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Psychological correlates of illusory body experiences

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Abstract—Postamputation phantom sensations and phantom pain, i.e., sensation or pain in the amputated limb, can be extremely distressing for people who have had amputations. Recent research on treating phantom phenomena has used the experimental induction of illusory body experiences. Although the suggestion has been that such experiences may influence the cortical remapping that occurs after amputation, the role of psychological factors in these experimental inductions has not been addressed. We used an able-bodied sample to investigate whether a common underlying propensity exists for illusory body experiences and whether the occurrence of these experiences is associated with previously neglected psychological variables. Psychometric measures of body plasticity, somatic preoccupation, and creative imagination were significantly and differentially associated with the occurrence of illusory body experiences. Hence, these measures have potential use in identifying patients most likely to benefit from treatment interventions using the induction of illusory body experiences.

Key words: body plasticity, illusory body experiences, phantom pain, somatic preoccupation.

INTRODUCTION

The experience of phantom sensations, most often described in the context of limb amputation, refers to the attribution of sensation to an absent body part. These phenomena have been recognized for well over a century, with earlier researchers tending to concentrate on psychoanalytic explanations [1,2]. More recently, however, interest has resurged in this area, especially from a neurological perspective [3–5]. Of particular interest has been evidence that relates phantom sensation to cortical reorganization in the somatosensory cortex and the suggestion that greater neural plasticity is associated with more severe phantom limb pain (i.e., pain often described as burning, cramping, and shocking-shooting experienced in a limb that is no longer present [6–9]).

Research employing the experimental induction of so-called "phantom sensations" with upper-limb amputees has been an important element in exploring illusory body experiences and has shown some therapeutic potential in terms of pain relief [4]. However, such research has failed to adequately address the potential importance and influence of psychological variables in this process. Hence, the current research, involving able-bodied participants, investigated whether a common underlying propensity exists for such illusory body experiences and to what extent such experiences are associated with previously neglected psychological variables. We suggest

Abbreviations: CIS = Creative Imagination Scale, ENP = Extending Nose Procedure, GHQ = General Health Questionnaire, MBP = Mirror Box Procedure, NS = nonsignificant, PTSD = post-traumatic disorder, RHP = Rubber Hand Procedure, TABP = Trinity Assessment of Body Plasticity, VR = virtual reality.

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that if standardized psychometric instruments can be used to identify those most susceptible to illusory body experiences, then these instruments could be used to help select those patients most likely to benefit from interventions that induce illusory body experiences, attempting to treat phantom sensation and pain.

Recently, Ramachandran and Rogers-Ramachandran used a Mirror Box Procedure (MBP) to treat phantom limb pain [4]. In this procedure, upper-limb amputees placed their intact arm into a box, with a mirror down the midline, so that when viewed from slightly off-center, the reflection of their arm gave the impression of having two intact arms. Individual differences were observed in the extent to which participants were susceptible to the MBP illusion. Moreover, although this technique had quite dramatic therapeutic value for some people, it was only moderately effective, or completely ineffective, for others. More worriedly, some investigators have recently found that using the MBP to induce illusory body experiences can actually worsen phantom limb pain in people who have had an amputation.*

A second procedure inducing an illusory body experience, the Extending Nose Procedure (ENP), described by Ramachandran and Blakeslee [10], produces the illusion of one's nose extending. This sensation was induced by having a volunteer sit in front of a blindfolded participant (both individuals face the same direction), while the experimenter tapped the nose of the participant and manipulated the participant's hand to tap the volunteer's nose simultaneously and in synchrony. Although this procedure is not suggested to have any therapeutic value, it is, like the MBP, thought to relate to neurological mechanisms underlying proprioceptive and somatosensory feedback. This is also true of a third type of induced illusory body experience, the Rubber Hand Procedure (RHP), described by Botvinick and Cohen [11]. In this procedure, the illusion that a prosthetic hand is one's own was induced by observing the stroking of a prosthetic hand while feeling the synchronized stroking of one's own obscured hand, placed behind a screen, to the side of the prosthetic hand [11,12].

An important question arising from these demonstrations is whether or not the individual differences in susceptibility to these illusory body experiences could be associated with other variables. In the case of people with amputations, it is especially important to establish some protocol that will help select those who are most likely to benefit from procedures used to induce illusory body experiences, such as MBP. An important first step in achieving this goal is to identify variables that may help explain some of the variability in responses to induced illusory body experiences.

