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Are you suggesting that's my hand? The relation between hypnotic suggestibility and the rubber hand illusion

Perception

Short Report

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Abstract. Hypnotic suggestibility (HS) is the ability to respond automatically to suggestions and to experience alterations in perception and behaviour. Hypnotically suggestible participants are also better able to focus and sustain their attention on an experimental stimulus. The present study explores the relation between HS and susceptibility to the rubber hand illusion (RHI). Based on previous research with visual illusions, it was predicted that higher HS would lead to a stronger RHI illusion. Two behavioural output measures of the RHI, an implicit (proprioceptive drift) and an explicit (RHI questionnaire) measure were correlated against HS scores. Hypnotic suggestibility correlated positively with the implicit RHI measure contributing to 30% of the variation. However, there was no relation between HS and the explicit RHI questionnaire measure, or with compliance control items. High hypnotic suggestibility may facilitate, via attentional mechanisms, the multisensory integration of visuoproprioceptive inputs that leads to greater perceptual mislocalisation of a participant's hand. These results may provide insight into the multisensory brain mechanisms involved in our sense of embodiment.

Keywords: Individual differences, Proprioception, Harvard Group Scale, Hypnotisability, multisensory integration, Embodiment, Body image

1 Introduction

The sense of one's own body is intimately related to our sense of self. Body image and physical appearance is central in medical and health contexts, (e.g., cosmetic and reconstructive surgery, physical therapy, and rehabilitation), acquired physical diseases or injuries (e.g., skin diseases, or burns) and psychopathology in relation to eating disorders, body dysmorphic disorder, social phobia, and mood disorders (Cash 2004). Many treatments can dramatically change the functioning and appearance of the body, which in turn can alter the person's body image and well-being. Our sense of embodiment is rich and complex, yet elusive and hard to measure (Longo et al 2008). Experimental approaches make it possible to perceptually 'incorporate' an external object into the representation of the body. A prime example is the so-called *rubber hand illusion* (Botvinick and Cohen 1998), where a prosthetic hand is perceived as being incorporated by the participant. There are considerable individual differences in the extent to which the illusion is experienced. Much debate continues about the necessary and sufficient conditions eliciting the rubber hand illusion. Here we investigate whether hypnotic suggestibility contributes to people's experience of the illusion.

Hypnotic suggestibility (HS) refers to an individual's ability to experience suggested alterations in physiology, sensations, emotions, thoughts, or behaviour following a hypnotic induction procedure (Elkins et al 2014), and to respond in an automatic way to direct verbal suggestions (Braffman and Kirsch 1999; Weitzenhoffer and Hilgard 1962). Importantly, HS is also a strong predictor of an individual's responsiveness to suggestion outside a hypnotic context (Braffman and Kirsch 1999) and is measured using scales such as the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS:A; Shor et al 1962). Scores on the HGSHS:A are normally distributed and remain stable over a person's lifetime (Hilgard 1965; Piccione et al 1989).

The rubber hand illusion (RHI; Botvinick and Cohen 1998) is an intriguing illusion used in research to investigate body ownership, awareness and body image (e.g., Ehrsson et al 2004; Longo et al 2008, 2009; Tsakiris and Haggard 2005). In the RHI, participants view a prosthetic (rubber) hand, which is stroked simultaneously with their own adjacent hidden hand (see Methods; Figure 3). Under such conditions, most people attribute the rubber hand to their own body, and report that "it feels like the rubber hand is my hand" (Botvinick and Cohen 1998; Ehrsson et al 2004). In contrast, asynchronous stimulation, where tactile stimulation is out of phase, typically does not elicit the illusion to the same extent. The *difference* in performance between the synchronous (experimental) and the asynchronous (control) conditions gives a measure of the magnitude of the illusion. The synchronous stimulation condition in particular, arguably presents a strong implicit suggestion to participants that the rubber hand is to be experienced as their own. Direct verbal suggestions given in a hypnotic context have previously been shown to be effective in creating alterations in the sense of ownership and awareness of body parts (Deeley et al 2013b; Oakley and Halligan 2013; Walsh et al 2014a; Walsh et al 2014b).

HS individuals are characterised by heightened attentional focus (Crawford and Gruzelier 1992; Rainville et al 2002; Tellegen and Atkinson 1974) and can block out sources of distraction better than low HS participants (Fehr and Stern 1970; Jamieson and Sheehan 2004; Mitchell 1970; Nuys 1973); an ability that is strengthened by a hypnotic induction procedure (Deeley et al 2012). The capacity to strongly focus on the salient cues of an experimental stimulus facilitates the production of illusions (Power and Day 1973). Previous research has indicated that highly hypnotically suggestible participants report more direction changes of a stationary light source (autokinetic effect; Wallace et al 1976), a greater illusory effect to the Ponzo illusion (Miller 1975), and a greater frequency of reversals with Necker cube and Schroeder staircase illusions (Wallace 1988; Wallace et al 1976). These effects were observed in the absence of any hypnotic induction. Individual differences in HS, in terms of suggestibility itself and/or attentional focus, might therefore explain some of the variance observed in the magnitude of response to the RHI.

