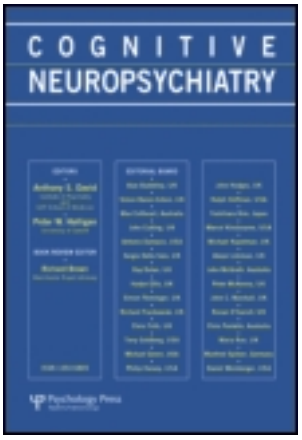

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"That's not my arm": A hypnotic analogue of somatoparaphrenia

Alena Rahmanovic [a], Amanda J. Barnier [a], Rochelle E. Cox [a], Robyn A. Langdon [a] & Max Coltheart [a]

[a] Macquarie Centre for Cognitive Science (MACCS), Macquarie University, Sydney, Australia

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"That's not my arm": A hypnotic analogue of somatoparaphrenia

Alena Rahmanovic, Amanda J. Barnier, Rochelle E. Cox, Robyn A. Langdon, and Max Coltheart

Macquarie Centre for Cognitive Science (MACCS), Macquarie University, Sydney, Australia

Introduction. "Instrumental hypnosis" allows researchers to model clinical symptoms in the laboratory, creating "virtual patients" with reversible disturbances in, for example, perception, action, memory, or belief. We used hypnosis to temporarily recreate somatoparaphrenia, a delusional belief that one's own limb belongs to someone else.
Methods. We compared a "Fully Formed" somatoparaphrenia suggestion with a "Factor 1 + Factor 2" suggestion that attempted to generate the delusional belief from analogues of its hypothesised underlying factors (i.e., paralysis plus disrupted critical belief evaluation). We tested and then challenged subjects' responses to these suggestions.
Results. Although many hypnotic subjects experienced temporary paralysis, only a minority claimed their arm did not belong to them. Notably, the Fully Formed suggestion was more successful in recreating features of somatoparaphrenia than the Factor 1 + Factor 2 suggestion. In response to the challenges, some of those who developed temporary somatoparaphrenia maintained their belief throughout the hypnosis session.
Conclusions. We discuss these findings in terms of the "two-factor" theory of delusions and we highlight the advantages versus disadvantages of using hypnosis to explore such delusional beliefs in the laboratory.

Keywords: Delusion; Hypnotic analogues; Somatoparaphrenia.

Correspondence should be addressed to Amanda J. Barnier, Macquarie Centre for Cognitive Science (MACCS), Macquarie University, Sydney, NSW 2109, Australia. E-mail: amanda.barnier@mq.edu.au

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INTRODUCTION

Delusions are central, puzzling features of both neuropsychological and psychiatric conditions. One to two per cent of the population experience a delusional belief at some stage in their lives (Davies, Coltheart, Langdon, & Breen, 2002). Until recently, delusions have been difficult to investigate because they frequently cooccur with other symptoms and impairments. However, "instrumental hypnosis" offers a viable technique for studying delusions in the laboratory (Cox & Barnier, 2010). As described by Oakley and Halligan (2009), hypnosis can create "virtual patients" by generating reversible psychological disturbances in neurologically intact individuals. Hypnotic suggestions can be targeted to selectively manipulate aspects of information processing thought to be involved in the disorder of interest. Current hypotheses about the underlying processes that contribute to these disorders can then be tested and new hypotheses informed by the results (Langdon, 2009). The present study applied this approach to somatoparaphrenia (the delusional belief that one's own arm(s) and/or leg(s) belongs to someone else) for the first time. We aimed to use hypnosis to: (1) recreate the delusional belief, (2) generate the belief from analogues of the delusion's hypothesised underlying factors, and (3) challenge the belief in various ways to test its persistence.

Somatoparaphrenia

Somatoparaphrenia is the delusional belief that one's own arm(s) and/or leg(s) (most often just the left arm) belongs to someone else (Coltheart, 2005, 2007; Gerstmann, 1942); the limb(s) may be attributed to the patient's examiner, or to some relative of the patient, a person who may not even be present in the same room as the patient. For instance, Bisiach, Rusconi, and Vallar (1991) described an 84-year-old woman who developed somatoparaphrenia after a right hemisphere stroke. She claimed that her left arm was her mother's. When asked what her mother's arm was doing there, she replied "I don't know. I found it in my bed." When asked where her own left arm was, she pointed in a forward direction and said "It's under there" (see also Bottini, Bisiach, Sterzi, & Vallar, 2002).

Somatoparaphrenia is often accompanied by left-sided paralysis and by anosognosia (denial or lack of awareness) of that paralysis and hence the question arises as to whether paralysis, or anosognosia, or both, are necessary for somatoparaphrenia to occur. The patient GH described by Halligan, Marshall, and Wade (1995) was floridly somatoparaphrenic, and had a left-sided paralysis, but had no anosognosia. At a time when both the somatoparaphrenia and the paralysis were present, the patient showed no denial of the impairments or handicaps associated with his right

temporoparietal stroke. Hence, this patient provides some evidence that somatoparaphrenia may occur in the absence of anosognosia.

As for paralysis, of the 56 patients described in the comprehensive review of somatoparaphrenia by Vallar and Ronchi (2009), all except one were listed as having motor impairment. The only exception was Case 4 of Cereda, Ghika, Maeder, and Bogousslavsky (2002). Table 1 of Vallar and Ronchi stated that paralysis was absent in this case, but in the paper by Cereda and colleagues there is no explicit mention of any testing for paralysis with this case; testing for sensory loss was reported (and this loss was present for the left arm). Thus, we cannot be certain that left-sided paralysis was absent in this one case and since it was present in all of the other 55 cases we assume, in this first hypnotic analogue, that somatoparaphrenia is always accompanied by left-side paralysis (for which some patients are anosognosic and some are not).

Recreating delusions with hypnosis

Hypnosis can alter experience and behaviour in ways that mimic the features of pathological conditions. This has made hypnosis a powerful tool for exploring clinical phenomena (for review, see Barnier & Oakley, 2009; Cox & Barnier, 2010; Oakley & Halligan, 2009) including functional amnesia (Barnier, 2002), auditory hallucinations (Szechtman, Woody, Bowers, & Nahmias, 1998), conversion disorder paralysis (Halligan, Athwal, Oakley, & Frackowiak, 2000), paranoia (Zimbardo, Andersen, & Kabat, 1981), obsessive compulsive disorder (Woody, Lewis, et al., 2005), déjà vu (O'Connor, Barnier, & Cox, 2008), and hysterical blindness (Bryant & McConkey, 1989a, 1989b).

