empathic Concern scale inquires about respondents' tendency to experience feelings of warmth, concern or compassion for others. Finally, Personal Distress scale measures the feelings of personal anxiety in response to distress or discomfort in others (Davis, 1980). The questionnaire has been shown to be stable and internally consistent across a range of cultures with Cronbach's alpha ranging from .72 to .80 (Gilet, Mella, Studer, Grühn, & Labouvie-Vief, 2013).

Experimental Phase

The experiment was conducted in a quiet room at Edith Cowan University or in a quiet location at the participant's residence or office. Prior to commencing the experiment participants were provided with the participant information letter (see Appendix A). After ensuring that the participants understood the research requirements they were asked to sign the consent form (see Appendix B).

Experimental Set Up. Figure 1 shows the placement of the fake hand on the table to the right of a screen covered, in a black barber's cape. On arrival, participants

were requested to sit at a table opposite the experimenter with the fake hand visible and towards the dorsal medial line. The participant's left hand was hidden by a cardboard box wall, additionally a black barber's cape was draped over the shoulder of the participant and used to conceal the beginning of the fake hand. This created the appearance that the hand was in fact connected to the body as shown in Figure 2. This technique is consistent with the techniques used in much of the research on the RHI (Perez-Marcos, Sanchez-Vives, & Slater, 2012).

Figure 1. Experimental set up showing the fake hand, screen and barbers cape.

Figure 2. Participant seated at the experiment.

Participants were asked not to move during the experiment and to focus their eyes on the fake hand, where it was being stroked. Participants were also asked not to try and 'guess' what the experiment aimed to achieve.

Figure 3 shows the participant's hidden real hand and the wooden fake hand being stroked synchronously for a period of two minutes. At the conclusion of the two minutes the barber's cape was removed and the participant completed the strength of illusion questionnaire.

Figure 3. The experimental manipulation in progress.

Initial Data Analysis and Screening of Initial Results

Embodiment and Rubber Hand Illusion Questionnaire Correlations. For analytical purposes it was decided to use the averaged RHI questionnaire scores across nine items as a measure of embodiment. Table 1 shows the correlation matrix between each RHI questionnaire item and the final embodiment score indicating that all combinations among the questionnaire items were significant. As expected, the individual items on the questionnaire were strongly correlated with the embodiment score and also with each other. Importantly the intercorrelations between the questions are similar to (although slightly stronger than) those reported by Asai et al. (2011).

Based on these intercorrelations, the embodiment score was used as a measure of sensitivity to the RHI, with higher total scores indicating a stronger experience of the illusion.

Table 1

Intercorrelations of RHI questionnaire items and total embodiment score.

Item	1	2	3	4	5	6	7	8	9
Embodiment score	.66**	.81**	.85**	.80**	.76**	.80**	.74**	.80**	.65**
1. It seemed as if I were feeling the touch of the paintbrush in the location where I saw the fake hand touched.	-	.59**	.60**	.37**	.42**	.42**	.38**	.36**	.32**
2. It seemed as though the touch I felt was caused by the paintbrush touching the fake hand.		-	.76**	.56**	.48**	.58**	.47**	.58**	.47**
3. I felt as if the fake hand was my hand.			-	.62**	.58**	.61**	.59**	.57**	.45**
4. I felt as if my (real) hand were drifting toward the right (toward the fake hand).				-	.65**	.61**	.48**	.74**	.50**
5. It seemed as if I had more than one left hand.					-	.60**	.64**	.53**	.32**
6. It seemed as if the touch I was feeling came from somewhere between my own hand and the fake hand.						-	.62**	.65**	.42**
7. It felt as if my (real) hand was turning ‘‘wooden”.							-	.56**	.42**
8. It appeared (visually) as if the fake hand where drifting toward the left (towards my real hand).								-	.55**
9. The fake hand began to resemble my own (real) hand, in terms of shape, skin tone, freckles or some other visual feature.									-

Note: $n = 69$

** $p < .01$ (2-tailed).

Data Screening. Participants’ scores on the IRI, DASS and the strength of the illusion were examined for outlying cases. Analysis of box plots revealed a number of outlying cases in scores on the IRI and DASS (more than two standard deviations from the mean) and also a number of extreme cases (more than three standard deviations from the mean) in scores on the DASS. Each of the extreme and outlying cases on the DASS were examined individually and identified as scores representing a clinically significant level of depression, anxiety or stress (scores in the severe to extremely severe range). While the study was not targeting this population it was decided that

excluding cases on this basis was not appropriate and they were retained in the study. Individuals who scored in the severe to extremely severe range on any scale of the DASS were followed up to ensure that they were aware of support.

Examination of the outlying scores on the IRI revealed that the majority of these cases were clustered on the perspective taking and empathic concern subscales and that when combined into the total score were within normal bounds. One case was identified where an individual scored within the normal range on all the sub-scales but whose total score was an outlier. In both of these cases the data were retained in the study.