Here, two widely used methods, one implicit, the other explicit, were adopted to measure the RHI. The implicit 'proprioceptive drift' method (Ionta et al 2013; Schütz-Bosbach et al 2009a; Schütz-Bosbach et al 2009b; Tsakiris and Haggard 2005), measures how the perceived location of the participant's hand shifts towards the rubber hand during the illusion. The second explicit method uses an 'RHI questionnaire' (Botvinick and Cohen 1998) to measure the participants' conscious experience of the illusion by asking them to agree or disagree to statements relating to ownership and location of the rubber hand (Table 1; Longo et al 2008). While original research has suggested common brain mechanisms for illusory hand ownership and proprioceptive drift (Botvinick and Cohen 1998), more recent behavioural (e.g., Kammers et al 2009; Rohde et al 2011) and neuroimaging (Ehrsson et al 2004; Tsakiris et al 2007) findings have established that distinct multisensory mechanisms underlie the two phenomena (Blanke 2012), and that the two measures assess related, but distinct, aspects of the experience of the RHI (Fiorio et al 2011; Rohde et al 2011). A number of conceptual models (Figure 1; Makin et al 2008; Rohde et al 2011; Tsakiris et al 2010) have proposed that proprioceptive drift relies on integration of visual and proprioceptive information (Visuoproprioceptive stream, Figure 1a; Rohde et al 2011) while the illusory feeling of ownership toward the rubber hand is thought to rely on integration of visual and tactile information (Visuotactile stream, Figure 1b; Ehrsson et al 2004).

The aim of the present study was to measure the relation between hypnotic suggestibility and susceptibility to the rubber hand illusion, while controlling for compliance. We predicted that HS would be associated with greater response to the rubber hand illusion, as measured both implicitly (proprioceptive drift) and explicitly (RHI questionnaire).