Of particular relevance, hypnosis has been used increasingly in recent years to model and explore clinical delusions (e.g., Barnier, Cox, Connors, Langdon, & Coltheart, 2011; Barnier et al., 2008; Connors, Barnier, Coltheart, Cox, & Langdon, in press; Cox & Barnier, 2009a, 2009b). Hypnosis seems well suited to modelling delusions because both hypnotic experiences and delusions are: (1) believed with conviction, (2) resistant to rational counterargument, and (3) maintained regardless of evidence to the contrary (Kihlstrom & Hoyt, 1988). Also, both delusions and hypnotic experiences are experienced as involuntary and as compellingly real (McConkey, 1991). Indeed, Sutcliffe (1961) argued that hypnotised individuals are essentially deluded about the real state of the world.

The ability of hypnosis to create temporary but compelling delusional beliefs is illustrated by our recent success in recreating mirrored-self misidentification (the belief that one's mirrored reflection is a stranger; Barnier et al., 2008, 2011). We gave high hypnotisable subjects a "Fully

Formed'' hypnotic suggestion—a suggestion that explicitly suggested the full or complete delusional content– to ''see a stranger'' when they looked in the mirror. In response, many high hypnotisable individuals reported seeing a stranger who had physical characteristics different to their own; some subjects even looked around the room to try to find the stranger they saw in the mirror. Our subjects showed striking similarities to clinical patients with mirrored-self misidentification, especially in the ways they reported their belief, reacted to the surrounding environment, and resisted information that contradicted their belief (Bortolotti, Cox, & Barnier, in press). These and other related findings (e.g., Burn, Barnier, & McConkey, 2001; Cox & Barnier, 2009a, 2009b; Noble & McConkey, 1995; Sutcliffe, 1961) show that talented hypnotic subjects temporarily come to believe false things about themselves and the world. Based on this, we aimed first to use a Fully Formed suggestion to try to recreate somatoparaphrenia by instructing subjects to believe that their arm belonged to someone else. We also tested a second version of the suggestion informed by a prominent current model of delusions: the ''two-factor'' theory.

Generating the delusion from its underlying factors

Delusional belief has been explained by Coltheart, Langdon, and colleagues' (Langdon & Coltheart, 2000; see also Coltheart, 2007) two-factor theory of monothematic delusions. By their view, two factors are involved in the production and maintenance of delusions. Factor 1 explains why the delusional belief arises in the first place; it is responsible for the specific content of the delusion. Since individuals can have Factor 1 impairments without developing a delusion (Coltheart, 2007; Langdon & Coltheart, 2000), a second factor is said to be involved. Factor 2, which Langdon and Coltheart (2000) argue may be common across all delusions, at least all monothematic delusions (i.e., delusions with a single theme), explains why the delusional belief is not rejected. Factor 2 is commonly described as involving a disruption of critical belief evaluation.

With respect to somatoparaphrenia, and for the reasons outlined earlier, we hypothesise that Factor 1 involves paralysis. The patient with somatoparaphrenia is no longer able to move her paralysed limb, which is at odds with her prior experience of her limb. This generates the thought that the limb cannot be hers: it is an alien limb. This initial thought is then accepted uncritically as true. It is possible for paralysis to generate an initial implausible thought of this type, we think, because human beings are biased to generate personal-level rather than subpersonal-level causal explanations (Langdon & Coltheart, 2000). To clarify, whereas personal-level explanations locate cause somewhere in the interaction between the self, as a whole,

and the external (nonself) environment, subpersonal-level explanations locate cause in the subpersonal, or the component, parts of a self. For example, to blame a fault with my own arm and brain—e.g., paralysis of my arm caused by a stroke affecting my brain—as the cause for my not moving the arm when commanded to do so is to generate a subpersonal-level explanation. In contrast, a personal-level explanation would locate the blame externally, beyond the component parts of self—say with another person (not me!) whose arm it must be.

Although the thought that one's own arm belongs to someone else is patently implausible, there is evidence that initial thoughts of this type do arise immediately following paralysis. For example, Meador, Loring, Feinberg, Lee, and Nichols (2000) reported a study of nondelusional epileptic patients who received intracarotid amobarbitol injections to their nonlanguage dominant hemisphere (which was almost always the right hemisphere). Immediately after the injection, subjects experienced paralysis of their contralateral arm and were subsequently asked whose arm it was. In response, 88% claimed that their arm belonged to someone else. Thus, it appears that the deactivation of the nonlanguage dominant hemisphere resulted in these subjects generating and uncritically accepting the thought that their (temporary) paralysed arm belonged to someone else.

Although the cognitive disruptions that are involved in clinical delusions, such as somatoparaphrenia, are often caused by right prefrontal brain lesions or neurochemical imbalance, there are alternate ways that the cognitive processes involved in belief formation and evaluation may be disrupted in delusions. For instance, McKay, Langdon, and Coltheart (2005) applied the two-factor theory to explain some clinical delusions that appear to resist a purely "brain deficit" account (e.g., "Reverse Othello", which is a delusional belief in the continuing fidelity of a partner who has left one) where Factor 1 is conceived as more motivational and "functional" rather than "organic" and where Factor 2 may also reflect motivational forces (e.g., self-defensive mechanisms). In other words, the two-factor theory is conceived as a general cognitive explanatory approach, whereby any disruptions in optimal cognitive processing, akin to Factors 1 and 2, should result in delusional beliefs similar to clinical cases.

Thus, the two-factor approach to cognitive theorising about delusions can also accommodate recent dimensional approaches to delusional ideation. Dimensional approaches focus on commonalities between clinical and nonclinical cases of delusional ideation and allow for variation in levels of delusional conviction and fixity (whether in clinical or nonclinical contexts; see Peters, Joseph, Day, & Garety, 2004). That it is sometimes difficult to discriminate between clinical delusions and the delusion-like ideas of nonclinical people (with regard to implausibility or conviction) is consistent with the proposal that the same (right hemisphere) cognitive processing that

is involved in critical belief evaluation is compromised in both cases, perhaps to lesser degree in the nonclinical cases—or perhaps to the same degree, with the main difference between the clinical and nonclinical cases being whether or not the delusional beliefs/ideas are dysfunctional in the individuals' lives (see, for discussion, Langdon, in press; Langdon & Connaughton, in press).