Mahalanobis distances were used to assess for multivariate outliers and Cooks distance to assess the influence of individual cases on the results. Mahalanobis distances were generated in SPSS and assessed against the chi squared distribution with k (number of predictor variables) degrees of freedom, χ^2 (3) = 16.27. Cooks distance is a measure of the impact individual cases have on the predictive efficiency of the regression model as a whole. Threshold values for examination are based on sample size with scores greater than 4/(n-k-1) considered to be worth further examination, for this study scores greater than 0.1 (or 10% of the model variance) were examined. One multivariate outlier was identified, however this had a negligible influence on the overall model as measured by Cooks distances (Cooks distance .005) and was therefore retained in the study.

Results

PASW 20 Statistics package (SPSS) for Windows was used to screen and analyse participant performance on the IRI, DASS and strength of the illusion.

Correlations between the RHI and Empathy and Depression measures

An initial analysis between the RHI as measured by embodiment scores and the depression, mental distress and empathy measures was undertaken by reviewing the

intercorrelations between the variables. The intercorrelations, using Spearman's *r* and shown in Table 2, indicated that embodiment of the illusion was significantly correlated with total DASS ($r = .46$, $p < .01$) and also each of the sub scales Depression ($r = .38$, $p < .01$), Anxiety ($r = .28$, $p < .05$) and Stress ($r = .39$, $p < .01$); and with the total IRI score (empathy traits) ($r = .32$, $p < .05$), and with the cognitive aspects of empathy Fantasy ($r = .31$, $p < .01$) and Perspective Taking ($r = .25$, $p < .05$).

A number of significant correlations between the empathy and depression scales were also identified. Significant positive correlations between both Fantasy and Personal Distress and the DASS and its subscales were observed, however no significant correlations were observed for the other empathy subscales of Perspective Taking and Emotional Concern.

Table 2

Intercorrelations (Spearman's rho) of embodiment with measures of empathy and depression.

	2	3	4	5	6	7	8	9	10
1. Embodiment	**.32***	**.25***	**.31****	.15	.21	**.46****	**.38****	**.28***	**.39****
Empathy Scale									
2. IRI Total	-	**.48****	**.58****	**.59****	**.57****	**.25***	.09	.21	**.26***
3. Perspective Taking		-	-.01	**.38****	-.05	.02	.08	-.02	-.07
4. Fantasy			-	.07	**.33****	**.37****	.17	**.37****	**.37****
5. Empathic Concern				-	.06	-.08	-.12	-.05	-.08
6. Personal Distress					-	**.40****	**.32****	**.29***	**.41****
DASS									
7. DASS Total						-	**.79****	**.79****	**.89****
8. Depression							-	**.47****	**.55****
9. Anxiety								-	**.63****
10. Stress									-

Note: $N = 69$. IRI = Interpersonal Reactivity Index. Perspective Taking and Fantasy are thought to be cognitive empathy traits, while Empathic Concern and Personal Distress are thought to be emotional empathy traits. DASS = Depression, Anxiety and Stress Scale.

* $p < .05$ and ** $p < .01$ (both 2-tailed).

Regression Analysis in predicting the RHI

A series of simple linear regression analyses were conducted to identify the predictive ability of the various criterion variables. Firstly on the depression scale of the DASS, secondly, overall mental distress using the DASS total score and finally on cognitive measures of empathy (perspective taking and fantasy). Following this a hierarchical multiple regression using a forward entry method was conducted to examine the predictive ability of combined mental distress and cognitive empathy. The bases for selection of these variables were the correlations identified in Table 2.

Shapiro-Wilk's test indicated that scores on the RHI questionnaire, DASS total, all DASS subscales and perspective taking were not normally distributed ($p < .001$) which was confirmed by visual inspection of the normal Q-Q plots. Conversely, the distribution of fantasy was normally distributed (Shapiro-Wilk, $p > .001$). The maximum Mahalanobis distance value for each regression did not exceed the critical value for relevant *df* indicating that multivariate outliers were not an issue in the sample.

In addition to non-normality a number of predictor variables suffered from significant levels of skewness, with the DASS and its subscales being positively skewed and perspective taking negatively skewed. To correct this, a square root transformation was applied to the DASS and a square transformation to perspective taking. This technique effectively corrected the skewness in the variable but, with the exception of perspective taking, did not correct the non-normality of the variables. The transformed data provided slightly better predictive power for each of the regressions that follow – at the expense of significantly complicating the data analysis as some variables were transformed to a square root and others not transformed. As normality of the predictor variables is not essential for multiple regression (Field, 2009), the analysis that follows is based on the raw (untransformed) data.

The normal P-P plot of regression standardised residuals, and the scatter plot of standard residuals against standardised predicted values were examined for each regression model. These indicated that the assumptions of normality, linearity and homoscedasticity of residuals had been met. Collinearity tolerance statistics were greater than 0.02 for all variables, suggesting multicollinearity was not an issue for the predictor variables.