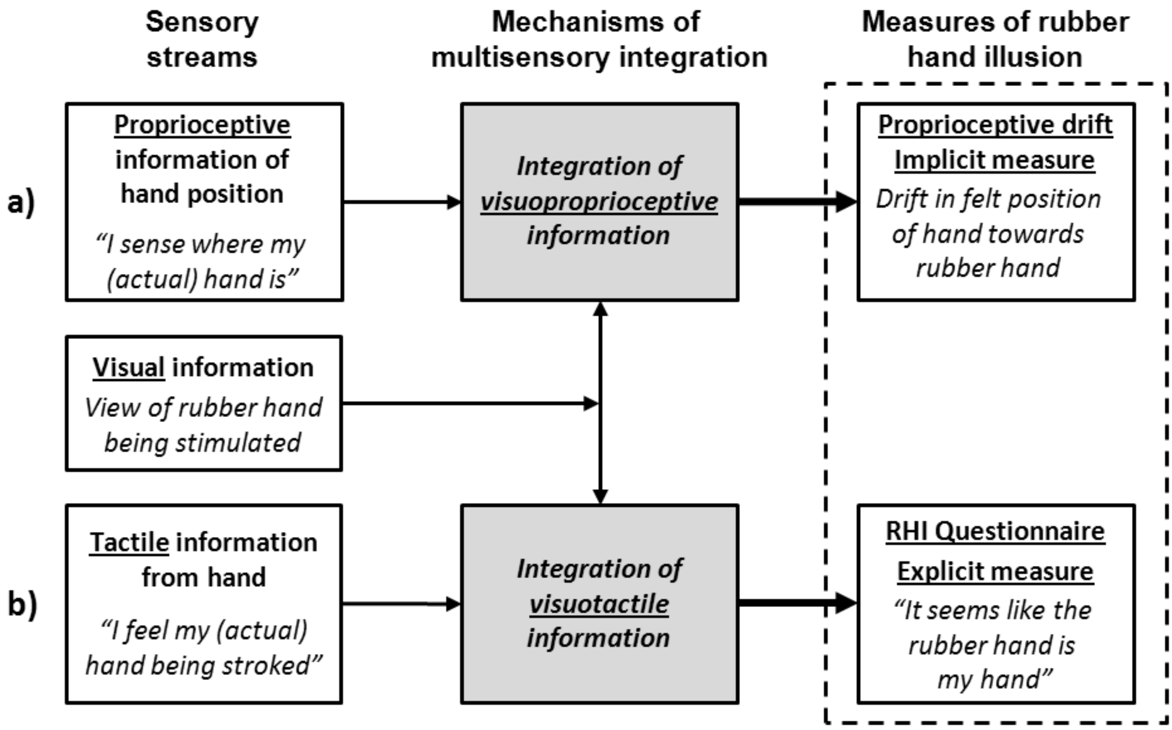

Figure1. Theoretical model showing how different sensory streams are integrated via two related but distinct multisensory mechanisms (grey boxes) during the rubber hand illusion (RHI). The original rubber hand illusion (Botvinick and Cohen 1998) has suggested common brain mechanisms for explicit illusory hand ownership and explicit proprioceptive drift measures (dashed box). However, more recent research (see text) indicates that *distinct* multisensory mechanisms underlie the two phenomena. **a)** Visual and proprioceptive information are integrated leading to mislocalisation of actual hand position, as measured implicitly using 'proprioceptive drift', and **b)** Visual and tactile information are integrated leading to an illusory feeling of ownership over the hand, as measured explicitly using the RHI questionnaire.

2 Results

There were no significant correlations between hypnotic suggestibility (HS) as measured by the HGSHS:A score and estimates of pre-stimulation index finger position (see Method); Pearson's r=0.174; p=0.440. Just viewing the rubber hand prior to stimulation did not appear to influence felt finger position in relation to HS (Pavani et al 2000). Consistent with previous studies (e.g., Longo et al 2008) there was significant proprioceptive drift in both the synchronous (2.2 cm, SD=2.8), $t(21) = 3.643$, $p < 0.001$ (1-tailed), and the asynchronous condition (1.1 cm, SD=2.8), $t(21) = 1.895$, $p < 0.05$ (1-tailed), revealing an overall proprioceptive bias towards the body midline (Ghilardi et al 1995). Critically, proprioceptive drift was significantly larger in the synchronous than the asynchronous condition, $t(21)$=1.990; $p < 0.05$ (1-tailed), indicating that participants experienced the RHI as measured implicitly.

To explore if hypnotic suggestibility was associated with a greater response to the RHI, a Pearson correlation was performed. When tested separately, no significant correlations were observed for the synchronous (Pearson's r = 0.20, p = 0.371) nor the asynchronous (Pearson's r = -0.29, p = 0.190) conditions. Importantly, a moderate strength positive correlation (Pearson's r = 0.55, p = 0.008) was observed between hypnotic suggestibility (HGSHS:A score) and the magnitude of the illusion as measured by the difference between the experimental and the control (i.e., synchronous minus asynchronous) conditions in proprioceptive drift (Figure 2a); the observed statistical power was 0.80

(Ellis 2010; two-tailed test at $\alpha = 0.05$). While the standard HGSHS:A score is the main index of hypnotic suggestibility, an additional *subjective* score applied to the same scale to measure how suggestive effects are experienced, is thought to provide a more complete assessment of HS (Kirsch et al 1990). The subjective score showed a strong correlation with the difference in proprioceptive drift (Pearson's $r = 0.70$, $p < 0.001$), with an observed statistical power of 0.98 (Ellis 2010; two-tailed test at $\alpha = 0.05$). Thus as predicted, significant relationships between HS and the implicit proprioceptive drift measure of the rubber hand illusion were observed.