If, as discussed previously, functional factors (e.g., motivational forces) can contribute to delusion formation, it allows that hypnotic suggestions might also cause (temporary) delusions. Hypnotic suggestions can generate anomalous experiences and false beliefs about the world, and the hypnotic context can disrupt hypnotised subjects' reality monitoring and belief evaluation, depending upon their degree of hypnotisability (Barnier & McConkey, 2004; Barnier et al., 2008; Cox & Barnier, 2010; Cox & Bryant, 2008). So, in this study we set out to use hypnotic suggestions to recreate somatoparaphrenia. To recap, we aimed to determine whether a Fully Formed somatoparaphrenia suggestion to experience one's own limb as belonging to someone else would produce temporary somatoparaphrenia in hypnotisable subjects. We also aimed to use a second suggestion to try to generate the delusional belief from analogues of its hypothesised underlying factors: paralysis (Factor 1) and disrupted belief evaluation (Factor 2). A specific hypnotic suggestion for paralysis (e.g., the arm immobilisation item from standardised scales) can be readily experienced by high and medium hypnotisable subjects (Weitzenhoffer & Hilgard, 1962; Woody, Barnier, & McConkey, 2005). Thus, our Factor 1 suggestion instructed subjects to experience paralysis of their arm. We hypothesised that a paralysis suggestion would provide the content of the delusion and generate the initial thought that the targeted arm was alien. Although the hypnotic context itself can disrupt belief evaluation, we added a Factor 2 suggestion that was based on Turner and Coltheart's (2010) view that Factor 2 involves a failure in normal plausibility checking. Thus, our Factor 2 suggestion instructed subjects to accept any explanation of what was happening as plausible. We hypothesised that this Factor 2 suggestion would lead subjects to uncritically endorse the thought (generated by the paralysis) that the target arm was alien. From these combined suggestions, which aimed to mimic the hypothesised building blocks of paralysis and disrupted belief evaluation, can we generate the delusional belief that "this arm belongs to someone else"?

Challenging delusions

Like many patients with other delusions, people with somatoparaphrenia vehemently defend their beliefs in the face of contradictory evidence (Coltheart, 2007; Vallar & Ronchi, 2009). For instance, Feinberg, Deluca,

Giacino, Roane, and Solms (2005, pp. 103–104) described a woman who developed somatoparaphrenia following a right hemisphere stroke resulting in left arm paralysis. She repeatedly denied that her left hand belonged to her:

Examiner: *(indicating patient's left hand)* What is this over here? Take a look over here. What is this?
Patient: Your fingers
Examiner: Take a good look. What is it? *(taps the back of patient's hand)*
Patient: The back of your hand.
Examiner: The back of my hand?
Patient: Yes.
Examiner: Suppose I told you that this was your hand?
Patient: I wouldn't believe you.
Examiner: You wouldn't believe me?
Patient: No, no.
Examiner: This is your hand.
Patient: No.

Somewhat paradoxically, patients will even defend their own delusional belief while recognising that similar belief content in other patients is delusional (e.g., Startup, 1997). There are yet others who understand that their own delusional beliefs are illogical yet cannot help endorsing them. For example, one of us (RL) once interviewed a delusional patient who stated that he realised that his own belief made no logical sense, but that he still could not help believing that it was true.

Clinical interventions may aim to resolve or lessen such delusional beliefs (Brakoulias et al., 2008). But little is known about how people with somatoparaphrenia react when their beliefs are challenged in different ways (Halligan et al., 1995). Indeed, repeated or particular challenges may inadvertently strengthen patients' beliefs or even have unintended negative consequences (Coltheart, 2007). Hypnosis can provide a safe alternative testing ground for possible therapeutic techniques since hypnotic delusions are similarly defended in the face of contradiction. For example, in a contradiction procedure, Noble and McConkey (1995; see also Burn et al., 2001) asked their hypnotic sex change subjects what they would say to a hypothetical doctor (an authority figure) who said that there was no reason to believe they were the suggested sex; 83% of hypnotic virtuosos (excellent hypnotic subjects) still maintained their belief that they were the opposite sex. They made comments such as "the doctor's a quack". In a confrontation procedure, Noble and McConkey asked subjects to open their eyes, look at themselves on a monitor and describe what they were experiencing; 73% still maintained their belief and made comments such as "that wasn't me, that was someone else there" (p. 72). Using similar challenges, Cox and

Barnier (2009a) found that 70% of high hypnotisable subjects who were experiencing a hypnotic identity delusion (hypnotic reverse intermetamorphosis; the delusional belief that I have physically and psychologically become another person) maintained their belief throughout a contradiction and a confrontation. And Barnier et al. (2008) found that 100% of those who were experiencing hypnotic mirrored-self misidentification (described earlier) maintained their belief throughout a contradiction and a confrontation. Consistent with this work, we explored the impact of three different challenges on subjects' experiences of hypnotic somatoparaphrenia.

THE PRESENT STUDY

To develop a credible laboratory analogue of somatoparaphrenia during hypnosis we gave high, medium, and low hypnotisable subjects one of two versions of a hypnotic suggestion. Version 1 was a Fully Formed suggestion that explicitly told subjects that their nondominant arm would belong to someone else. Version 2 was a "Factor 1 + Factor 2" suggestion. Motivated by a two-factor account of somatoparaphrenia which conceives of Factor 1 as involving paralysis, we first suggested that subjects' nondominant arm would be paralysed but that they would not remember being told this (to model, for example, a patient who regains consciousness after suffering a stroke that causes paralysis). We then suggested that any explanations subjects generated to account for their experience of paralysis would seem plausible (to model Factor 2, and also informed by Turner and Coltheart's, 2010, view that Factor 2 involves a failure in normal plausibility checking). To test these suggestions we: (1) administered a series of behavioural tests involving subjects' arms (to index paralysis); (2) asked questions about the subjects' arms (to test awareness of the hypnotic suggestion); and (3) asked questions about ownership of arms (to index delusional beliefs). Next, we challenged delusional responses with: (1) a contradiction, where we asked subjects what they would say if a doctor walked into the room and said that the subject's arm did in fact belong to them (based on Noble & McConkey, 1995); (2) a confrontation, where we asked subjects to look at their arms in a mirror and to describe how the arm looked and felt (based on Noble & McConkey, 1995); and (3) a peer model challenge, where we showed subjects a video of a patient with somatoparaphrenia and asked them what they thought about the patient's claims about her arm (based on Rokeach, 1964).

Consistent with previous work on hypnotic delusions, we expected that highs would experience hypnotic somatoparaphrenia more than mediums and lows, irrespective of which suggestion they received. We speculated that the Fully Formed and Factor 1 + Factor 2 suggestions might lead to either different levels or different kinds of responding. The Factor 1 + Factor 2

suggestion might be more effective in recreating somatoparaphrenia because it more closely resembles the delusion's proposed underlying factors. Finally, we expected that continued challenges to subjects' hypnotic delusions might breach or lessen their conviction; we were particularly interested in which challenges would be most successful.

METHOD

Design and subjects

Twenty-five (six males, 19 females) high hypnotisable subjects of mean age 20.96 years ($SD = 5.66$), 37 medium hypnotisable subjects (five males, 32 females) of mean age 21.14 years ($SD = 5.71$), and 23 low hypnotisable subjects (10 males, 13 females) of mean age 22.22 ($SD = 5.55$) were tested in a 3 (hypnotisability: high vs. medium vs. low) $\times$ 2 (suggestion: Fully Formed vs. Factor 1 + Factor 2) between subjects design. Subjects were undergraduate psychology students at Macquarie University who received credit towards their psychology course or $20 remuneration for their involvement. They were carefully selected on the basis of their scores on a modified 10-item version of the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A; Shor & Orne, 1962) and a modified 11-item version of the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C; Weitzenhoffer & Hilgard, 1962).[1] Highs scored 7–10 ($M = 8.38$, $SD = .93$) on the HGSHS:A and 8–11 ($M = 9.16$, $SD = 1.14$) on the SHSS:C. Mediums scored 3–7 ($M = 4.68$, $SD = 1.45$) on the HGSHS:S and 4–7 ($M = 5.46$, $SD = 1.19$) on the SHSS:C. Lows scored 0–3 ($M = 1.87$, $SD = .83$) on the HGSHS:A and 0–3 ($M = 1.91$, $SD = 1.04$) on the SHSS:C.