Depression. A simple regression was conducted using the depression scale of the DASS to examine its ability to predict scores on the RHI, with depression score as the predictor variable and RHI embodiment as the criterion variable. The simple regression results indicated that depression scores predicted 10.9% of the variance in RHI embodiment scores $F(1.67) = 8.212$, $p = .001$, $R^2 = .109$, adjusted $R^2 = .096$, with a small effect size of $f^2 = .122$. The unstandardised and standardised regression coefficient, and squared semi-partial correlation is presented in Table 3, together with effect size.

Table 3

Unstandardised (B) and Standardised (β) Regression coefficients, and Squared Semi-Partial Correlations (sr2) for a Simple Regression Model Predicting Scores on the RHI Questionnaire.

	Unstandardised Coefficients		Unstandardised Coefficients	Significance			Effect Size
Variable	*B*	*S.E*	β	*t*	*p*	sr^2	f^2
(Constant)	-11.07	2.12					
Depression	.58	.20	.33	3.87	.006	.33	.122

Note: $N = 69$.

Mental Distress. The total DASS score is considered to be a measure of mental distress. The ability of mental distress to predict RHI scores was measured using a simple linear regression with DASS total score as the predictor variable and RHI embodiment as the criterion variable.

The simple regression results indicated that total DASS scores predicted 14.1% of the variance in RHI embodiment scores $F(1.67) = 11.01$, $p = .001$, $R^2 = .141$, adjusted $R^2 = .128$, with a medium effect size of $f^2 = .161$. The unstandardised and standardised regression coefficient, and squared semi-partial correlation is presented in Table 4, together with effect size.

Table 4

Unstandardised (B) and Standardised (β) Regression coefficients, and Squared Semi-Partial Correlations (sr2) for a Simple Regression Model Predicting Scores on the RHI Questionnaire (effect sizes are provided).

	Unstandardised Coefficients		Unstandardised Coefficients	Significance			Effect Size
Variable	*B*	*S.E*	β	*t*	*p*	sr^2	f^2
(Constant)	-13.40	2.46					
DASS	.24	.07	.38	3.32	.001	.38	.161

Note: $N = 69$. DASS = Depression, Anxiety and Stress Scale total score.

Empathy. To explore if empathy would be predictive of embodiment scores the correlations in Table 2 were examined to identify significant correlations between embodiment and empathy. Based on this analysis the fantasy and perspective taking sub-scales of the IRI were entered into a hierarchical regression model. The results of the first step of the hierarchical regression showed that fantasy predicted 9.5% of the variance in RHI embodiment scores $F(1, 67) = 7.053$, $p = .010$, $R^2 = .095$, adjusted $R^2 = .082$, the effect size was small $f^2 = .105$. On step two, the entry of perspective taking accounted for an additional 1.8% of the variance in RHI embodiment scores, an increase that was not significant $\Delta R^2 = .018$, $\Delta F (1, 66) = 1.37$, $p = .247$. In combination the two predictor variables accounted for 11.4% of the variance in RHI embodiment scores. The variance accounted for by these predictors was significant, $F(2, 66) = 4.23$, $p = .019$, $R^2 = .114$, adjusted $R^2 = .087$, the overall effect size was small $f^2 = .129$. For each

predictor, unstandardised and standardised regression coefficients, and squared semi-partial correlations are presented in Table 5, effect sizes are provided for each step of the regression model.

Table 5

Unstandardised (B) and Standardised (β) Regression coefficients, and Squared Semi-Partial Correlations (sr2) for Each Predictor in a two step forward entry Multiple Regression Model Predicting Scores on the RHI Questionnaire (effect sizes are provided for each step).

	Unstandardised Coefficients		Unstandardised Coefficients	Significance			Effect Size
Variable	*B*	*S.E*	β	*t*	*p*	sr^2	f^2
Step 1							
(Constant)	-21.75	5.72					
Fantasy	.83	.31	.31	2.66	.010	.31	.105
Step 2							
(Constant)	-30.59	9.47					
Fantasy	.84	.31	.31	2.68	.009	.31	
Perspective Taking	.42	.36	.14	1.17	.247	.14	.129

Note: $N = 69$. Perspective Taking and Fantasy are thought to be cognitive empathy traits of the Interpersonal Reactivity Index.

Combined Empathy and Mental Distress. Analysis of the simple regression models identified that mental distress (total DASS score) and the depression sub-scale predicted essentially the same amount of variance in RHI embodiment scores. For this reason the mental variable distress (which includes depression) was selected for inclusion in a stepwise hierarchical regression together with empathy. The results of the first step of the hierarchical regression showed that in combination, participant scores on the cognitive empathy scales (perspective taking and fantasy) predicted 11.4% of the variance in RHI embodiment scores $F(2, 66) = 4.23$, $p = .019$, $R^2 = .114$, adjusted $R^2 = .087$, the effect size was small $f^2 = .129$. On step two, DASS total score was added to the regression equation and accounted for an additional 11.1% of the variance in RHI embodiment scores $\Delta R^2 = .114$, $\Delta F (1, 65) = 9.29$, $p = .003$. In combination the three

predictor variables accounted for 22.4% of the variance in RHI embodiment scores. The variance accounted for by these predictors was significant, $F(3, 65) = 6.27$, $p = .001$, $R^2 = .224$, adjusted $R^2 = .189$, and the overall effect size was medium $f^2 = .289$. For each predictor, unstandardised and standardised regression coefficients, and squared semi-partial correlations are presented in Table 6, effect sizes are provided for each step of the regression model. At the second stage of the multiple regression only the DASS total score remained a significant predictor.