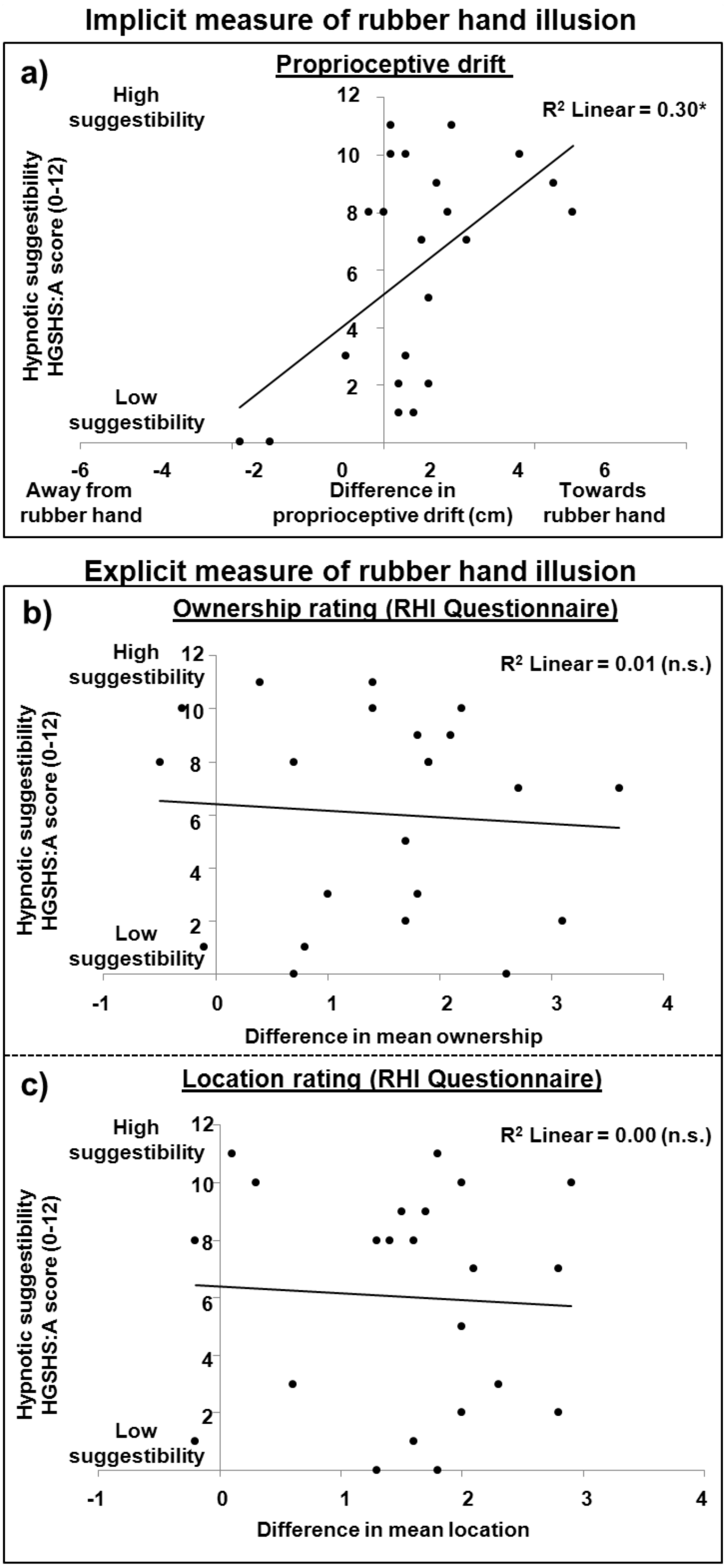

Figure 2. Pearson correlations between hypnotic suggestibility (Harvard Group Scale of hypnotic suggestibility HGSHS:A) score and a) implicit (proprioceptive drift; significant positive correlation; *p=0.008) and b, c) explicit measures of the rubber hand illusion [RHI questionnaire; negative correlations, both non-significant (n.s.); p > 0.194).

For the RHI questionnaire items, there was stronger agreement with the overall Ownership ratings in the synchronous condition (see Table 1; mean rating = 0.5, SD=1.8), than in the asynchronous condition (mean rating = -1.0; SD=1.8); t(21)=6.499; p<0.0001. Likewise for the overall Location ratings, agreement was stronger in the synchronous condition (mean rating = 0.5; SD=1.6) than in the asynchronous condition (mean rating = -1.1; SD=1.8); t(21)=7.758; p<0.0001. Therefore the mean difference in ratings between the experimental (synchronous) and the control (asynchronous) conditions was 1.5 (SD=1.8) for mean Ownership and 1.6 (SD=1.7) for mean Location ratings (Table 1), confirming that participants experienced the rubber hand illusion as measured explicitly via the RHI questionnaire.

Table 1. Mean ratings (N=22; standard deviation of the group mean is given in brackets) for RHI questionnaire items across synchronous (Synch) and asynchronous (Asynch) tactile stimulation conditions. Participants used a 7-point Likert scale ('-3' = "strongly disagreed"; '0' = "neither agreed nor disagreed"; '+3' = "strongly agreed"). Compliance items were included to detect any suggestibility-related role play during the illusion.

Item Nr.	"During the experiment there were times when…	Synch	Asynch	Synch - Asynch
	<u>OWNERSHIP Items</u>			
1	… it seemed like the rubber hand was my hand"	0.8 (1.6)	-1.0 (1.8)	1.8 (1.7)
2	… it seemed like the rubber hand was part of my body"	0.1 (1.9)	-1.1 (1.8)	1.2 (1.8)
3	… it seemed like I was looking directly at my own hand, rather than at a rubber hand"	0.4 (1.9)	-0.9 (1.8)	1.3 (1.8)
4	… it seemed like the rubber hand belonged to me"	0.4 (1.8)	-1.2 (1.7)	1.8 (1.7)
5	… it seemed like the rubber hand began to resemble my real hand"	0.7 (1.6)	-0.7 (1.8)	1.4 (1.8)
	Ownership overall mean	**0.5 (1.8)**	**-1.0 (1.8)**	**1.5 (1.8)**
	<u>LOCATION Items</u>			
6	… it seemed like the touch I felt was caused by the paintbrush touching the rubber hand"	1.4 (1.3)	-0.9 (2.0)	2.3 (1.6)
7	… it seemed like the rubber hand was in the location where my hand was"	-0.3 (1.8)	-1.2 (1.6)	0.9 (1.7)
8	… it seemed like my hand was in the location where the rubber hand was"	0.3 (1.7)	-1.0 (1.8)	1.3 (1.7)
	Location overall mean	**0.5 (1.6)**	**-1.1 (1.8)**	**1.6 (1.7)**
	<u>COMPLIANCE Items</u>			
9	…it seemed like I couldn't really tell where my hand was	-0.4 (1.3)	-1.2 (1.2)	0.8 (1.2)
10	…it seemed like my hand was normal	0.8 (1.2)	1.0 (1.2)	-0.2 (1.2)
11	…it seemed like I had three hands	-2.1 (1.0)	-1.9 (1.4)	-0.2 (1.2)