Procedure

Subjects were tested individually by a single (male or female) experimenter (the hypnotist) in 1.5 hour sessions.

[1] The 10-item modified HGSHS:A included: head falling, eye closure, hand lowering, finger lock, moving hands together, communication inhibition, experiencing of fly, eye catalepsy, posthypnotic suggestion, and posthypnotic amnesia; arm rigidity and arm immobilisation items were removed to ensure that the procedure could be conducted within the time limits of a 1 hour class. The 11-item tailored SHSS:C included: hand lowering, moving hands apart, mosquito hallucination, taste hallucination, arm rigidity, dream, age regression, arm immobilisation, anosmia, negative visual hallucination, and posthypnotic amnesia; the auditory hallucination item was removed to ensure that the procedure could be conducted within the time limits of a 1 hour individual session.

Hypnosis session. Following informed consent, the hypnotist asked subjects if they were right or left handed, and arranged the room so that the hypnotist and the tray with the scissors, comb, and bottle were next to the subject's nondominant (i.e., targeted) arm. The hypnotist then administered the SHSS:C hypnotic induction (Weitzenhoffer & Hilgard, 1962), which involved suggestions for subjects to relax, close their eyes, and pay attention to the hypnotist's voice. Following this, the hypnotist administered the first 10 SHSS:C items.

Somatoparaphrenia suggestion. Next, the hypnotist randomly allocated subjects to the Fully Formed condition ($N = 43$, 13 highs, 18 mediums, 12 lows) or the Factor 1 + Factor 2 condition ($N = 42$, 12 highs, 19 mediums, 11 lows) and administered the appropriate somatoparaphrenia suggestion. The hypnotist told subjects in the Fully Formed condition that their nondominant arm (targeted arm) would feel as though it belonged to someone else. Consistent with previous hypnotic analogues we worded the suggestion to focus on the subject's altered experience or feeling in their arm. We did not use the word "belief" and we did not use the term "your arm", which would have contradicted the suggestion and confused subjects. The hypnotist also told subjects that they would forget that he/she had suggested this. The verbatim suggestion was (instructions in parentheses are for the hypnotist):

> Whenever I tap my pen like this *[tap pen three times on table]*, this arm *[touch targeted arm]* will feel that it belongs to someone else. Each and every time you hear me tap my pen like this *[tap pen three times on table]*, this arm *[touch targeted arm]* will feel that it belongs to someone else, but you will forget that I told you this. This will happen until I say "this arm belongs to you again". So whenever I tap my pen, this arm *[touch targeted arm]* will belong to someone else, but you will forget that I told you this. This will happen until I say "this arm belongs to you again". Do you understand?

The hypnotist told subjects in the Factor 1 + Factor 2 condition that their nondominant arm was paralysed (Factor 1) and that any explanations they came up with to account for this paralysis would seem plausible (Factor 2). The hypnotist also told them that they would forget that he/she had suggested these things. The verbatim suggestion was:

- Factor 1: Whenever I tap my pen like this *[tap pen three times on table]*, this arm *[touch targeted arm]* will feel paralysed. Each and every time you hear me tap my pen like this *[tap pen three times on table]*, this arm *[touch targeted arm]* will feel totally paralysed, but you will forget that I told you this. This will happen until I say "this arm is no longer paralysed". So whenever I tap my pen, this arm *[touch targeted arm]* will feel paralysed, but you will forget that I told you this. This will

happen until I say "this arm is no longer paralysed". Do you understand?

- Factor 2: You will not know why the arm feels paralysed and you will search for explanations to account for it. Any explanations you come up with will seem plausible. So any thoughts or explanations you come up with to account for the paralysed arm will seem plausible. You will forget that I told you this until I say "this arm is no longer paralysed". Do you understand?

Tests of the suggestion. To index paralysis due to the somatoparaphrenia suggestion, the hypnotist administered five tests including: (1) pick up scissors test, (2) pick up comb test, (3) pick up bottle test, (4) open bottle test, and (5) raise arm test. A tray containing a pair of scissors, a comb, and a small glass bottle with a screw-on lid was located approximately 20 cm from the subject's targeted arm, and 70 cm from their nontargeted arm. Thus, the objects were easier to reach with the targeted arm. In the pick up scissors, pick up comb, and pick up bottle tests, the hypnotist instructed subjects to pick up each object in turn, and explain what it could be used for. In the open bottle test, the hypnotist asked subjects to open the bottle. In the raise arm test, the hypnotist pointed to subjects' nontargeted arm and asked them to hold it straight out in front of them. The hypnotist then pointed to subjects' targeted arm and asked them to hold it out in exactly the same way.

To index awareness of the hypnotic suggestion, the hypnotist asked those who used their nontargeted arm in any of the behavioural tests, why they did so. For example, if subjects opened the bottle with one hand, the hypnotist said: "I noticed you just opened the bottle using only your [nontargeted] hand. Why did you do that?"

To index delusional beliefs due to the somatoparaphrenia suggestion, the hypnotist pointed to the subject's targeted arm and said "Look at this arm over here. Can you tell me about this arm? Whose arm is it?"

Challenges. The hypnotist then challenged subjects' delusional experiences with three techniques: (1) a contradiction, (2) a confrontation, and (3) a peer model. In the contradiction, the exact wording varied depending on how subjects responded when asked "Whose arm is it?" If subjects claimed that their targeted arm did not belong to them and specified a person whose arm it was, the hypnotist said:

> What would you say if (specified owner) walked into this room and said that this arm *[point to subject's targeted arm]* is not theirs, and that it is actually yours?

If subjects claimed that their targeted arm did not belong to them but did not specify who it belonged to, the hypnotist said:

> What would you say if a doctor walked into this room and said that this arm *[point to subject's targeted arm]* is actually yours?

If subjects claimed that their targeted arm belonged to them, but it felt paralysed, the hypnotist said:

> What would you say if a doctor walked into this room and said that this arm *[point to subject's targeted arm]* looks fine and that it is normal?

In the confrontation, the hypnotist referred to a mirror (approximately 40 cm $\times$ 60 cm) positioned on a small table 1 m away from the subject, and said:

> Now I'd like you to swivel your chair around and look in the mirror to your left. What do you see in the mirror? I want you to pay attention to your arms. How do they look? Do they look how they normally look? Do they feel how they normally feel?

In the peer model, the hypnotist played a 50 s video on a 24-inch Apple Mac computer screen. The video was a reenactment of a clinician talking to a patient with somatoparaphrenia (based on Feinberg et al., 2005). Afterwards, the hypnotist asked subjects:

> What did you think about the woman in the video who said that her hand belonged to the other woman? Did her behaviour seem normal? Think about what she just said about her hand not belonging to her. How does that make you feel?

Cancellation and deinduction. Following these challenges, the hypnotist cancelled the somatoparaphrenia suggestion and administered the SHSS:C (Weitzenhoffer & Hilgard, 1962) hypnotic deinduction, where subjects were instructed to awaken gradually as the hypnotist counted from twenty to one.

Posthypnotic inquiry. After the hypnosis session, the hypnotist asked subjects to rate how much their arm felt that it belonged to someone else (0 = "not at all", 6 = "completely") and how much they believed their arm belonged to someone else (0 = "not at all", 6 = "completely"). Finally, the hypnotist debriefed subjects, invited them to ask questions, and thanked them for their time.

RESULTS

Indexing paralysis

All subjects received five behavioural tests that were specifically designed to index the paralysis component of our suggestions. These tests included: (1) pick up scissors test, (2) pick up comb test, (3) pick up bottle test, (4) open bottle test, and (5) raise arms test. Subjects were scored as passing these tests if they did not use their targeted arm. Figure 1 presents the percentage of highs, mediums, and lows in each suggestion condition who passed each of these five tests. Subjects also received a "total paralysis" score, which was calculated by adding the number of behavioural tests that subjects passed (producing a score with a minimum of 0 and a maximum of 5).

Chi-square analyses initially examined any impact of hypnotisability on the five behavioural tests (collapsed across suggestion conditions). Focused comparisons between highs and lows found differences in pass rates on all

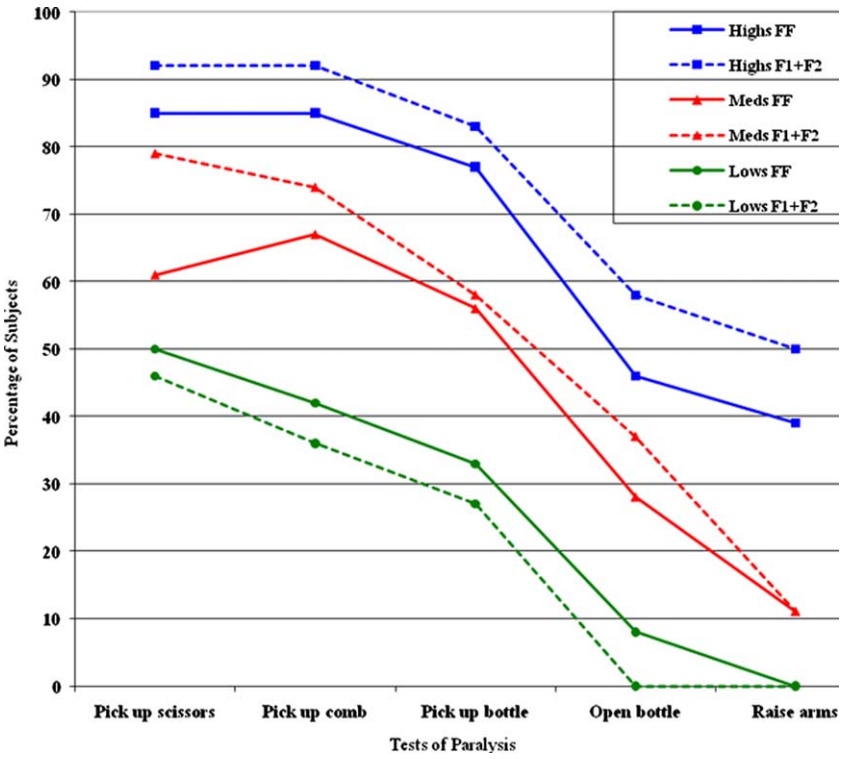

Figure 1. Subjects who passed the behavioural tests according to hypnotisability and suggestion condition. "FF" = Fully Formed; "F1 + F2" = Factor 1 + Factor 2.

five tests, all χ^2s(1, $N = 48$) > 9.00, all ps < .003, with highs more likely to pass each test than lows. Comparisons between highs and mediums found a difference in pass rates only on the raise arms test, $\chi^2(1, N = 62) = 10.96$, $p = .003$, with 11 highs passing this test compared to only four mediums. Finally, comparisons between mediums and lows found differences in pass rates on the pick up comb, pick up bottle, and open bottle tests, all χ^2s(1, $N = 60$) > 3.95, all ps < .05, with mediums more likely to pass these three tests than lows. Thus, highs and mediums passed more behavioural tests than lows. Chi-square analyses then compared the Fully Formed and Factor 1 + Factor 2 conditions within each hypnotisability group across the five behavioural tests. For highs, for mediums, and for lows separately, we found no significant differences across the two suggestions, all χ^2s < 1.41, all ps > .23. This indicates that the Fully Formed suggestion and the Factor 1 + Factor 2 suggestion were equally likely to produce paralysis.

This is consistent with our analysis of total paralysis scores. A 3 (hypnotisability: highs vs. mediums vs. lows) × 2 (suggestion: Fully Formed vs. Factor 1 + Factor 2) between subjects ANOVA of these scores revealed only a significant main effect of hypnotisability, $F(2, 79) = 12.67$, $p < .0005$. Follow-up comparisons ($p < .05/3$) revealed that highs passed more behavioural tests ($M = 3.60$, $SD = 1.68$) than lows ($M = 1.22$, $SD = 1.35$); mediums ($M = 2.41$, $SD = 1.76$) did not differ from either highs or lows. The following transcript illustrates the compelling experience of one subject in the Factor 1 + Factor 2 condition in response to the behavioural tests.

Hypnotist: I noticed that you reached across your body to pick up the objects with your right hand. Why did you do this?
Subject: I can't move my left arm.
Hypnotist: Why can't you move your left arm?
Subject: It's not there.
Hypnotist: Tell me more about that. How does it feel?
Subject: Like it's not there.
Hypnotist: Ok. Now I'd like you to open your eyes again and this time I'd like you to pick up the bottle.
Subject: (Reaches across body and picks up bottle with dominant hand).
Hypnotist: Tell me, what can a bottle be used for?
Subject: Drinking.
Hypnotist: Now I'd like you to open the bottle.
Subject: (Opens bottle with dominant hand only).
Hypnotist: Ok. Now I'll just take back the bottle. Now just close your eyes again and continue to listen to my voice. Tell me, did you find it easy or hard to open the bottle?
Subject: Difficult.
Hypnotist: Why is that?
Subject: Because I only have one hand.

Hypnotist: Where is your other hand?
Subject: I don't know.

Notably, highs experienced paralysis whether they were specifically instructed to (as Factor 1 in the Factor 1 + Factor 2 condition) or not (as in the Fully Formed condition).

Response to questions indexing awareness of the suggestion

During the behavioural tests, if subjects responded in a way that was consistent with the suggestion (i.e., they only used their nontargeted arm), they were asked why they did so ($n = 59$). Subjects were scored as being unaware if they never attributed their behavioural responses to the suggestion. Of the 59 subjects who were asked questions indexing awareness, 58 were unaware of the suggestion. Only one medium displayed awareness of the suggestion, saying that she picked up the scissors and comb with her nontargeted hand because "I've been told that it [targeted arm] belongs to someone else". When asked why they reached across their body to pick up objects with their nontargeted hand, subjects who were unaware of the suggestion generated confabulations such as "because I am right handed", "it was easier to do", "because that's the only hand I can use", and "my [targeted] hand wouldn't move".

High hypnotisable subjects in the Factor 1 + Factor 2 condition, who received the Factor 2 instruction that any explanation for their paralysis would seem plausible, gave sensible descriptions of their paralysis when asked about their target arm (e.g., "I noticed you opened the bottle using just one hand. Why is that?"). They made comments such as: "It's asleep", "it's hard to move ... it's really sore", and "my left hand didn't move ... pins and needles." These subjects remained consistent in their explanations and could elaborate on them if prompted. For instance, when the hypnotist asked one subject why he reached across his body to pick up the objects with his dominant hand, he replied that his arm was tired. Later, when asked why he opened the bottle with just one hand, he said "I slept on it weird and it's tired today."

Experiencing the somatoparaphrenia delusion

To determine whether subjects experienced the somatoparaphrenia delusion, their responses to the arm ownership test were categorised as either: (1) no experience of delusion (i.e., subjects acknowledged ownership of the targeted

arm) or (2) experience of delusion (i.e., subjects either did not acknowledge arm ownership, denied arm ownership, or said the targeted arm belonged to someone else). Overall, eight subjects (seven highs and one medium) experienced the delusion. All had received the Fully Formed suggestion that their arm belonged to someone else. Given the small numbers, we did not conduct formal statistical tests. However, these numbers suggest that highs were more likely to experience the somatoparaphrenia delusion than either mediums or lows. Also, these numbers imply that amongst these highs, the Fully Formed suggestion was more successful in creating the delusion than the Factor 1 + Factor 2 suggestion. Specifically, whereas 53.8% of highs in the Fully Formed condition made comments about arm ownership that were consistent with the delusion, no highs in the Factor 1 + Factor 2 condition did so.

Of the eight subjects who experienced the delusion, five failed to acknowledge that their arm belonged to them and made comments such as "I don't know whose arm it is." Two specifically denied that their arm belonged to them and made comments such as "it's not mine". And one said that her arm belonged to someone else, saying "it's an old man's". For example, one high given the Fully Formed suggestion said in response to the arm ownership test:

Subject:	Is that mine?
Hypnotist:	Do you think it's yours?
Subject:	It looks a bit different.
Hypnotist:	In what ways does it look different?
Subject:	Longer fingers.
Hypnotist:	Okay. So whose arm do you think it is?
Subject:	Not mine!

During the postexperimental inquiry, subjects made reality and belief ratings about their delusion experiences on a 7-point Likert scale. Separate 3 (hypnotisability) × 2 (suggestion) between subjects ANOVAs of reality and belief ratings revealed significant main effects of hypnotisability (reality: $F(2, 78) = 16.22$, $p < .0005$; belief: $F(2, 76) = 11.15$, $p < .0005$) and significant main effects of suggestion (reality: $F(1, 78) = 16.88$, $p < .0005$; belief: $F(1, 76) = 14.90$, $p < .0005$). The Hypnotisability × Suggestion interactions were not significant. Follow-up comparisons ($p < .05/3$) revealed that highs rated their experience of somatoparaphrenia as more real and believable (reality $M = 2.58$, $SD = 1.87$; belief $M = 2.60$, $SD = 2.04$) than both mediums (reality $M = 1.08$, $SD = 1.32$; belief $M = 0.74$, $SD = 2.00$) and lows (reality $M = 0.39$, $SD = 1.31$; belief $M = 0.77$; $SD = 2.00$); mediums and lows rated reality and belief similarly. Notably, collapsed across hypnotisability, subjects given the

Fully Formed suggestion rated their experience of somatoparaphrenia as more real ($M = 2.02$, $SD = 1.81$) and believable ($M = 2.02$, $SD = 2.12$) than subjects given the Factor 1 + Factor 2 suggestion (reality $M = 0.67$, $SD = 1.30$; belief $M = 0.61$, $SD = 1.32$). However, the interactions were not significant. These results are consistent with the behavioural data and indicate that highs experienced a more compelling delusion than mediums and lows, and that the Fully Formed suggestion was more effective than the Factor 1 + Factor 2 suggestion.

Response to challenges

All subjects received three challenges to their suggested experience—a contradiction, a confrontation, and a peer model. We focus on the impact of each challenge on the subset of eight subjects who experienced the somatoparaphrenia delusion.

In the contradiction, if subjects had previously denied ownership of their arm, the somatoparaphrenia delusion was challenged by asking them what they would say if a doctor (or the person they claimed their arm belonged to) entered the room and said that the targeted arm actually belonged to the subject. If subjects openly disagreed with the doctor (e.g., "he's wrong because it's not fine"), or provided evidence to the contrary (e.g., "I don't have control over it"), their response was categorised as "maintained experience". If subjects agreed with the doctor (or person they claimed their arm belonged to), their response was categorised as "breached experience". If subjects commented in other ways (e.g., "I'm not sure what I'd say"), their responses were categorised as "unclear". Of the eight subjects who experienced the delusion, three (37.5%) maintained their experience in the face of the contradiction, three (37.5%) breached, and two (25.0%) gave unclear responses.

In the confrontation, subjects were asked to look into a mirror and to focus on their arms. They were asked: (1) "do they look how they normally look?" and (2) "do they feel how they normally feel?" If subjects said that their targeted arm did not look or feel normal (e.g., "it looks a bit different . . . longer fingers"), their responses were categorised as "maintained experience". If subjects said that their targeted arm looked and felt normal, their responses were categorised as "breached experience". If subjects commented in other ways (e.g., "I don't know"), their responses were categorised as "unclear". Of the eight subjects who experienced the delusion, three (37.5%) subjects maintained their experience in the face of the first confrontation question ("do they look how they normally look?"), four (50.0%) breached, and one (12.5%) gave an unclear response. Similarly, four (50.0%) subjects maintained their experience in the face of the second

confrontation question (“do they feel how they normally feel?”), two (25.0%) breached, and two (25.0%) gave unclear responses. Here is how one high experiencing the somatoparaphrenia delusion reacted to this confrontation challenge:

Hypnotist: Can you tell me about this arm?
Subject: It’s old (subject scrunches up her face in disgust as she looks at the arm).
Hypnotist: Whose arm is it?
Subject: It’s an old man’s (maintains strong expression of disgust as she continues to look at the arm).
Hypnotist: What do you see in the mirror?
Subject: It’s old, and it’s got knuckles, and it’s all fingers.

In the peer model, subjects were asked to watch a video reenactment of a patient with somatoparaphrenia. Analyses focused on responses to three questions: (1) “what did you think about the woman in the video?”, (2) “did her behaviour seem normal?”, and (3) “thinking about what she just said about her hand belonging to the other woman, how does that make you feel?” Here, subjects were commenting mostly on their reactions to the woman in the video rather than their own experiences at that moment, so responses were not categorised in terms of maintaining or breaching experiences. Rather, specific responses to each question were categorised. Of the eight subjects who experienced the delusion, in response to the first question (“what did you think about the woman in the video?”), six (75.0%) said that the woman was mistaken, one (12.5%) said that she was correct, and one (12.5%) said that she was hypnotised. In response to the second question (“did her behaviour seem normal?”), six (75%) said that her behaviour was abnormal, one (12.5%) said her behaviour was normal, and one (12.5%) said her behaviour was “sort-of” normal. Thus, the majority believed that the woman in the video was mistaken and that her behaviour was abnormal. However, in response to the third peer model question (“thinking about what she just said about her hand belonging to the other woman, how does that make you feel?”), subjects experiencing the temporary somatoparaphrenia delusion made a number of interesting comments. Two said that they felt similar to the woman in the video. One said: “Maybe I feel quite the same, it’s weird. It’s not me moving it, it’s something... I don’t know”. The other said: “feels like it’s not really mine”. Thus, for a few subjects, the peer model challenge seemed to reinforce rather than diminish the somatoparaphrenia delusion.

DISCUSSION

The aims of this study were to produce a credible laboratory analogue of somatoparaphrenia using first a Fully Formed suggestion and second a Factor 1 + Factor 2 suggestion that aimed to generate the delusion from its hypothesised underlying factors: paralysis plus disrupted belief evaluation. This is the first time that hypnotic methods have been applied to this delusion. Our findings indicate that hypnosis can model somatoparaphrenia in a small group of high hypnotisable individuals.

Hypnotic somatoparaphrenia

Seven highs (28% of all highs) and one medium—all from the Fully Formed condition—failed to acknowledge ownership of their targeted arm, denied ownership of the arm, or claimed that their arm belonged to someone else on the ownership of arm test. These experiences were compelling. For instance, during the postexperimental inquiry, these subjects made comments such as: "It [targeted arm] just didn't feel like it belonged to me . . . it didn't feel like it was connected", "It [targeted arm] felt like it was removed. Wasn't feeling like the rest of my body . . . This [targeted] hand was like it was a dead weight . . . it was just there, but it wasn't part of me . . . and there wasn't any awareness that it was mine", "[the targeted arm] just didn't feel like anything. Felt like it wasn't there", and "I felt like I had one arm . . . it wasn't normal at all . . . it was weird". The high hypnotisable subject who said that her arm belonged to an old man commented that her experience "was very convincing, I was grossed out by it [targeted arm]".

Despite these compelling experiences, this pass rate of 28% for highs is lower than pass rates reported for other hypnotic delusions with similar subjects. For instance, hypnotic analogues of mirrored-self misidentification produced pass rates of 67% (Barnier et al., 2008) and 68% (Barnier et al., 2011), hypnotic analogues of sex-change delusions produced pass rates of 89% (Noble & McConkey, 1995), and hypnotic analogues of identity delusions produced pass rates of 78% (Cox & Barnier, 2009a).The lower pass rate in this experiment may be due, in part, to the tests of paralysis that preceded the test of the somatoparaphrenia delusion (ownership of arm test). In other work on hypnotic delusions, tests of the suggestion were administered immediately after the suggestion. But in this study we gave subjects five behavioural tests of paralysis first. These may have progressively breached subjects' experiences of hypnotic somatoparaphrenia before we had a chance to test it. In our ongoing work on hypnotic somatoparaphrenia, we have administered an immediate test of the suggestion, followed by paralysis

tests and have obtained a pass rate of 60%. Notably though, in the present study, a subset of highs passed all of the paralysis tests and still reported delusional experiences on the ownership of arm test.

Challenging hypnotic somatoparaphrenia

Clinical delusions can be maintained over extended periods of time in the face of persistent challenges (e.g., from friends and family members). For this reason, we developed contradiction, confrontation, and peer model procedures to challenge hypnotic somatoparaphrenia. Although these challenges breached the experiences of many participants, some maintained their delusion in the face of all three challenges. There were interesting differences in the success of the challenges, both across the three and compared to other experiments involving hypnotic analogues of delusions. For subjects experiencing hypnotic somatoparaphrenia, the contradiction and confrontation were more successful in breaching the delusion than the peer model. The peer model challenge was inspired by the book *The Three Christs of Ypsilanti* (Rokeach, 1964); this was the first time this type of challenge has been used in hypnosis delusion research. This challenge was designed to explore whether subjects would give up their delusion when faced with someone expressing the same delusional beliefs. However, this challenge appeared to reinforce two subjects' experiences who claimed that they felt similar to the patient and that listening to her beliefs helped give meaning to their own experiences. In this analogue of somatoparaphrenia, the contradiction and confrontation were more successful in breaching the delusion than for other hypnotic analogues, such as hypnotic sex change, hypnotic identity delusions, and hypnotic mirrored-self misidentification (see Cox & Barnier, 2010). As already noted, this may have occurred because the suggested somatoparaphrenia experience had already been challenged by the paralysis tests.

Overall, the challenge procedures appeared to be more successful in breaching the experiences of our hypnotic subjects than occurs in many clinical cases, although, as noted later, several researchers (e.g., Brakoulias et al., 2008; Chadwick & Lowe, 1990, 1994) have reported success in reducing delusional conviction in a number of schizophrenic patients using cognitive behaviour therapy. The level of breaching in this study and similar studies may be due to the level of hypnotisability of our subjects, the types of challenges, and/or to the number of consecutive challenges that are administered in a short period of time. For instance, in our work on hypnotic mirrored-self misidentification, most subjects maintained their delusion in response to direct contradiction challenges but breached in response to visual challenges (where the hypnotist appeared in the mirror

beside the subject). Importantly, challenging hypnotised subjects presents considerably fewer risks than those associated with challenging clinical patients, so we can test a series of relentless, consecutive challenges. In all of our hypnotic analogues there has been a subset of talented hypnotic individuals who resisted all such challenges to their delusions.

As noted earlier, delusions are typically seen as resistant to challenge and yet there is clinical evidence that delusional beliefs can be shifted. For instance, Chadwick and Lowe (1990, 1994) were able to reduce the delusional conviction of a number of schizophrenic patients. They encouraged patients to think of their delusional belief as just one possible interpretation of events. The experimenter then pointed out inconsistencies in the client's belief, showing alternative explanations, and the two sometimes agreed that the alternative account was more plausible. For those who still maintained their delusion, reality testing followed. This involved the experimenter and client devising an activity that would test the delusional belief. Overall, three out of the six subjects significantly reduced their delusional conviction, and an additional two abandoned their delusional beliefs. Despite such findings, clinicians are generally cautious in directly challenging deluded individuals' beliefs lest they have unintended consequences (Coltheart, 2007) and interfere with the therapeutic relationship. For this reason, hypnotic analogues may provide a useful testing ground for exploring the impact of different types of collaborative reality testing on temporary, reversible delusions.

Somatoparaphrenia within the two-factor framework

This study explored whether suggestions that more closely model the hypothesised underlying factors of somatoparaphrenia can create delusional experiences that are at least as successful as a Fully Formed suggestion. Our Factor 1 component of the combined Factor 1 + Factor 2 suggestion drew upon Coltheart's (2007; see also Coltheart, 2005; Davies et al., 2002) proposal that Factor 1 in somatoparaphrenia involves paralysis. The Factor 2 component of the combined Factor 1 + Factor 2 suggestion was informed by Turner and Coltheart's (2010) proposal that Factor 2 involves bypassing the normal process of checking beliefs for plausibility. We found that the Factor 1 + Factor 2 suggestion was successful in creating paralysis but not somatoparaphrenia. Only the Fully Formed suggestion was effective in creating the full blown delusion. So although subjects in the Factor 1 + Factor 2 condition were given suggestions derived from the hypothesised underlying factors that contribute to somatoparaphrenia, this was not enough to initiate the belief that their arm belonged to someone else.

There are a number of possible interpretations of these findings. The first is that the two-factor explanatory framework might be incorrect or, at least, inappropriate for somatoparaphrenia; but, if not applicable to somatoparaphrenia, what other alternative account of delusions might apply then? "One-factor" theorists, who follow Brendan Maher (1974, 1988), take the view, counter to the two-factor approach, that a Factor 1 perceptual anomaly is sufficient to generate a delusional belief. However, if we are correct in hypothesising that Factor 1 in somatoparaphrenia involves paralysis, then it is clear that paralysis alone is not sufficient to generate somatoparaphrenia; many patients who develop paralysis do not generate somatoparaphrenia and the subjects in our own study who received a Factor 1 + Factor 2 suggestion manifested paralysis but not somatoparaphrenia.

Another possibility is that any "bottom-up" accounts of delusions of this type, whether one-factor or two-factor, do not apply to somatoparaphrenia. By "bottom-up" we mean any account that locates the trigger of the delusional content in some form of aberrant perceptual experience or sensory input. An influential alternative to bottom-up accounts of this type is the more traditional "Jaspers'" approach to bizarre ("primary") psychiatric delusions (see, for discussion, Langdon, in press; Langdon & Bayne, 2010); this is the alternate view that bizarre delusional content arises Fully Formed in consciousness as the immediate "brute product" of an underlying disease process. However, to argue for such a "brute product" account would ignore the compelling evidence, as reviewed in the Introduction, that paralysis is a necessary (bottom-up) causal contributor to the generation of somatoparaphrenia. It is for these reasons that we continue to favour a two-factor account of somatoparaphrenia and suggest that the reason(s) our Factor 1 + Factor 2 suggestion did not result in somatoparaphrenia lie with this study's hypnotic operationalisation of Factor 2, as discussed in more detail later.

Somewhat unexpectedly, the Fully Formed suggestion was just as effective as the Factor 1 + Factor 2 suggestion in creating paralysis, reinforcing that the Factor 1 component of our combined Factor 1 + Factor 2 suggestion is still worth pursuing. Recall that the majority of our subjects (irrespective of suggestion condition) duly experienced paralysis. This is perhaps not surprising since paralysis is a hypnotic item that is usually passed by a large proportion of hypnotic subjects (Barnier & McConkey, 2004). However, the subjects given the Fully Formed suggestion did not receive an explicit suggestion to experience paralysis. Rather, they were told that their (targeted) arm would belong to someone else—no mention was made of paralysis. Yet, without direct instruction, these subjects in the Fully Formed condition appeared to reason "backwards" that they would not be able to move the "other person's arm" and so manifested paralysis of the targeted arm as a component of somatoparaphrenia. So, if this Factor 1 paralysis

suggestion for somatoparaphrenia is correct, one possible reason that the Factor 1 + Factor 2 suggestion did not generate somatoparaphrenia is the inferential leap that hypnotised subjects needed to make from the Factor 1 + Factor 2 components to a full blown somatoparaphrenia belief. Some of our other findings related to the mirrored-self misidentification delusion provide partial support for this suggestion.

The only other hypnotic work that has attempted to recreate a delusion from combined Factor 1 + Factor 2 suggestions is a study on mirrored-self misidentification (Connors et al., in press). In this study, high hypnotisable subjects received either a hypnotic induction (hypnosis condition) or imagination instructions (waking condition), followed by a suggestion for either Factor 1 alone or a suggestion for Factor 1 + Factor 2. The Factor 1 suggestion in this case was that subjects would be unable to recognise the person they saw in the mirror (i.e., subjects were told "you will see a face in the mirror that you will not be able to identify"). The Factor 2 suggestion was similar to the suggestion used in the current study (i.e., subjects were told "you will not know why you are not able to recognise this person in the mirror and you will search for explanations to account for it. Any explanation you come up with will seem plausible."). Connors et al. (in press) found that 70% of subjects in the hypnosis condition reported seeing a stranger in the mirror (and passed the suggestion), compared to 22% of subjects in the waking condition. Notably, in the hypnosis condition, the Factor 1 alone suggestion was just as effective (73% pass rate) as the Factor 1 + Factor 2 suggestion (67% pass rate) in producing the delusion (suggesting that the hypnotic context, which is known to disrupt critical belief evaluation, may be sufficient to play the role of Factor 2). Such an interpretation is generally consistent with Langdon and Bayne's (2010) proposal that Factor 2 involves a form of inhibitory failure to reason about a belief as if it might not be true. Interestingly, Connors et al.'s pass rates in the hypnosis condition were remarkably similar to pass rates obtained using Fully Formed suggestions (67% pass rate in Barnier et al., 2008; 68% pass rate in Barnier et al., 2011) that specifically instructed subjects to see a stranger in the mirror. This set of results is generally consistent with our suggestion that the Factor 1 + Factor 2 somatoparaphrenia suggestion may have failed because the inferential leap from the Factor 1 + Factor 2 components was too great. The hypnotised subjects needed to work from an experience of paralysis to the belief that their arm belongs to someone else. