Do those who are prone to psychosis have a more malleable body representation?

Student ID: 9419009

Word count: 4474

Abstract

Past studies using the rubber hand illusion have demonstrated that those with a vulnerability to psychosis experience body illusions, such as the rubber hand illusion much stronger. However, the precise mechanisms underlying this relationship is not fully understood as current experiments may be limited in giving a full explanation to the mechanisms underlying this relationship. The present study aims to remedy this by providing an alternative to the rubber hand illusion that more accurately captures the mechanisms that underlie the bodily distortions experienced in psychosis. Participants were 30 students from Manchester who completed both conditions of the original rubber hand illusion, but also completed a modified version called the missing finger illusion. This modified version allowed for the measurement of participant's body representation malleability through the administration of varying levels of incoming sensory information. A facet of the psychosis-proneness measures, referential thinking appeared to be highly related to the experience of the RHI and the experience of an increasing invisible finger. Limitations regarding questionnaires used to measure body representation malleability and practical applications of our research are explored.

Introduction

Clinical disorders such as schizophrenia are often associated with positive symptoms such as psychosis (Stahl, 2000). Individuals who experience psychosis, or are at risk of developing psychosis (psychosis-proneness) often experience body disturbance symptoms such as the experience of morphological distortions in the body image, such as changes in the size and shape of the body image and irregularities in inhabiting one's body, such as feelings of the body not being one's own (Chapman, Chapman and Raulin, 1978; Lenzenweger, 2006, 2010). This suggests that their ability to accurately perceive their own body may be impaired. Understanding how body representation stability differs in psychosis-prone individuals may provide a deeper understanding to the disturbances in self-processing that leads to the development of psychosis (Nelson et al. 2007).

Our sense of embodiment, the sense of a body part as belonging to oneself depends on both bottom up factors such as incoming multisensory sensory information (MSI) and top-down factors such as body representations, the perceptions we hold about how our bodies are supposed to look (Costantini and Haggard, 2007). Body illusions, such as the Rubber Hand Illusion (RHI; Botvinick and Cohen, 1998) provide evidence for MSI's contribution to embodiment. In the RHI, participants observed a rubber hand being stroked in synchrony or asynchrony to their own hand which is hidden from view. Experiments with the rubber hand illusion provides evidence that MSI contributes to embodiment because the effects of the illusion occur when seen and felt touch are integrated (i.e. when they occur synchronously rather than asynchronously). In the RHI, participants report higher subjective feelings of ownership over the rubber hand after synchronous stroking (Botvinick and Cohen, (1998). This body illusion also leads participants to judge their hand as being closer to the rubber hand in space (proprioceptive drift; Botvinick and Cohen, 1998). Proprioceptive drift has been associated with a higher rating of the feeling of ownership over a rubber hand (Tsakiris

and Haggard, 2005). Proprioceptive drift can therefore be considered objective behavioural evidence for the illusion. This demonstrates the RHI can alter body experience, however there are multiple factors that can constrain the effects of the illusion. Top down cognitions regarding one's own body, including body posture (Austen, Soto-Faraco, Enns and Kingstone, 2004) and visual appearance (Tsakris and Haggard, 2005) have shown that large differences in appearance between the rubber hand and participant's own hand to reduce the effects of the illusion. This suggests that the effectiveness of the RHI also depends on the existing body representations held by individuals and their ability to map these representations with the rubber hand.

Individuals with schizophrenia and psychosis-proneness report more subjective ownership and show larger proprioceptive drift after the RHI (Peled et al., 2000; Asai et al., 2011; Thakkar et al., 2011; Germine et al., 2013). Indeed, previous research has suggested that the abnormalities in the cognitive and perceptual experience of schizophrenic symptomology may be a result of an inability to competently pair incoming MSI with existing representations (Fleminger, 1992; Gilbert and Sigman, 2007; Schneider et al., 2002). This suggests that psychosis-prone individuals have a stronger association with the RHI due to a less stable body representation and thus rely more heavily on incoming MSI. Germine et al., (2013) proposed that psychosis-prone individuals have a more malleable body representation and therefore rely more heavily on incoming sensory information, this increases the tendency to experience abnormalities in inhabiting one's body and experience body image distortions. A problem with this definition of "malleability" with regards to the RHI is that it suggests psychosis-prone individuals are more likely to incorporate incoming sensory information and therefore embody the rubber hand. However, it is not clear why relying on incoming sensory information leads to inaccurate body experiences, as relying on incoming sensory information should produce an accurate body experience. As the RHI uses

a rubber hand that closely resembles a human hand it is not clear if RHI measures the tendency to incorporate inaccurate body information. It could be argued that incorporating incoming sensory information with a human shaped object more strongly could still be classed as normal and does not tell us anything about the distortions in body image that are typically experienced by those with psychosis symptoms. As a result, uncertainties remain over if the RHI measures the tendency to incorporate inaccurate body information. This suggests that inferring the strength of body representations from current experiments looking at the relationship between psychosis-proneness and the RHI may be limited.