There were no significant correlations for either standard or subjective HGSHS:A scores with the overall Ownership ratings (see Method) for the separate synchronous (Pearson's r = 0.195), asynchronous (Pearson's r = 0.184), conditions, nor for the difference (synchronous – asynchronous; Figure 2b; Pearson's r = -0.068; all p>0.373). Likewise, there was no significant relation, for the difference (synchronous – asynchronous; Figure 2c; Pearson's r = -0.036 all p>0.632) for the overall Location questionnaire data. Thus contrary to our prediction, there was no relationship between HS and the explicit RHI questionnaire measure.

Importantly, the correlation observed between proprioceptive drift and HGSHS:A score (r=0.55; Figure 2a) was significantly greater than the mean overall Ownership [Figure2b; Z=2.14493; p=0.032 (2-tailed)] and Location [Figure2c; Z=2.1005; p=0.036 (2-tailed)] questionnaire correlations (Steiger 1980), demonstrating a clear dissociation between implicit and explicit measures of the RHI. Furthermore, there was no correlation between the proprioceptive drift (implicit) and RHI questionnaire (explicit) overall Ownership (Pearson's r = 0.231; p=0.301) and Location (Pearson's r = 0.216; p=0.334) ratings.

To control for experimental demand effects, we included compliance items (Ehrsson et al 2004; Table 1; item numbers 9-11) in the RHI questionnaire. Pearson correlations indicated no significant relation with the HGSHS:A score for the first two compliance items (all p > 0.283). The correlation for the final compliance item ("It seemed like I had three hands"; Table 1; item number 11) tended towards, but did not reach significance (Pearson's *r* = -0.387; p = 0.076; 2-tailed). Twenty-one out of 22 participants disagreed with this item (the remaining participant neither agreed nor disagreed); however, participants with lower HS scores disagreed slightly more. Thus, there was no evidence that participants engaged in role-playing or compliant behaviour during the RHI.

3 Discussion

The present study measured the relation between hypnotic suggestibility (HS) and susceptibility to the rubber hand illusion. Results confirmed that participants experienced the classic illusion as measured implicitly, using mislocalisation of felt finger position (proprioceptive drift), and explicitly using the RHI questionnaire (Botvinick and Cohen 1998). As predicted, HS correlated positively with proprioceptive drift. Contrary to prediction, however, HS did not correlate with feelings of ownership and location for the rubber hand (RHI questionnaire). Furthermore, there is no evidence that participants engaged in role-playing or compliant behaviour during the experimental procedures.

The finding that HS correlates with proprioceptive drift, but not the RHI questionnaire ratings, casts light on the potential mechanisms underlying both hypnotic suggestibility and the rubber hand illusion. According to conceptual accounts (Blanke 2012; Makin et al 2008; Rohde et al 2011; Tsakiris et al 2010), separate mechanisms of multisensory integration underlie the spatial update of hand position (proprioceptive drift) and feeling of ownership (Longo et al 2008; Rohde et al 2011). Proprioceptive drift is thought to rely on visuoproprioceptive integration alone (Figure 1a; Rohde et al 2011) whereas the feeling of ownership is associated with visuotactile integration (Figure 1b; Holmes et al 2006; Rohde et al 2011).

High HS is the propensity to respond to direct verbal suggestions for alterations in perceptual experiences and behaviour (Shor et al 1962), and an increased attentional capacity (Rainville et al 2002; Tellegen and Atkinson 1974), which may facilitate the integration of multisensory inputs and lead to a spread of attention across sensory modalities (Ramakonar et al 2011; Talsma et al 2010). Interestingly, this facilitation seems to only occur for the visuoproprioceptive stream (Figure 1a) which may relate to the subjective involuntariness of ideomotor responses (e.g. "my hand feels as if it is moving by itself") observed during hypnotic procedures (Deeley et al 2013b; Oakley and Halligan 2013; Santarcangelo et al 2008; Wallace and Hoyenga 1980; Walsh et al 2014a; Walsh et al 2014b).