Table 6

Unstandardised (B) and Standardised (β) Regression coefficients, and Squared Semi-Partial Correlations (sr2) for Each Predictor in a two step forward entry Multiple Regression Model Predicting Scores on the RHI Questionnaire (effect sizes are provided for each step).

	Unstandardised Coefficients		Unstandardised Coefficients	Significance			Effect Size
Variable	*B*	*S.E*	β	*t*	*p*	sr^2	f^2
Step 1							
(Constant)	-30.56	9.47					
Perspective Taking	.42	.36	.14	1.17	.247	.14	
Fantasy	.84	.31	.31	2.68	0.009**	.31	.129
Step 2							
(Constant)	-36.05	9.10					
Perspective Taking	.63	.34	.20	1.83	.071	.20	
Fantasy	.56	.31	.21	1.82	.074	.20	
DASS	.23	.07	.36	3.05	0.003**	.33	.289

Note: $N = 69$. Perspective Taking and Fantasy are thought to be cognitive empathy traits of the Interpersonal Reactivity Index. DASS = Depression, Anxiety and Stress Scale total score.

** $p < .01$ (2-tailed).

Post-hoc analysis of the results revealed that the actual power of the regression model was .96, suggesting that there is a 96% likelihood of the result reflecting a real effect (Lipsey, 1990).

Individual Differences

Four possible patterns of individual differences were explored. Firstly those individuals who did experience the RHI were different to those who did not in their scores on the depression scale of the DASS and, secondly experiencers and non-experiencers would have differencing levels of mental distress measured by the total DASS score. Thirdly, the empathy subscales were tested to identify if experiencers and non-experiencers had differing level of empathy; and finally the data was tested to see if individuals with differing levels of mental distress would have different empathic responses.

RHI, Depression and Mental Distress. The sample was first split based on whether an individual experienced or did not experience the RHI. The basis of the split was the total score on the RHI questionnaire, with individuals who scored -24 or lower (on a range of -27 to +27) being categorised as not experiencing the illusion. Exploration of the data sets thus created revealed they were not normally distributed and for this reason standard *t* tests could not be used. For this reason the non-parametric alternative, the Mann – Whitney *U* test, was used to determine if there were differences in mean scores for depression and mental distress between experiencers and non-experiencers of the illusion.

The Mann – Whitney *U* test indicated that the depression scores of individuals who did not experience the illusion (*Mean Rank* = 22.06, *n* = 17) were significantly lower than those who did experience the illusion (*Mean Rank* = 39.23, *n* = 52), *U* = 222.00, *z* = -3.10 (corrected for ties), *p* = .002, two tailed. This represents a medium effect size, *r* = .37, using Cohen's (1988) suggested ranges.

The Mann – Whitney *U* test indicated that the mental distress (total DASS scores) of individuals who did not experience the illusion (*Mean Rank* = 18.09, *n* = 17)

were significantly lower than those who did experience the illusion (*Mean Rank* = 40.53, $n = 52$), $U = 154.50$, $z = -4.01$ (corrected for ties), $p < .001$, two tailed. This represents a medium/large effect size, $r = .48$, using Cohen's (1988) suggested ranges.

Empathy and Mental Distress. Similar to the data for depression and mental distress the data for the empathy sub-scales was not normally distributed and for this reason the non-parametric Mann-Whitney U test was used to measure mean differences in empathy scores for those who experienced the illusion and those who did not. Examination of the cognitive aspects of empathy revealed no significant mean differences in empathy between experiencers and non-experiencers.

A multiple analysis of variance (MANOVA) was conducted to test whether scores on the IRI subscales was significantly different for high versus normal versus low mental distress scores. Similar to the regression models developed above only those subscales with significant correlations in Table 2 (fantasy and personal distress) were included in the MANOVA. Assumptions of no multivariate outliers, multivariate normality and homogeneity of variance-covariance matrices were met. The MANOVA was not statistically significant Pillai's trace $F(4, 132) = 1.50$, *ns*, indicating that there was no significant effect of mental distress on empathy scores.

Discussion

The aim of the current research was to examine the ability of depression, mental distress and empathy to predict embodiment of the RHI. The illusion was induced using a standard approach (Botvinick & Cohen, 1998) and questionnaires were then used to measure embodiment of the illusion, empathy and mental distress. The findings identified strong positive correlations between mental health and the RHI, however they did not provide support for existing research into the relationship between the RHI and empathy.

Depression was found to have a significant correlation with scores on the embodiment questionnaire ($r = .31$, $p < .01$) and was also a moderate predictor of reported strength of the RHI, explaining 10.7% of the variance in scores. Mental distress (as measured by the DASS total score) was found to have a significant correlation with scores on the embodiment questionnaire ($r = .38$, $p < .01$) and was also a moderate predictor of reported strength of the RHI, explaining 12.8% of the variance.

Additional analysis of the data was undertaken to determine if individuals who experienced the illusion had significantly different levels of depression and mental distress than those who did not experience the illusion. Participants were separated into experiencers and non-experiencers based on their total score on the RHI questionnaire and differences in responses measured using a non-parametric test, (Mann – Whitney U) due to violation of normality assumptions. The results indicated that individuals who did not experience the RHI had significantly lower scores on the depression scale ($U = 222.00$, $z = -3.10$ (corrected for ties), $p = .002$) and the DASS total score ($U = 154.50$, $z = -4.01$ (corrected for ties), $p < .001$), both findings had medium to large effect sizes (depression $r = .37$, mental distress $r = .48$). This provides additional support for the finding that embodiment of the RHI increases as mental health decreases.

The role of empathy in embodiment of the RHI was also explored. The cognitive aspects of empathy (fantasy and perspective taking) had significant correlations with the strength of embodiment of the illusion (fantasy: $r = .31$, $p < .01$; perspective taking: $r = .25$, $p < .05$). When entered into a hierarchical regression the cognitive aspects of empathy (fantasy and perspective taking) accounted for 11.4% of the variance in RHI embodiment, which is contradictory to the findings of Asai et al. (2011) who found the affective aspects of empathy were predictive of embodiment of the RHI.

Further exploratory testing examined mental distress and empathy as combined predictors of strength of the RHI. A forward entry, hierarchical regression indicated 22.4% of the variance in RHI embodiment scores could be predicted by a combination of the cognitive components of the DASS total score and the cognitive aspects of the IRI empathy scale (perspective taking and fantasy), however only the DASS total score was a significant predictor in the second stage of the regression model.

Mental Health

Existing individual differences research on the RHI has focussed on whether individuals with some form of mental disorder experience the illusion differently to healthy individuals. A range of disorders have been examined including schizophrenia, schizotypal personality disorder and eating disorders in a variety of clinical and non-clinical settings. These studies have separately identified that a particular disorder is associated with experiencing the illusion more strongly than healthy controls, with the current findings that an individual's level of depression or mental distress positively predicted strength of the RHI providing further support. Importantly the current study is the first to postulate that a general connection exists between an individual's mental health and strength of the illusion.

Previous research has identified that individuals with schizophrenia experienced the illusion more strongly than healthy individuals (Thakkar et al., 2011). While their study was conducted with a relatively asymptomatic sample Thakkar and colleagues used multiple techniques to assess the impact of the illusions. Their research identified that schizophrenics reported experiencing the illusion more strongly ($t(43) = 2.0$, $p = .05$; $d = .60$) than healthy participants, as measured by proprioceptive drift ($t(43) = 2.8$, $p = .009$; $d = .48$) (Thakkar et al., 2011). Similarly, Asai et al. (2011) identified a correlation between an individual's positive symptoms of schizotypal personality

disorder (positive schizotypy) and reported strength of the RHI (r = .37). While schizotypal personality traits were measured, Asai et al. should be distinguished from the study by Thakkar et al. in that the population studied was not clinical in nature.

Research into individuals with an eating disorder has also identified similar outcomes. In their study of individuals with an anorexia and bulimia Eshkevari et al. (2012) found that 22.8% of the variance in reported strength of the RHI could be attributed to an the presence of an eating disorder psychopathology (Eshkevari et al., 2012). While depression was not one of the factors examined, mental distress (measured using the same approach as the current study) was identified as a non-significant predictor in a multiple regression equation. The results of the current study provide support for the contention that in general as mental health decreases strength of embodiment of the illusion increases, which parallel the findings of studies into particular mental health issues including schizophrenia, schizotypal personality disorder, and eating disorders.

The current findings support existing research suggesting that the RHI is entrained differently for individuals with impaired mental health when compared to healthy individuals. In essence, causal explanations of the RHI are generally based on visual capture (the tendency for visual information about hand location to dominate proprioceptive information) and multisensory integration (a tendency for body ownership to be driven by spatiotemporal congruence of visual and tactile stimulation). The current study found that individuals with increased depressive symptoms and/or higher mental distress experience the illusion more strongly, suggesting that individuals with these conditions may be more susceptible to visual capture.

Visual capture within multisensory integration has been advanced as the dominant explanation for entrainment of the illusion. However it does not appear to be a

sufficient explanation when observing the illusion across multiple mental health issues. One disorder where visual capture has been shown to be a sufficient explanation is eating disorders. Previous findings indicated that these individuals continue to experience the illusion even when stroking is asynchronous, which for most individuals inhibits formation of the illusion (Eshkevari et al., 2012). In contrast, research has also indicated that proprioceptive awareness in individuals with schizophrenia and schizotypal personality disorder is influenced less by visual information than non-schizophrenics, suggesting that visual capture is not likely to be the cause (Thakkar et al., 2011). Importantly research by Tsakiris et al. (2011) suggested that interoceptive awareness (the minds awareness of internal body functions such as heartbeat and digestive processes) may provide a consistent explanation across a range of mental health outcomes.