Each of the procedures just outlined places participants in a context that suggests, to some extent, an altered body experience. While neurological and sensory factors will undoubtedly play a role in these protocols, it is important to rule out confounding variables and identify other salient ones. Based on recent evidence that phantom phenomena in people with amputations are not a product of neural or sensory factors alone [13], we therefore sought to explore whether the propensity for illusory body experiences is a coherent construct in itself, such that scores on different experimental protocols would be correlated. Our first hypothesis, based on an assumption of a common factor underlying the three induction procedures, was that the extent of illusory body experiences would be correlated across the three induction procedures. Our second hypothesis was that those people who are more preoccupied with somatic experience and who therefore "take notice" of their body to a greater extent [14], would be more likely to report illusory body experiences to a greater extent. Our third hypothesis was that given the suggestible nature of the induction procedures, those participants who were more suggestible would report illusory body experiences to a greater extent.

Our fourth and final hypothesis incorporated the concept of "body plasticity," or how rigidly or fluidly people view their own body. Some people, for instance, feel uncomfortable with the idea of organ transplantation, possibly because it involves reassessing the psychological boundaries of their body. On the other hand, other people happily contemplate transplantation from humans or animals, of hands or internal organs, including complete artificial hearts.† We hypothesized that greater body plasticity would be associated with the induction of stronger illusory body experiences.

A demonstration that any of these variables co-vary with illusory body experiences could provide important theoretical insights into these phenomena. Furthermore, in the clinical context, this could help identify patients

*Peter Halligan (2002), personal communication.

†MacLachlan M, Gallagher P, editors. Enabling technologies: body image and body function. Edinburgh, Scotland: Churchill Livingston. In press 2003.

with the greatest propensity for these experiences and therefore possibly those most likely to benefit from interventions based on such induction procedures. While we do not view the induction procedures necessarily as analogues of the phantom limb experiences reported by people with amputations, the work of Ramachandran and others, has demonstrated that illusory body experiences can be therapeutically relevant to phantom experiences. Nonetheless, because of the possibility of induction procedures worsening phantom limb pain, we felt it was important ethically to research the development of appropriate psychometric protocols, in the first instance, with an able-bodied sample of participants, who were unlikely to be harmed by any of the induction procedures.

METHODS

Participants

Fifty-two able-bodied undergraduate students at Trinity College, Dublin, participated in the study under conditions of informed consent and in accordance with the ethical procedures of the University. The 8 males and 44 females ranged in age from 18 to 41 years (mean age = 21.25, standard deviation [SD] = 4.29).

Measures and Procedures

Three experimental protocols (RHP, MBP, and ENP) designed to induce illusory body sensations were counterbalanced across subjects. These subjects also completed the following instruments: the Trinity Assessment of Body Plasticity (TABP),* the General Health Questionnaire (GHQ) [15], and the Creative Imagination Scale (CIS) [16]. The GHQ and the CIS were administered by MacLachlan to all participants, while the TABP and the three experimental protocols were administered by Desmond and Horgan to all participants.†

Rubber Hand Procedure

The RHP involves the referral of tactile sensations to an artificial or prosthetic hand and has been reported in two previous studies [11,12]. The participant was seated resting his or her left arm on a table. The left hand was obscured by placing it underneath a prosthetic hand and both wrists were covered. The participant was instructed to focus his or her gaze on the prosthetic hand while both the prosthetic and the obscured hand were tapped simultaneously across the same fingers, with two paintbrushes, for 5 min. Participants subsequently completed a two-part questionnaire that requested an open-ended description of their experience. It asked them to affirm or deny, on a 7-point scale ranging from –3 (strongly disagree) to +3 (strongly agree), statements investigating the occurrence of nine specific perceptual effects designed to elicit the extent to which the participant believed that the rubber hand was their own hand (previously described by Botvinick and Cohen [11]). Examples of these statements included “I felt as though the rubber hand were my own,” and “The rubber hand began to resemble my own (real) hand in terms of shape, skin tone, freckles, or some other visual feature.” Lower scores on this questionnaire indicated that no illusory body sensations were experienced, and higher scores indicated that participants experienced a stronger illusion that the rubber hand was their own.