Conversely, the mechanism for visuotactile integration does not seem to interact with HS during the illusion (Figure 1b). Stimulus-driven, bottom-up mechanisms induced by crossmodal visuotactile interactions can automatically capture attention towards multisensory events (Tsakiris and Haggard 2005). Previous research has mapped the visuotactile and proprioceptive integration mechanisms onto anatomically distinct neuronal regions (Ehrsson et al 2004; Fiorio et al 2011; Kammers et al 2009; Tsakiris et al 2007; Zeller et al 2011). Neural activity in premotor cortex is thought to reflect the phenomenal effect of the illusion, i.e. the feeling of ownership of the rubber hand (Ehrsson 2007; Ehrsson et al 2005; Ehrsson et al 2004; Limanowski and Blankenburg 2015), whereas proprioceptive drift is associated with distinct brain areas including right posterior insula (Tsakiris et al 2007), left inferior parietal lobule (Kammers et al 2009) and left extrastriate body area (EBA; Wold et al 2014). This neuroimaging evidence indicates that separate processes are involved in the feeling of ownership and in proprioceptive drift.

A rubber hand is a suggestive stimulus and may involve strong social pressure to comply by 'performing' in line with the perceived demands of the experimental task (Spanos et al 1992; Wagstaff 1981). The explicit RHI questionnaire measure with its subjective character might therefore be more prone to demand characteristics (Bowers 1966; Hilgard 1965; Sheehan and Perry 1976). However, no correlation was observed between HS and the RHI questionnaire, or the compliance items explicitly designed to control for these effects (Table 1; Ehrsson et al 2004). In contrast, the implicit proprioceptive drift measure, which relies on a perceptual judgement of felt finger position, and does not involve leading questions, showed the predicted association with HS. Also, there was no evidence of proprioceptive drift being automatically driven by visual dominance over somatosensation prior to stimulation (Botvinick and Cohen 1998; Hagura et al 2007; Pavani et al 2000). Collectively these findings indicate that the greater implicit response to the RHI is neither due to social compliance nor visual capture, but rather may be attributable to the greater attentional abilities associated with HS. They also imply that responsiveness to direct verbal suggestions, as measured by the HGSHS:A, does not play a significant role in the RHI using the experimental procedures employed here.

Botvinick and Cohen's seminal work (Botvinick and Cohen 1998), suggests common brain mechanisms for illusory hand ownership and proprioceptive drift. Therefore, it could be argued that the lack of a relationship between one aspect of the RHI (i.e., the explicit questionnaire) and hypnotic suggestibility implies no relationship between HS and the rubber hand illusion, as classically proposed. However, recent behavioural (Holle et al 2011; Kammers et al 2009; Wold et al 2014) and neuroimaging (Tsakiris et al 2007) findings have indicated that the RHI is a multi-facetted and complex illusion which can be broken down into separate constructs (e.g. Figure 1) and that separate cognitive multisensory mechanisms underlie different aspects of the illusion (Blanke 2012; Makin et al 2008; Rohde et al 2011; Tsakiris et al 2010). Our results indicate that hypnotic suggestibility, impacts at least one key aspect (implicit proprioceptive drift) of the illusion, but not another (explicit RHI questionnaire). Another interpretation of the current finding is that participants may have perceived a change in judged location of their hand that was induced merely by tactile stimulation of their hand finger and vision of the rubber hand (i.e., visuotactile input), but that participants did not actually experience any "illusion". However, there are a number of reasons why we believe this is not the case. First, for the Ownership questionnaire item previously shown to have the largest component loading in the experience of body-ownership during the RHI (Longo et al 2008), i.e., "it seemed like the rubber hand was my hand", participants reported a difference in rating between with the synchronous and asynchronous conditions of 1.8 (7 point scale; see Table 1, item 1; "Synch - Asynch"). This difference is consistent with the experience of an illusion, and is comparable to other studies employing similar experimental designs (e.g., Holle et al 2011; Tsakiris et al 2011). Second, conceptual models (e.g., Makin et al 2008) would predict a resultant change in explicit *ownership* ratings resulting from the integration of tactile and visual (i.e., visuotactile) input (Figure 1b), whereas the present results clearly show the effect is in the implicit drift data. Finally, participants' descriptions of their experience recorded immediately after the experiment are consistent with the experience of an illusion. During synchronous stimulation, representative participants reported that: "It was uncanny - the rubber hand does not particularly look like my hand - it plainly is not my hand - yet it felt like she [the experimenter] was stroking my hand.", or, : "I felt that it [the rubber hand] was my hand the instant the paintbrush touched my [real] hand". Together, these lines of evidence suggest that the perceived change in judged location of the hand was not due to *visuotactile* (but rather visuoproprioceptive) integration, and that participants experienced a compelling rubber hand illusion.

We argue that superior attentional ability associated with high hypnotic suggestibility may facilitate the multisensory integration which leads to perceptual mislocalisation of a limb. However, an alternative and not incompatible explanation of our results proposes that hypnotic suggestibility, which can facilitate automatic response to direct verbal suggestions (Elkins et al 2014), may have lead to hand mislocalisation via implicit processes. Implicit learning is the acquisition of complex information in an incidental manner, and without awareness of what has been learned (Reber 2013). Thus, highly HS participants may have shown a greater response on the implicit localisation (i.e., proprioceptive drift) measure merely because they are more susceptible to implicit cues. Indeed, improved performance in a hypnotic setting has previously been demonstrated in a procedural based sequence learning task (Nemeth et al 2013). This line of reasoning leads to a testable hypothesis for future research: if the RHI involves implicit learning, then repeated exposures to the rubber hand paradigm should lead to change in hand localisation estimates for highly suggestible participants over time.

Some caution is appropriate when considering our results in relation to hypnotic suggestibility. While the HGSHS:A (Shor et al 1962) is commonly considered the 'gold standard', there are other measures of HS (e.g., Barnier and McConkey 2004; Bowers 1993; Spanos et al 1983; Weitzenhoffer and Hilgard 1962). Any one measure of hypnotic suggestibility does not necessarily produce a completely reliable measure, and does not correlate perfectly with other single measures, of HS (Halligan and Oakley 2013). Furthermore, there is clear phenomenological and behavioural evidence of two subtypes of highly suggestible individuals (McConkey and Barnier 2004; Sheehan and McConkey 1982; Terhune and Cardeña 2010). Distinct subtypes of highly HS individuals have been identified (Barber 1999; Terhune and Cardeña 2010), including 'dissociative' participants who, in response to a hypnotic induction, exhibit pronounced distortions in awareness, relative to a second subtype of highly HS participants who are characterised by endogenously-directed attention. The 'dissociative' subtype may be more prone to experiences of greater distortion in *bodily* awareness and may therefore prove to be more susceptible to the rubber hand illusion.

Future work could examine the relation of HS with other behavioural and physiological correlates of the RHI e.g. skin temperature, which cools during the illusion (Moseley et al 2008). Skin temperature correlates with an explicit *subjective* rating of illusion, i.e., "vividness" (Moseley et al 2008), hinting that no relationship may exist between HS and thermal measures of limb ownership. However, the insula which is implicated in proprioceptive drift (see above) is also associated with the sensation of cooling (Hua et al 2005); this region could be involved in the cooling of the counterpart real hand that can accompany feelings of ownership of a rubber hand (Moseley et al 2008). Further research could also explore whether individual differences in hypnotic suggestibility extend to the perceptual illusion of body swapping (Petkova et al 2011; Salomon et al 2013). An interesting research question is whether hypnotic procedures (Deeley et al 2013a; Walsh et al 2014b) would further modulate performance during the RHI. First, a formal hypnotic induction procedure which can help participants 'to enter a hypnotic state' (Mazzoni et al 2013) is predicted to enhance attentional focus thereby increasing the implicit response to the RHI. Second, 'targeted' suggestions given after a hypnotic induction procedure could be employed to create additional specific changes in perceptual experience or behaviour, e.g., "at the sound of a tone, you will, ("or will not", dependent on the experimental condition) experience the "hand" you see in front of you as your hand". Direct verbal suggestions targeting hand ownership have previously been shown to manipulate subjective ratings relating to the hand (Deeley et al 2013b; Walsh et al 2014a; Walsh et al 2014b) and may therefore indirectly affect explicit RHI questionnaire ratings. Such research could have experimental and clinical significance given the potential role of suggestion in the aetiology and treatment of clinical symptoms involving body image and embodiment.

In conclusion, hypnotic suggestibility (HS) scores predicted differences in proprioceptive drift, but not in subjective experience. These findings help clarify what distinguishes participants who exhibit proprioceptive drift towards the rubber hand during the illusion from those who do not. The superior attentional ability associated with high hypnotic suggestibility may facilitate the multisensory integration of visuoproprioceptive inputs leading to a greater perceptual mislocalisation of an experimental participant's real hand towards the rubber hand. A better understanding of the experiences and conditions underlying our rich and complex, yet elusive, sense of embodiment may have far-reaching effects on human development and quality of life.

4 Method

Twenty-three healthy, English-speaking participants (all right-handed as assessed by the Edinburgh Handedness Inventory; 14 female) were recruited randomly from a pool of approximately 350 volunteers who were screened 12 - 24 months previously for suggestibility in a hypnotic context using the Harvard Group Scale (HGSHS:A; Shor et al 1962). Participants' mean HGSHS:A score was 6.2 (SD = 3.8; range 0 to 11) and their mean age was 34.0 (SD = 13.4) years. The study was approved by the King's College London ethics committee and conducted in accordance with the Helsinki Declaration (2008). All participants provided written informed consent.

Briefly, participants sat at a table wearing a smock that concealed their arms, and placed both hands inside a black box (Figure 3). No mirror was used during these procedures. A lid on top of the box could be raised to reveal the rubber hand to the participant, while simultaneously concealing the experimenter from view. At the start of each block, participants placed both hands inside the box and were instructed not to move. Next participants reported their felt right index finger position using a random offset ruler (pre-stimulation finger position). The lid was raised and a 2 minute stimulation phase began in which the index and middle fingers of the participant's right hand (not visible to the participant) and the (visible) rubber hand were stroked using identical paintbrushes, at a rate of 1 stroke per second. In the synchronous condition, the participant's right hand and the visible rubber hand were stroked simultaneously, while in the asynchronous condition stroking was 180 degrees out of phase. At the end of 2 minutes, tactile stimulation ceased, the lid of the box was lowered concealing the rubber hand, and a post-induction proprioceptive location of the participant's right index finger was taken (post-stimulation finger position). Participants then removed their hands from the box to complete an eleven-item pen and paper questionnaire (see Table 1). Items in the questionnaire were based on those from Longo *et al*. (Longo et al 2008); 5 items relate to the component of Ownership (Table 1; numbers 1-5), and 3 items to the component of Location (Table 1; numbers 6-8) associated with the RHI. The last 3 items served as controls for suggestibility and task-compliance (Table 1; numbers 9-11; Ehrsson et al 2004). The experiment consisted of 8 blocks (4 synchronous and 4 asynchronous), lasting 2 minutes each. The order of presentation of the synchronous and asynchronous blocks was randomised across participants. Participants completed a questionnaire at the end of each block. The order of questionnaire items was randomised for each participant from block to block. Experimenter DNG, a visiting United States researcher, conducted the experiment, was unknown to all participants and blind to their HS scores during testing. No hypnotic induction or targeted suggestions were used and the terms 'hypnosis' or 'illusions' were not mentioned throughout (Gandhi and Oakley 2005).

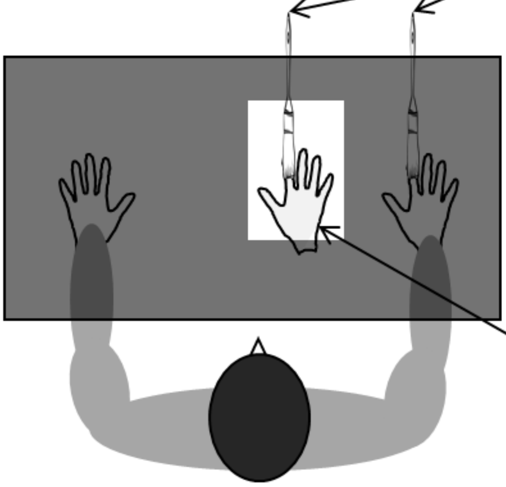

Figure 3. Schematic of experimental set-up as viewed from above. No mirror was used during these procedures. The participant sat at a table and placed both hands inside a black box (top of box shown transparent here for illustration). When a lid on top of the box was raised, the participant could view a rubber hand through an aperture cut into the top of the box. Then the participant's hidden (to them) right hand and visible rubber hand were stroked with identical paintbrushes by the experimenter. In this way, participants could *feel* their right hand being stroked, while *seeing* the rubber hand being stroked. Stroking was either synchronous (as shown) or asynchronous depending on the experimental condition. The *difference* in performance between the experimental (synchronous) and the control (asynchronous) conditions gives a measure of the magnitude of the illusion.

Pearson correlations were performed for HGSHS:A scores for all participants (N=23) to explore the linear relation of hypnotic suggestibility (HS) with both the implicit (proprioceptive drift) and explicit (RHI questionnaire) outcome measures. The Cook's distance (D_i) statistic was used to identify outliers and influential points. Cook's D was calculated using the cut-off of $D_i = 0.174$ (4/n; where n is the sample size; Bollen and Jackman 1990). Twenty-two of the 23 observations were less than the cut-off (mean Cook's distance = 0.025; SD = 0.025; range 0.002 to 0.079). However one observation point had a Cook's distance of 0.333, in excess of the cut-off, and was removed from the analysis. The significant correlation of the difference (i.e. synchronous minus asynchronous) did not change when the regression was performed with ($r = 0.49$; $p = 0.019$) or without ($r = 0.70$; $p < 0.001$) this outlying data point. For the RHI questionnaire items, ratings from the five ownership and three location questions were collapsed to form overall Ownership and Location difference scores (Table 1).

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