Interoceptive Awareness. As discussed earlier Tsakiris et al. (2011) suggested that interoceptive awareness might serve as an alternative to multimodal sensory integration in explaining entrainment of the illusion. In particular, research has previously found that individuals with depression (O Pollatos, Traut-Mattausch, & Schandry, 2009), anorexia nervosa (Olga Pollatos et al., 2008) and schizophrenia (Palaniyappan, Mallikarjun, Joseph, & Liddle, 2011) have lower interoceptive awareness than healthy individuals. The current results indicate that a positive relationship exists between depression or mental distress and embodiment of the RHI (Table 2), and the positive beta weights in the regression equations in Tables 3 and 4. This suggests that the current findings could be explained by poor interoceptive awareness of those individuals with high depression and mental health scores. While this was not explicitly examined the results of the current study are consistent with the proposal of Tsakiris et al. and warrant further research consideration.

Empathy

The current findings do not support Asai et al's. (2011) study that identified significant correlations between affective aspects of empathy and the RHI in a non-clinical sample. In the current study only the cognitive aspects of empathy had significant correlations with strength of the RHI (fantasy scale: $r = .31$, $p < .01$; perspective taking $r = .25$, $p < .05$). The affective sub-scales of empathic concern and personal distress did not have significant correlations with strength of the RHI (empathic concern, $r = .15$, *ns;* personal distress, $r = .21$, *ns*). By contrast, Asai et al's study found significant correlations for the IRI total score ($r = .27$, $p < .05$) and the emotional concern sub-score ($r = .31$, $p < .01$ (an affective form of empathy). A similar significant correlation was found for the IRI total score in the current study ($r = .30$, $p < .05$. In this context it should be noted that Davis (1980) specifically cautions against using the IRI total score as an overall measure of empathy, rather the four subscales should be seen as two clusters of two – forming affective and cognitive aspects of empathy. It is for this reason that in the current study the IRI total score has not been used.

It has been proposed by Asai et al. (2011) that the correlation between empathic concern and the RHI may be explained by an individual's concern for the fake hand based on shared interpersonal representations. In contrast a cognitive empathy explanation was suggested by the nature of the questionnaire items on embodiment of the illusion (Asai et al., 2011). The questionnaire items do not contain any emotional aspects; rather they focus on appearance and visual cues (See Appendix C). These factors are inherently external in nature suggesting that the cognitive aspects of empathy would be activated in an attempt to imagine the experience of others (Asai et al., 2011; Rankin et al., 2006). In this context, the current findings support the notion that the

fantasy scale (which focuses on the individual's ability to empathise with characters in a book or movie or other fictional situations) and the perspective taking scale (focussing on the ability to adopt another person's point of view) are logical predictors of experiencing the RHI. The findings also indicated that the greater the ability of an individual to cognitively empathise, rather than emotionally, with an external perspective the more likely they were to adopt a "non-real" hand as part of their body. In effect, the current results show a positive correlation between cognitive empathy and entrainment of the illusion. The current research identified that stronger entrainment of the illusion is associated with poorer mental health suggesting that too much empathy might be equally detrimental to an individuals' mental well-being.

Limitations

Measurement of the RHI. In the current study the strength of the RHI was measured using a subjective standard self-report questionnaire, which has been shown to correlate (r = .56) with proprioceptive drift, an objective measure of the illusion (Asai et al., 2011). In similar research two alternative measures of the illusion have been used: proprioceptive drift and galvanic skin conductance (Folegatti et al., 2012; Guterstam et al., 2011). The use of an objective measure of the illusion may have provided different results to those identified in the current study, as these measures are likely to be more sensitive to the physiological experience of the illusion, rather than the individuals' cognitive appraisal of the experience. This could be as a result of raw participant scores of illusion strength are significantly skewed towards neutral or negative responses to experiencing the illusion. The use of objective measures such as changes in skin temperature may detect physiological responses to the illusions considerably better than an individual's cognitive appraisal.

Sample population. The sample used in the current study was drawn predominantly from university students and the researcher's personal network. As a consequence there were very few participants who had significant levels of depression/mental distress, which may have masked the strength and direction, of the relationship between depression/mental distress and the RHI.

Future Research

The current results, together with the existing literature, indicate that individuals with a range of mental conditions experience the RHI more strongly, than healthy individuals. In order to identify the underlying reasons for this correlation further research is required. Additionally, the current findings do not provide support for the existing research for the empathy construct in explaining the illusion. A critical facet of the exiting research is what drives formation of the RHI, with the traditional explanation based on visual capture and multi-sensory integration.

Interoception. The current study has identified that as mental distress increases entrainment of the RHI increases. As has previously been noted existing research into the RHI focusing on multimodal sensory integration, and more specifically visual capture, does not appear to be able to explain this relationship. In contrast deficits in interoceptive awareness have been identified in individuals with poor mental health, notably depression, schizophrenia and anorexia and further research into this area is required.

One study in which interoceptive awareness was measured in conjunction with the RHI found that participants who performed below average on a heart rate awareness task (a standard measure of interoceptive awareness) experienced the illusion significantly more strongly than high awareness participants (Tsakiris et al., 2011). Mean proprioceptive drift for the high interoceptive awareness participants was 0.11

cm, while for the low awareness participants it was 1.98 cm, a significant difference ($t(44) = -2.57$, $p < .05$, two tailed, $d = .77$). The results of this study suggested that it is not low interoceptive awareness that increases the strength of the RHI, rather high interoceptive awareness *inhibits* the development of the illusion (Tsakiris et al., 2011). The authors stated that individuals with greater interoceptive awareness are likely to display more effective monitoring of bodily sensations and stimuli (such as vision and touch) and better integration of this information with interoceptive stimuli.

Tsakiris et al. (2011) identified that interoceptive awareness is also impaired in individuals with depression (O Pollatos et al., 2009), anorexia nervosa (Olga Pollatos et al., 2008) and schizophrenia (Palaniyappan et al., 2011). This suggests that there is potential for interoceptive awareness to serve as a unifying explanation for the illusion across a range of mental health issues. In particular, future research could examine the interoceptive awareness, depression and the RHI in a single study, which has not previously been attempted. Such a study could involve individuals with both clinical and sub-clinical depressive symptoms and healthy individuals in comparing their entrainment of the illusion and levels of interoceptive awareness.

Empathy and the RHI. The conflicting results found for the role of empathy between the current study and that of Asai et al. (2011) indicate a need for further research. Asai and colleagues found significant correlations for the affective aspects of empathy to strength of the illusion, however the findings of the current study identified correlations with cognitive aspects of empathy. This could be as a result of sampling differences, as while both studies are based on university student samples, the participants in the current study were older and had a greater proportion of women. Further research using different measures of empathy may provide valuable insights,

not only into the construct of empathy itself, but also into its role in embodiment of the RHI.

Conclusion

This study explored the ability of depression, mental distress and empathy to predict the strength of the rubber hand illusion. The RHI was induced using a standard technique and the strength of the illusion measured by a commonly used questionnaire. Depression and empathy were measured using the DASS and IRI respectively. An individual's score on the DASS depression scale and the DASS total score were found to predict reported strength of the RHI such that as depression or mental distress increased so did strength of the illusion. Contrary to existing research only cognitive aspects of empathy were found to significantly predict the strength of the illusions, not affective aspects.

This study has demonstrated that individuals with depression or poor general mental health experience the illusion more strongly than those who are psychologically healthy. This is consistent with existing research, which has identified individuals with eating disorders, schizotypal personality disorders and schizophrenia as experiencing the illusion more strongly than health controls.

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Appendix A: Information Sheet – Rubber Hand Illusion

My name is David Parrick and I would like to thank you for your interest in this study which is titled: The Effect of Empathy and Depressive Symptoms on the Strength of the Rubber Hand. This research project is being undertaken as part of the requirements of the Bachelor of Science (Psychology) (Honours) program at Edith Cowan University, Joondalup Campus.

The purpose of this research is to explore the influence of depression and empathy on the strength of the rubber hand illusion. Through this study I hope to contribute to the existing research by identifying new factors that influence the strength of the illusion in individuals.

The research being conducted has two phases. In the first I will induce the illusion which involves having your left arm and hand hidden from view after which I will stroke your left index finger (using a paint brush) from the palm to the tip of the finger. It is possible, but unlikely, that the placement of your arm or the nature of the brush will feel uncomfortable – please let me know if this occurs and I will endeavour to accommodate you. Following inducement of the rubber hand illusion you will be asked to complete two questionnaires. The first measures the perceived strength of the illusion while the second is a measure of depression. It is expected that the research protocol will take approximately 30 minutes to complete although times may vary depending on the individual.

This study has been approved by the Edith Cowan University Human Research Ethics Committee. All data will remain confidential. Your identity will not be disclosed in any reports or publications arising from the study. Your participation is voluntary thus you are able to withdraw from the study at any time and can request for the removal of any data you have supplied. No names or identifying information is required.

If you would like to ask any questions regarding the study, please feel free to contact me David Parrick (Tel. 0415 206 216; email dparrick@our.ecu.edu.au) or my supervisor Dr Ken Robinson (Tel.6304 5526; email k.robinson@ecu.edu.au). If you would like to speak to a person independent of the research you can contact Ethics Officer Kim Gifkins (Tel. 6304 2170; email k.gifkins@ecu.edu.au).

Yours sincerely
David Parrick

Appendix B: Consent Form

Project Title: The Effect of Empathy and Depressive Symptoms on the Strength of the Rubber Hand

I _____ have read the information provided with this consent form and any questions I have asked have been answered to my satisfaction. The study includes completing a 28 item self-report questionnaire to assess empathy and a nine item self-report questionnaire to assess the strength of the Rubber Hand Illusion. I understand that the research protocol may take 30 minutes. I agree to participate in the activities associated with this research and understand that I can withdraw consent at any time.

I understand that I will not be identified in any way in any publication from this project.

Signed _____

Appendix C: Self Report Questionnaire on the Strength of the Illusion

Please indicate the extent to which you agree with the following statements by circling the appropriate number.

The scale provided set out below:

-3….-2….-1….0…..1…..2…..3
Strongly Disagree Strongly Agree

It seemed as if I were feeling the touch of the paintbrush in the location where I saw the fake hand touched	-3 ….-2 ….-1….0…..1…..2…..3
It seemed as though the touch I felt was caused by the paintbrush touching the fake hand	-3 ….-2 ….-1….0…..1…..2…..3
I felt as if the fake hand was my hand	-3 ….-2 ….-1….0…..1…..2…..3
I felt as if my (real) hand were drifting toward the right (toward the fake hand)	-3 ….-2 ….-1….0…..1…..2…..3
It seemed as if I had more than one left hand	-3 ….-2 ….-1….0…..1…..2…..3
It seemed as if the touch I was feeling came from somewhere between my own hand and the fake hand	-3 ….-2 ….-1….0…..1…..2…..3
It felt as if my (real) hand was turning ‘‘wooden”	-3 ….-2 ….-1….0…..1…..2…..3
It appeared (visually) as if the rubber hand where drifting toward the left (towards my hand)	-3 ….-2 ….-1….0…..1…..2…..3
The fake hand began to resemble my own (real) hand, in terms of shape, skin tone, freckles or some other visual feature	-3 ….-2 ….-1….0…..1…..2…..3

Appendix D: Depression, Anxiety and Stress Scale – 21 (DASS-21)

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:
0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1 I found it hard to wind down

2 I was aware of dryness of my mouth

3 I couldn't seem to experience any positive feeling at all

4 I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion)

5 I found it difficult to work up the initiative to do things

6 I tended to over-react to situations

7 I experienced trembling (e.g., in the hands)

8 I felt that I was using a lot of nervous energy

9 I was worried about situations in which I might panic and make a fool of myself

10 I felt that I had nothing to look forward to

11 I found myself getting agitated

12 I found it difficult to relax

13 I felt down-hearted and blue

14 I was intolerant of anything that kept me from getting on with what I was doing

15 I felt I was close to panic

16 I was unable to become enthusiastic about anything

17 I felt I wasn't worth much as a person

18 I felt that I was rather touchy

19 I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)

20 I felt scared without any good reason

21 I felt that life was meaningless

Appendix E: Interpersonal Reactivity Index (IRI)

The following statements inquire about your thoughts and feelings in a variety of situations. For each item, indicate how well it describes you by choosing the appropriate letter on the scale at the top of the page: A, B, C, D, or E. When you have decided on your answer, fill in the letter in the column to the right of the question. **READ EACH ITEM CAREFULLY BEFORE RESPONDING.** Answer as honestly as you can. Thank you.

ANSWER SCALE:

A B C D E

DOES NOT DESCRIBE ME WELL — DESCRIBES ME VERY WELL

	Question	**Score**
1	I daydream and fantasize, with some regularity, about things that might happen to me.	
2	I often have tender, concerned feelings for people less fortunate than me.	
3	I sometimes find it difficult to see things from the "other guy's" point of view.	
4	Sometimes I don't feel very sorry for other people when they are having problems.	
5	I really get involved with the feelings of the characters in a novel.	
6	In emergency situations, I feel apprehensive and ill-at-ease.	
7	I am usually objective when I watch a movie or play, and I don't often get completely caught up in it.	
8	I try to look at everybody's side of a disagreement before I make a decision.	
9	When I see someone being taken advantage of, I feel kind of protective towards them.	
10	I sometimes feel helpless when I am in the middle of a very emotional situation.	
11	I sometimes try to understand my friends better by imagining how things look from their perspective.	
12	Becoming extremely involved in a good book or movie is somewhat rare for me.	

	ANSWER SCALE: **A B C D E** DOES NOT DESCRIBE ME WELL — DESCRIBES ME VERY WELL	
13	When I see someone get hurt, I tend to remain calm.	
14	Other people's misfortunes do not usually disturb me a great deal.	
15	If I'm sure I'm right about something, I don't waste much time listening to other people's arguments.	
16	After seeing a play or movie, I have felt as though I were one of the characters.	
17	Being in a tense emotional situation scares me.	
18	When I see someone being treated unfairly, I sometimes don't feel very much pity for them.	
19	I am usually pretty effective in dealing with emergencies.	
20	I am often quite touched by things that I see happen.	
21	I believe that there are two sides to every question and try to look at them both.	
22	I would describe myself as a pretty soft-hearted person.	
23	When I watch a good movie, I can very easily put myself in the place of a leading character.	
24	I tend to lose control during emergencies.	
25	When I'm upset at someone, I usually try to "put myself in his shoes" for a while.	
26	When I am reading an interesting story or novel, I imagine how I would feel if the events in the story were happening to me.	
27	When I see someone who badly needs help in an emergency, I go to pieces.	
28	Before criticizing somebody, I try to imagine how I would feel if I were in their place.	