An alternate explanation for how body representation malleability is related to inaccurate body experiences is that individuals with high representation malleability may be less able to use stored information about their body to interpret incoming sensory information. A modified version of the RHI, the Missing Finger Illusion (MFI) as shown in Lewis, Lloyd & Farrell's (2013) study could potentially measure body representation malleability more accurately. In the MFI a finger is cut from the rubber hand and the experimenter strokes the missing finger synchronously with the participant's real finger resulting in feelings of embodiment with the invisible finger. The Lewis et al. (2013) study found that first person accounts of the experience described the invisible finger length altering in correspondence to how the experimenter mimicked the stroking of the invisible finger. This suggests that embodiment depended on the participant's incoming sensory information. As psychosis-prone participants are thought to have a more malleable body representation and rely more heavily on incoming sensory information it would be logical to expect them to experience a longer invisible finger in the MFI. This is because of participant's ability to compare stored information about typical finger length to incoming sensory information.

The present study will provide a more accurate method of measuring the body malleability of psychosis-prone individuals through the MFI by measuring to what length participants can experience an invisible finger. This is a useful measure as we can deviate between typical body size through the manipulation of incoming sensory information and will therefore give us insight into a participant's ability to compare their body representations to incoming sensory information, which consequently will tell us the degree of their body representation malleability. This is because participants with high body malleability will experience a longer invisible finger. This will add to the literature by providing an experimental set up that can more precisely establish a relationship between the level of psychosis-proneness a person experiences and the malleability of their body representation by providing an experimental procedure that more accurately reflects the unusual body experiences that are typically experienced in cases of psychosis.

The study's first hypothesis is that synchronous stroking will produce significantly higher feelings of embodiment when compared to asynchronous stroking, as indicated by stronger feelings of subjective body ownership and higher proprioceptive drift. The second hypothesis is that psychosis-proneness will be positively associated with body ownership and proprioceptive drift, which indicate feelings of embodiment. The last hypothesis is that there will be a positive relationship between psychosis- proneness and invisible finger length in the MFI.

Method

Design

A repeated measures design was used for the experiment. The independent variable (IV) was the stroking type experienced. There are two levels, synchronous and asynchronous stroking conditions. The order in which participants took part in each level of

the IV was counterbalanced. There are three dependant variables (DV) for the experiment. The first being the self- reported feelings of body ownership. The second being proprioceptive drift measured in centimetres. Lastly, the length of the invisible finger which was also recorded in centimetres.

Participants

The study used 30 right-handed psychology students from the University of Manchester through a through a volunteer sampling method. Participants were free from tactile and proprioceptive impairments and have normal or corrected to normal vision. Participants were aged 18 to 23 years old.

Materials

Participants are across a table from the experimenter. A medium sized box constructed for the experiment was placed above the table (40cm x 27cm x 7cm). The participants index finger was placed on a marker which shielded their hand from view. The marker was placed 30.5cm away from the right side of the box. The other side of the box is open to allow the experimenter to see the participant's hand and allow them to stroke the hand. A rubber hand (right) with a missing index finger was arranged palm down on top of the box and in full view of the participant. There was a 10cm horizontal gap between the participant's real hand and the rubber hand. The right ring finger of the rubber hand was 11.5cm to the left of the marker where the participant's right index finger was placed. The rubber hand was covered from the wrist by a fake sleeve to appear as a plausible extension of the participant's right arm. The full experimental set up is visualised in figure 1.

Subjective body ownership measures

The participant's self-reported feelings of ownership are collected using modified versions of Botvinick & Cohen's (1998) and Longo et al.'s (2008) RHI questionnaire items adapted for the MFI. This was done by altering the questions on the original RHI and relating them to the invisible finger experienced in the MFI (e.g. "it felt as if the touch of the finger was located where I saw the invisible finger"). The questionnaire asks participants to rate to what extent they agreed with seven statements regarding the illusion using a Likert scale with 7 items, with scores ranging from -3 (strongly disagreeing with the statement) to +3 (strongly agreeing with the statement). Four control items were included to control for the validity of the participant's answers by stating scenarios that were unlikely to be experienced during the illusion (e.g. "it seemed as if I had three hands"). There was a total of seven questionnaire items, three illusion items and four control items which were aggregated separately and can be viewed in table 1.

Table 1. *Questionnaire items and category*

Question	Category
1. It seemed as though I had an invisible finger	Ownership
2. It seemed as though my finger was in the location of the invisible finger	Ownership
3. It seemed as though I felt the touch in the location that I saw the touch	Ownership
4. It seemed as though my real hand was drifting towards the rubber hand	Control

5.	It seemed as though I might have more than one right hand or arm	Control
6.	It appeared visually as if the rubber hand were drifting towards the right (towards my hand)	Control
7.	It seemed as though the touch I was feeling came from somewhere between my own hand and the rubber hand	Control

Proprioceptive drift measures

Proprioceptive measurements were gained by using a large box (46cm x 27cm x 12cm) fitted with a hidden ruler. This large box was placed over the equipment before and after each stimulation condition. Participants were asked to stop the experimenter's finger as it moved above their index finger. Proprioceptive drift was measured as the difference between pre-condition and post-condition hand location judgements in centimetres.

Psychosis-proneness measures

Psychosis-proneness is measures using 97 items from several questionnaires measuring positive psychosis proneness characteristics. Positive psychosis is measured as it is shown to be associated with the subjective experience of rubber hand ownership after synchronous stroking (Germine et al., 2013). The questionnaires included the Chapman Magical Ideation Scale (30 items; Eckblad and Chapman, 1983), the Schizotypal Personality Questionnaire (33 items; Raine 1991) and the Referential Thinking Scale (34 items; Lenzenweger et al., 1997). These questionnaire measures have established relationships with psychosis-proneness (Chapman et al., 1994; Lenzenweger, Bennett and Lilenfeld, 1997; Raine, 1991; Startup, Sakrouge and Mason, 2010) and subjective ownership in the RHI (Germine et al., 2013). The overall measure of positive psychosis-proneness was the sum of

scores on all three scales, where the higher the score the higher the participants level of psychosis-proneness (Germine et al., (2013).

Invisible finger measures

Invisible finger measurements were taken using small box (33cm x 18cm x 12cm) with a ruler attached to the side of the box. The box was placed next to the rubber hand when measuring for the invisible finger and placed diagonally facing away from the participant so the ruler was not visible. The measurements would be obtained as the experimenter strokes the participant's real finger in synchrony with the invisible finger. Participants were asked if they experienced an invisible finger. If answered no, no measurement will be recorded and these participants would be excluded from the Pearson's r analysis when looking for any relationship regarding invisible finger length. If answered yes however, the experimenter would increase the length of the invisible finger by 1cm, participants were instructed to say stop when they no longer felt the illusion of the invisible finger. This measurement is then recorded. The recorded value of 0cm indicated no increase over the initial 5cm invisible finger that was experienced. Values of 1cm or above indicated a growth of the invisible finger.

Procedure

Firstly, participants were asked to place their index finger on a marker underneath the small box. Participants were asked to keep their hand still and to focus on the rubber hand. The order of conditions is counterbalanced. Before each condition an initial proprioceptive measure was obtained. During the synchronous condition, participants observed the rubber hand with its missing finger being stroked at the same time as their own hand and index finger. When stroking the missing finger of the rubber hand, the experimenter mimed the stroking of a 5cm finger in the empty space that would have been occupied by the

index finger of the rubber hand, whilst simultaneously stroking the participant's index finger. During the asynchronous condition, there was a 600ms delay in this procedure as the experimenter stroked the rubber hand (Shimuda, Fukuda and Hiraki, 2009). This delay was achieved as the experimenter listened to a metronome app through earphones. The stroking in each condition lasted 5 minutes. A second proprioceptive measurement was then performed. After each condition, participants completed the RHI questionnaire. Participants were asked to repeat this procedure for the illusion in the alternate condition. Participants then completed the second phase of the experiment. Here, the experimenter placed the smallest box besides the rubber hand to be able to take invisible finger measurements. The participant once again experienced the synchronous stroking of the rubber hand and invisible finger with their corresponding body parts. The difference being that the length of the invisible finger participants could experience was measured. Lastly, participants are asked to complete the psychosis proneness questionnaires.

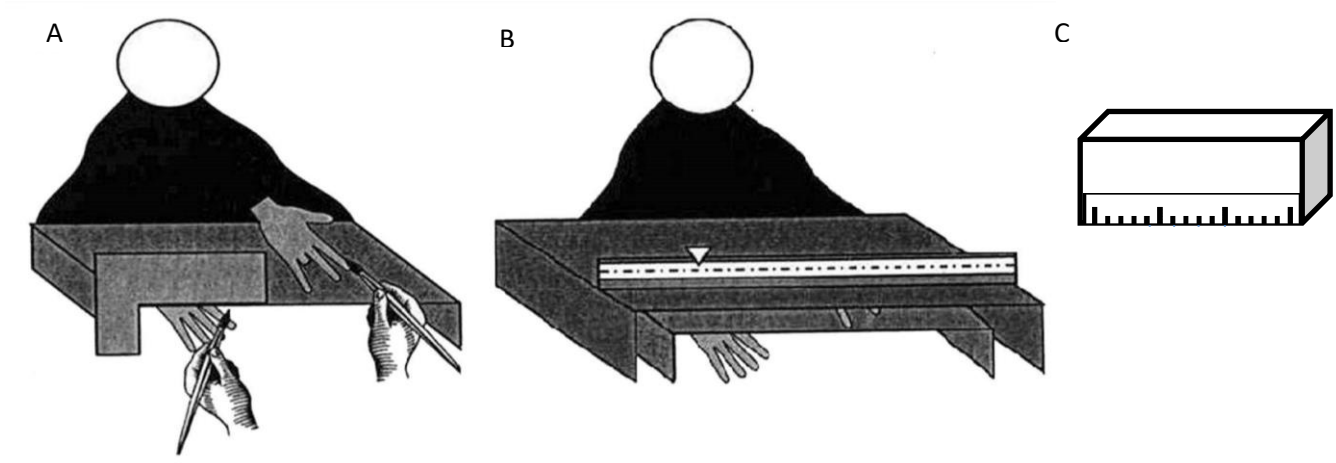

Figure 1 – (A) The medium sized box; (B) The largest box with a ruler attached to measure proprioceptive drift. (C) The smallest box with a ruler attached which was used to take invisible finger measurements.

Results

Descriptive statistics on participant's RHI measures and invisible finger length increase can be found in table 2. Participant's descriptive statistics detailing psychosis-proneness measures can be found in table 3.

Table 2. *Descriptive statistics for RHI measures and invisible finger growth*

	M	*SD*	95% CI
Synchronous condition			
Proprioceptive drift (cm)	1.8	2	1 - 2.5
Ownership rating (average of Q-1, 9 and 10)	1.3	1.8	0.6 – 2.0
Control rating (average of Q-3, 5, 6 and 7)	-1.5	0.9	-1.8 - -1.1
Asynchronous condition			
Proprioceptive drift (cm)	0.3	1.0	-0.6 – 0.7
Ownership rating (average of Q-1, 9 and 10)	-1.7	1.3	-2.2 - -1.2
Control rating (average of Q-3, 5, 6 and 7)	-1.8	1.1	-2.2 - -1.4
Invisible finger length (cm)			

Note: M = mean, *SD* = standard deviation, CI = confidence intervals

Table 3. *Descriptive statistics for psychosis-proneness measures*

	M	*SD*	95% CI
Psychosis-proneness scores			
Referential Thinking Scale	7.3	5.7	5.2 – 29.4
Magical Ideation Scale	1.3	1.8	5.8 – 10.5
Schizotypal Personality Questionnaire	-1.5	0.9	9.1 -13.6
Overall psychosis-proneness	9.0	5.1	7 – 10.9

Note: M = mean, *SD* = standard deviation, CI = confidence intervals

To assess whether participants reported the typical experiences associated with the RHI, we conducted a paired t-test which compared measures of the rubber hand illusion after each stimulation phase. As visualised in figure 2, when compared to asynchronous stimulation, synchronous stimulation produced significantly higher rubber hand ownership ratings on illusion items when compared to asynchronous stimulation, t (29) = 10.14; p <.001. The mean difference in scores was 3.001 (95% CI [2.40 – 3.61]), demonstrating a large effect size, d = 1.9. No significant difference was found for the control items in the two conditions indicating participants did not alter their scores on control items, t (29) = 1.97; p = .059. A boxplot summarises the questionnaire results in figure 2. Proprioceptive drift measurements were also found to be greater in the synchronous condition when compared to the asynchronous condition, t (29) = 3.37; p = 0.02. The mean difference in scores was 1.433cm (95% CI [0.562-2.304]), demonstrating a large effect size, d = 1.51.

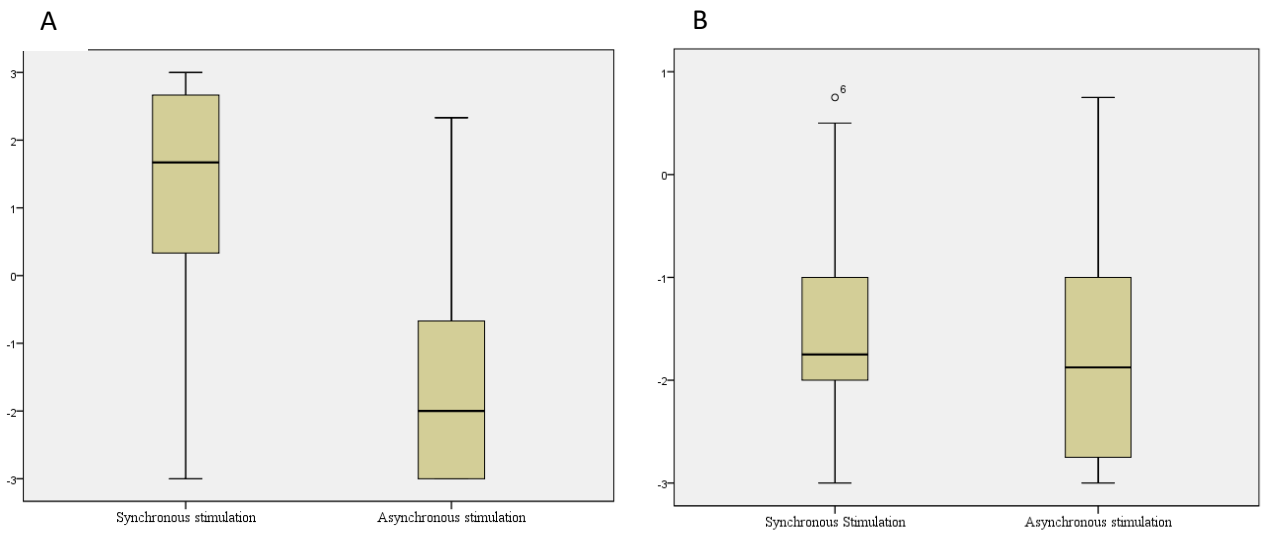

Figure 2. Scores on illusion (A) and control items (B) after synchronous and asynchronous stimulation. The x-axis shows how much the participants tended to agree (+3) or disagree (-3) with statements asked on the questionnaire.

Eight Pearson's correlations were computed to assess the relationship between illusion and control items on the rubber hand illusion questionnaire and psychosis-proneness measures, these correlations are found in table 3.

Table 3. *Relationship between ownership and control ratings with psychosis-proneness measures after synchronous stimulation*

	Illusion items	Control items
Psychosis-proneness measure		
Referential Thinking Scale	0.41*	-0.07
Magical Ideation Scale	0.16	0.59
Schizotypal Personality Questionnaire	0.29	0.17
Overall psychosis-proneness	0.33	0.68

Note: * $p < 0.05$, 3 illusion items, 4 items for control.

There was no correlation between overall levels of psychosis-proneness and ownership ratings, r (28) = .326, p = .079, 95% CI [-0.06 – 0.62]. When observing the questionnaires measuring psychosis-proneness individually however, no correlation was found between illusion items and scores on the Magical Ideation Scale, r (28) = .286, p = .125, 95% CI [-0.1 – 0.56] and the Schizotypal Personality Questionnaire, r (28) = .157, p = .407, 95% CI [-0.23 – 0.5]. However, a significant positive correlation was found with regards to the Referential Thinking Scale, r (28) = .404, p = 0.27, 95% CI [0.04 – 0.68].

Eight Pearson's correlations were computed to assess the relationship between proprioceptive drift measures after synchronous and asynchronous stimulation with psychosis-proneness measures, results are presented in table 4.

Table 4. *Relationship between proprioceptive drift scores and psychosis-proneness measures after synchronous and asynchronous stimulation.*

	Synchronous stimulation	Asynchronous stimulation
Psychosis-proneness measure		
Referential Thinking Scale	0.50*	0.68
Magical Ideation Scale	0.42*	0.39*
Schizotypal Personality Questionnaire	0.16	0.37*
Overall psychosis-proneness	0.42*	0.33

Note: *$p < 0.05$

It was found that proprioceptive drift after synchronous stimulation demonstrated a moderate, positive correlation with overall psychosis-proneness scores, r (28) = .415, p = .022, 95% CI [0.05 – 0.68]. However, proprioceptive drift after asynchronous stimulation was not associated with overall psychosis-proneness scores, r (28) = .329, p = .076, 95% CI [-0.05 – 0.63]. Scores for the Referential Thinking Scale, r (28) = .502, p = .005, 95% CI [0.16 – 0.74] and the Magical Ideation Scale, r (28) = .417, p = .022, 95% CI [0.06 – 0.69] showed a similar moderate, positive correlation with proprioceptive drift after synchronous stimulation. Lastly, scores on the Schizotypal Personality Questionnaire were not correlated with proprioceptive drift after synchronous stimulation, r (28) = .159, p = .402, 95% CI [-0.23 – 0.5].

Four Pearson's correlations were conducted to investigate the relationship between measures for psychosis-proneness and invisible finger length. Table 5 summarises these results.

Table 3. *Relationship between psychosis-proneness measures and invisible finger length scores.*

	Invisible finger length (cm)
Psychosis-proneness measure	
Referential Thinking Scale	0.40*
Magical Ideation Scale	0.36
Schizotypal Personality Questionnaire	0.47*
Overall psychosis-proneness	0.48*

Note: *p < 0.05

The Pearson's correlation analysis excluded five participants from the analysis as they did not experience an invisible finger. It was found that participant's scores of psychosis-proneness showed a moderate, positive correlation with the length of the invisible finger that was experienced, r (23) = .479, p = .015, 95% CI [0.1 – 0.74]. Scores on the Referential Thinking Scale also displayed a moderate, positive correlation with invisible finger length increase, r (23) = .400, p = .48, 95% CI [0.01 – 0.69], as well as scores on the Schizotypal Personality Questionnaire, r (23) = .474, p = .017, 95% CI [0.1 – 0.73]. However, scores on the Magical Ideation Scale displayed no correlation with invisible finger length, r (23) = .357, p = .079, CI [-0.04 – 0.66].

Discussion

The present found that synchronous stimulation produced significantly higher feelings of embodiment when compared to asynchronous stroking, as indicated by higher ratings of body ownership and higher proprioceptive drift. As a result, our first hypothesis was accepted. This is consistent with past research with the RHI (Botvinick and Cohen, 1998) and implies that feelings of embodiment with the rubber hand were successfully implemented in our participants. The questionnaire responses have also been shown to have high validity as participant's responses on the control items showed no significant differences. This indicates that participants were paying attention to the questionnaire items and their appraisal of questionnaire items were accurate.

Our second hypothesis which stated that psychosis-proneness would be related to feeling of embodiment however, were rejected. This is because our results indicated that overall-levels of psychosis-proneness were unrelated to scores of body ownership in the RHI questionnaire. This is not unexpected, as previous studies have found

similar dissociations between psychosis-proneness and self-report items measuring rubber hand illusion experiences (Asai et al., 2011). An explanation for these findings is that certain measures of overall psychosis-proneness could be more important to feelings of body ownership than others, for example Germine et al. (2013) found that the relationship between subjective experiences of ownership and scores on the Referential Thinking Scale were more strongly related when compared to scores on the Magical Ideation Scale and the Schizotypal Personality Questionnaire. Our results demonstrate a similar pattern, as scores on the Referential Thinking Scale displayed a significant, positive correlation with subjective ownership ratings with the rubber hand, unlike the Magical Ideation Scale and the Schizotypal Personality Questionnaire. This seems to suggest that participant's tendency to experience referential thinking (Lenzenweger et al., 1997) may be more important to feelings of embodiment than magical ideation (Eckblad and Chapman, 1983) or cognitive perceptual distortions (Raine, 1991). It could therefore be interpreted that certain psychosis characteristics, such as referential thinking does lead to a tendency to be embody the rubber hand. Furthermore, the objective measure of embodiment, proprioceptive drift did relate to overall levels of psychosis-proneness after synchronous stimulation. Similar findings for the psychosis-proneness predicting proprioceptive drift after synchronous stimulation has been reported before (Asai et al., 2011). This suggests that despite our initial hypothesis being rejected psychosis-prone participants to a certain extent still embodied the rubber hand on subjective measures, as indicated by scores on the Referential Thinking Scale and objective measures such as their levels of proprioceptive drift.

Lastly, our third hypothesis is accepted as a positive relationship between psychosis-proneness and invisible finger length was established. This suggests that participants with higher levels of psychosis-proneness had higher body representation malleability, therefore psychosis-prone participants were less able to compare incoming

sensory information with their existing body representation. This expands on previous literature as we can more accurately describe the process of embodiment that is experienced by psychosis-prone individuals as it more accurately defines the role of body representation in relation to incoming sensory information. The data shows that individual's levels of body malleability influences their ability to interpret incoming sensory information.

This research is important as it adds to our understanding of individual differences in psychosis-proneness. Understanding the relationship between body representation malleability and incoming sensory information adds to our understanding of the mechanisms that underlie psychosis development. Indeed, previous research by Cyhlarova and Claridge (2005) has indicated that those who indicate psychosis-proneness through questionnaire measures have a predisposition to schizophrenia. As a result, using the Missing Finger Illusion as a method to test for the onset of schizophrenia may be a possibility. Participants with unusually long invisible fingers will indicate highly malleable body representations and be identified as at risk of developing schizophrenia. This is useful as we could potentially utilise body illusions such as the MFI to warn potential long term sufferers of the severity of potential psychosis symptoms and help care and treat the potential onset of schizophrenia.

Limitations with this study is that it used a sample of psychology students. This is problematic as they may have prior knowledge of psychosis symptomology and attributed a link between the invisible finger procedure and the psychosis-proneness questionnaires. This puts the validity of their answers under question and future research should aim to use a more diverse sample. Another problem in the current study is that only three illusion items were used to assess participant's feelings of ownership with the rubber hand. The previous study by Germine et al., (2013) found a relationship between psychosis-proneness and rubber hand ownership using an extra two illusion items from questionnaires

by Botvinick and Cohen (1998) and Longo et al. (2008). Our study did not include a modified version of the questions “I felt as if the rubber hand was my hand” and “it seemed like I was looking directly at my own hand, rather than a rubber hand” and this may provide a problem for our study, as the limited number of illusion items may have factored into the relationship between ownership ratings and psychosis-proneness in our sample.

In conclusion, it was found that a certain psychosis characteristics were highly correlated with feelings of embodiment over a rubber hand in a modified version of the RHI. Highly psychosis-prone individuals also displayed a greater tendency to experience a longer invisible finger. This has implications in that it provides a greater understanding to the nature of the body representation in psychosis-prone individuals and opens potential diagnostic avenues for those working in health care.

References

Asai, T., Mao, Z., Sugimori, E., & Tanno, Y. (2011). Rubber hand illusion, empathy, and schizotypal experiences in terms of self-other representations. *Consciousness And Cognition*, *20*(4), 1744-1750. http://dx.doi.org/10.1016/j.concog.2011.02.005

AUSTEN, E., SOTO-FARACO, S., ENNS, J., & KINGSTONE, A. (2004). Mislocalizations of touch to a fake hand. *Cognitive, Affective, & Behavioral Neuroscience*, *4*(2), 170-181. http://dx.doi.org/10.3758/cabn.4.2.170

Botvinick, M., & Cohen, J. (2017). *Cite a Website - Cite This For Me*. Retrieved 28 April 2017, from

Chapman, L., Chapman, J., & Raulin, M. (1978). Body-image aberration in schizophrenia. *Journal Of Abnormal Psychology*, *87*(4), 399-407. http://dx.doi.org/10.1037/0021-843x.87.4.399

Chapman, L., Chapman, J., Kwapil, T., Eckblad, M., & et al. (1994). Putatively psychosis-prone subjects 10 years later. *Journal Of Abnormal Psychology*, *103*(2), 171-183. http://dx.doi.org/10.1037/0021-843x.103.2.171

Costantini, M., & Haggard, P. (2007). The rubber hand illusion: Sensitivity and reference frame for body ownership. *Consciousness And Cognition*, *16*(2), 229-240. http://dx.doi.org/10.1016/j.concog.2007.01.001

Cyhlarova, E., & Claridge, G. (2005). Development of a version of the Schizotypy Traits Questionnaire (STA) for screening children. *Schizophrenia Research*, *80*(2-3), 253-261. http://dx.doi.org/10.1016/j.schres.2005.07.037

Eckblad, M., & Chapman, L. (1983). Magical ideation as an indicator of schizotypy. *Journal Of Consulting And Clinical Psychology*, *51*(2), 215-225. http://dx.doi.org/10.1037/0022-006x.51.2.215

Fleminger, S. (1992). Seeing is believing: the role of 'preconscious' perceptual processing in delusional misidentification. *The British Journal Of Psychiatry*, *160*(3), 293-303. http://dx.doi.org/10.1192/bjp.160.3.293

Germine, L., Benson, T., Cohen, F., & Hooker, C. (2013). Psychosis-proneness and the rubber hand illusion of body ownership. *Psychiatry Research*, *207*(1-2), 45-52. http://dx.doi.org/10.1016/j.psychres.2012.11.022

Gilbert, C., & Sigman, M. (2007). Brain States: Top-Down Influences in Sensory Processing. *Neuron*, *54*(5), 677-696. http://dx.doi.org/10.1016/j.neuron.2007.05.019

Lenzenweger, M. (2006). Schizotypy. *Current Directions In Psychological Science*, *15*(4), 162-166. http://dx.doi.org/10.1111/j.1467-8721.2006.00428.x

Lenzenweger, M. (2010). *Schizotypy and schizophrenia* (1st ed.). New York: Guilford Press.

Lenzenweger, M., Bennett, M., & Lilenfeld, L. (1997). The Referential Thinking Scale as a measure of schizotypy: Scale development and initial construct validation. *Psychological Assessment*, *9*(4), 452-463. http://dx.doi.org/10.1037/1040-3590.9.4.452

Lewis, E., Lloyd, D., & Farrell, M. (2013). The Role of the Environment in Eliciting Phantom-Like Sensations in Non-Amputees. *Frontiers In Psychology*, *3*. http://dx.doi.org/10.3389/fpsyg.2012.00600

Longo, M., Schüür, F., Kammers, M., Tsakiris, M., & Haggard, P. (2008). What is embodiment? A psychometric approach. *Cognition*, *107*(3), 978-998. http://dx.doi.org/10.1016/j.cognition.2007.12.004

Nelson, B., Yung, A., Bechdolf, A., & McGorry, P. (2007). The Phenomenological Critique and Self-disturbance: Implications for Ultra-High Risk ("Prodrome") Research. *Schizophrenia Bulletin*, *34*(2), 381-392. http://dx.doi.org/10.1093/schbul/sbm094

Peled, A., Ritsner, M., Hirschmann, S., Geva, A., & Modai, I. (2000). Touch feel illusion in schizophrenic patients. *Biological Psychiatry*, *48*(11), 1105-1108. http://dx.doi.org/10.1016/s0006-3223(00)00947-1

Raine, A. (1991). The SPQ: A Scale for the Assessment of Schizotypal Personality Based on DSM-III-R Criteria. *Schizophrenia Bulletin*, *17*(4), 555-564. http://dx.doi.org/10.1093/schbul/17.4.555

Schneider, U., Borsutzky, M., Seifert, J., Leweke, F., Huber, T., Rollnik, J., & Emrich, H. (2002). Reduced binocular depth inversion in schizophrenic patients. *Schizophrenia Research*, *53*(1-2), 101-108. http://dx.doi.org/10.1016/s0920-9964(00)00172-9

Shimada, S., Fukuda, K., & Hiraki, K. (2009). Rubber Hand Illusion under Delayed Visual Feedback. *Plos ONE*, *4*(7), e6185. http://dx.doi.org/10.1371/journal.pone.0006185

Stahl, S. M. (2000). Psychosis and schizophrenia. *Essential Psychopharmacology second edition (Stahl SM ed). Cambridge University Press*, 365-399.

Startup, M., Sakrouge, R., & Mason, O. (2010). The criterion and discriminant validity of the Referential Thinking (REF) scale. *Psychological Assessment*, *22*(1), 65-69. http://dx.doi.org/10.1037/a0016584

Thakkar, K., Nichols, H., McIntosh, L., & Park, S. (2011). Disturbances in Body Ownership in Schizophrenia: Evidence from the Rubber Hand Illusion and Case Study of a Spontaneous Out-of-Body Experience. *Plos ONE*, *6*(10), e27089. http://dx.doi.org/10.1371/journal.pone.0027089

Tsakiris, M., & Haggard, P. (2005). The Rubber Hand Illusion Revisited: Visuotactile Integration and Self-Attribution. *Journal Of Experimental Psychology: Human Perception And Performance*, *31*(1), 80-91. http://dx.doi.org/10.1037/0096-1523.31.1.80