Mirror Box Procedure

Two previous studies used the MBP as a therapeutic intervention [4,17]. Unlike these studies, our own procedures included a control condition in which participants were required to place both hands on a table and to rhythmically tap both left and right index fingers in a synchronized manner. At varying intervals, the participant was instructed to cease tapping either the left or right finger, while continuing to tap the opposite one, and following a brief pause, to recommence tapping both. After 2 min, the participant was asked to rate the difficulty of the task on a 4-point scale, where zero was the easiest and four was the most difficult. In our experimental condition, a mirror was placed vertically in the center of a cardboard box that had its front and top surfaces removed. The participant inserted both hands into the box, one at each side of the mirror. The left hand was obscured, and the participant was asked to look at the right hand and its reflection in the mirror, while repeating the same tapping task for 2 1/2 min. Each participant was subsequently required to rate the difficulty of the tapping task on a 4-point scale, where zero was the easiest and four was the most difficult. The serial order of administration of the control and experimental conditions was randomized. An overall

*Desmond D, Horgan O, MacLachlan M. Trinity Psychoprosthetics Group, Trinity College Dublin; 2001.

†Only 38 participants (4 males, 34 females, age range 18 to 41, mean age 20 years) completed the ENP.

score indicating the difficulty of the MBP was then calculated by subtracting the difficulty rating of the control condition from the difficulty rating of the experimental condition. A positive score would rate the experimental condition as more difficult.

Extending Nose Procedure

The ENP described by Ramachandran and Blakeslee aimed to produce the illusion that the participant's nose had stretched approximately 3 ft in front of his or her face [10]. The blindfolded participant was seated directly behind a volunteer, both of whom were facing in the same direction. The participant allowed the experimenter to passively manipulate his or her left hand so that the index finger was used to touch the volunteer's nose in a rhythmic tapping sequence. The experimenter simultaneously and synchronously tapped the participant's nose in the same manner. After 1 1/2 min, the participant was requested to give an open-ended description of his or her experience. The experimenters subsequently rated responses on a 3-point ordinal scale, where a score of zero indicated no experience of the illusion, one indicated the intermediate-strength illusion that the participants were touching their own nose, and two indicated a stronger sense of illusion that the participants experienced their own nose as stretched in front of their face.

Trinity Assessment of Body Plasticity

The TABP is a recently developed 20-item questionnaire designed to assess how rigidly, or fluidly, individuals identify with their somatic body. Low scores reflect the belief that the self is identified with a discrete physical body that should not be altered or interfered with in any way. High scores reflect the belief that self-identity is not restricted to the physical body but that it may include places or objects, can be modified, and does not "limit" the individual. Twenty items are scored on a 5- or 10-point Likert scale. The total range of possible scores is 0 to 115. Internal consistency for the TABP in this sample was good (Cronbach's Alpha = 0.70). Examples of items in the TABP included "How easy or uneasy would you feel if you were to receive a lung transplant?" which was answered on a 5-point scale, ranging from very at ease to very uneasy and "Sometimes I feel that I am more a part of my surroundings than a discrete being," which was answered on a 5-point scale, ranging from strongly agree to strongly disagree.

Other Measures

In addition, subjects completed the CIS and the GHQ [15,16]. The CIS consists of 10 items for measuring suggestibility, in terms of intensity of realism of individuals' responses to hypothetical scenarios described by a trained administrator. The scenarios examine a subject's ability to realistically imagine senses of weight, feeling, thirst, taste, smell, sound, heat, time, memory, and relaxation. The GHQ is a 60-item scale that provides a measure of psychological distress and associated dimensions of mental health problems. It consists of six subscales assessing "general illness, somatic illness, sleep disruption, social disruption, anxiety and dysphoria, and severe depression." Acceptable psychometric characteristics have been reported for each of these well-established measures [15,16].

RESULTS

Experimental Procedures

Table 1 gives the mean, SD, and range of scores that indicate the extent to which people experienced body sensations in the RHP and the MBP. Participants scored a mean of 3.69 (SD 7.74, range –21 to 18) on the RHP questionnaire. However, Pearson's coefficient of skew was –0.912, indicating that the data were skewed toward lower scores. As this score was outside the recommended range of ±0.50 for consideration of a normal distribution, nonparametric tests were used in subsequent analyses [18].

Participants scored a mean of 0.65 (SD 0.79, range –1 to 2) on the MBP questionnaire. Pearson's coefficient of skew was –0.284, indicating that the data were slightly skewed toward lower scores, albeit within the recommended range for a normal distribution [18]. We calculated this MPB score by subtracting difficulty ratings on the MBP control condition from difficulty ratings on the MBP experimental conditions. The positive score indicates that the participants found the MBP experimental condition more difficult than the MBP

Table 1.
Descriptive statistics for Rubber Hand Procedure (RHP) and Mirror Box Procedure (MBP).

Experimental Procedure	Mean	Standard Deviation	Median	Mode	Range
RHP	3.69	7.74	4.50	7.00	–21 to 18
MBP	0.65	0.79	1.00	1.00	–1 to 2

control condition, thus suggesting that participants' experienced the illusory sensation that the reflected hand in the mirror was their own, causing greater difficulty in this task.

In the ENP, 11 participants scored 0, indicating that they did not experience any illusory sensation; 23 achieved a scored of 1, indicating that they experienced the medium-strength sensation that their own hand was touching their nose; and 4 achieved a score of 2, indicating that they experienced the stronger illusory sensation that their nose had fully extended approximately 3 feet from their face.

Association of Experimental Procedures with Other Measures

Given the properties of the data, the use of nonparametric statistics would likely give the most parsimonious and most conservative statistical interpretation of our results. To test whether scores on the three experimental procedures were related, we performed Spearman's correlations. No significant associations were found between scores on the three protocols (MBP and ENP, ρ = –1.84, p = NS; MBP and RHP, ρ = 0.176, p = NS (nonsignificant); and ENP and RHP, ρ = 0.091, p = NS, thus failing to support our first hypothesis.

As scores on each of the protocols were found to be independent of each other, we performed a series of, Spearman's correlations (see **Table 2**) to determine whether each of the three protocols was associated with scores on the different psychometric instruments:

- Scores on the RHP were significantly correlated with scores on the TABP (ρ = 0.382, p < 0.01) and scores on the CIS (ρ = 0.237, p < 0.05).
- Scores on the ENP were significantly correlated with scores on the TABP (ρ = 0.302, p < 0.05), the GHQ total (ρ = 0.40, p < 0.01), the GHQ General Illness Subscale (ρ = 0.352, p < 0.05), and the GHQ Somatic Symptoms Subscale (ρ = 0.410, p < 0.01).
- Scores on the MBP were significantly associated with scores on the TABP (ρ = 0.271, p < 0.05).

Our second hypothesis that greater somatic preoccupation would be associated with stronger illusory body experiences was therefore only supported in the ENP. Our third hypothesis that suggestibility would be related to the strength of illusory body experiences was upheld only in the RHP. Finally, or fourth hypothesis, that greater body plasticity would be associated with stronger illusory body experiences, was supported in each of the three induction procedures.

Table 2.
Spearman's correlations (ρ) amongst three experimental procedures (RHP, MBP, and ENP) and psychometric measures (TABP, CIS, GHQ total score, and six subscales of GHQ).

	RHP	MBP	ENP	TABP
RHP	1.00	—	—	—
MBP	0.176	1.00	—	—
ENP	0.091	–0.184	1.00	—
TABP	0.382†	0.271*	0.302*	1.00
GHQ Total	–0.055	–0.140	0.400†	0.158
GHQ General	–0.004	–0.051	0.352*	0.132
GHQ Somatic	0.097	–0.222	0.410†	0.134
GHQ Sleep	0.062	–0.206	0.250	0.135
GHQ Social	–0.098	–0.021	0.049	–0.038
GHQ Anxiety & Dysphoria	–0.112	–0.135	0.183	0.144
GHQ Depression	–0.036	–0.127	0.063	–0.162
CIS	0.237*	0.221	–0.164	0.118

* = p < 0.05
† = p < 0.01
RHP = Rubber Hand Procedure
MBP = Mirror Box Procedure
ENP = Extending Nose Procedure
TABP = Trinity Assessment of Body Plasticity
CIS = Creative Imagination Scale
GHQ Total = Total General Health Questionnaire score

DISCUSSION

No association was found between the extent to which participants had illusory body experiences across the three induction protocols. This would suggest that no one common factor underlies such experiences. One possibility is that a common factor failed to occur because the effects were only weak or were reported only over a narrow range of ratings. However, summary descriptive data indicate that the illusory body experiences induced by the procedures were experienced to a reasonable extent by many subjects. Indeed, although skewed, scores for the RHP indicate that our effects were relatively strong compared with those reported by others [10]. On the other hand, few subjects experienced an extending nose in the ENP, although many did report feeling as if the volunteer's finger was their own, which we interpreted as an intermediate level of the illusion.

While ratings for illusory bodily experience across the three procedures were not related to each other, they were all related to scores on the measure of body plasticity. Had scores on the three procedures all been related, the obvious and straightforward interpretation would be that body plasticity and the propensity for illusory body experiences are related. However, given the relationships that pertained, one possibly could consider the results from both a stimulus and a response perspective. From a stimulus perspective, one could argue that different induction procedures influence different aspects of illusory body experience, and therefore scores on the procedures need not be related. From a response perspective, one could argue that people are likely to have illusory body experiences to different extents, depending on the mode of presentation and perhaps also on the relevant body part. Supporting this argument is the suggestion that cultural and familial rearing influence our awareness of different body parts and our propensity to feel "phantoms" in them [19]. No doubt, such influences would also be subject to individual differences.

Body plasticity, somatic preoccupation, and suggestibility were significantly and differentially associated with the occurrence of the three illusions. While body plasticity was associated with the occurrence of all three, somatic preoccupation and suggestibility were associated with only the ENP and RHP, respectively. Rather than privileging the reporting of somatic symptoms on the GHQ by describing it as "somatisation" (implying a psychodynamic process of conversion), we have chosen to describe it as "somatic preoccupation," because this does not assume a causal mode, but rather reflects a concern with somatic distress. It is important to note that the GHQ Somatic subscale was the only specific subscale where a significant relationship between any induction procedure and any of the five specific subscales pertained. The General subscale (reflecting a general neurotic state) and the GHQ total score (which would in any case be confounded by the inclusion of the Somatic subscale) each were associated less strongly with scores on the ENP. These results suggest that a particular relationship exists between somatic preoccupation and the ENP. It may be that primarily haptically mediated illusions are associated somehow more closely with somatic preoccupation than with the illusions produced by the RHP and MBP, which are also strongly influenced by visual perception. Understanding the nature of this relationship should be an important target for future research.

Only illusory body experiences induced through the RHP were associated with scores on CIS: those who scored higher on the scale (indicating greater suggestibility) were more likely to have the illusory body experience of the rubber hand being their own. This result therefore suggests that a greater degree of suggestibility is involved in the RHP than in the other two induction procedures. However, it is notable that the effect size difference between the RHP and the MBP is negligible, with the greatest difference actually being with the nonsignificant negative association between the ENP and suggestibility. Again, it is possible that while suggestibility is an aspect of the illusory body experience, its effects are less strong in procedures primarily mediated through haptics rather than in those that also involved visual perception.

While our induction procedures just described have used rather low-technical methods of inducing illusory body experiences, the use of virtual and augmented reality environments is another sphere in which this research may have relevance. Most virtual reality (VR) environments rely largely on visual manipulations, and so, the aforementioned speculations relating to the relative influence of visual and haptic feedback may be salient to VR too. While it is recognized that continued research is needed to fully develop the potential of VR technology [20], it has already been used in the treating of many disorders including phobias, post-traumatic disorder (PTSD) and eating disorders, as well as the rehabilitation of visual and executive function disorders [20]. However, considerable individual differences have also been noted in people's reactions to VR environments, including negative behavioral reactions [21]. It would therefore be interesting to explore whether measures of body plasticity, somatic preoccupation, or suggestibility are also associated with experiences in VR environments.

CONCLUSION

It is important to emphasize that the effect sizes reported here are modest and that while the relatively large number of participants in this study will confer statistical significance on these associations, their clinical relevance is still questionable. Furthermore, while the

TABP may have some value in predicting those most likely to have illusory body experiences amongst the able-bodied, it will be necessary to identify what aspects of this construct, as measured by the TABP, are important and to demonstrate its therapeutic relevance with amputees suffering from phantom limb pain. While the potential for establishing a screening instrument to match appropriate patients to processes that induce illusory body experiences has been highlighted, more work on refining the factors conceptually and on inducing the illusions methodologically is recommended. Such greater clarity may allow us, in turn, to refine therapeutic interventions related to these methods and to related methods such as VR.

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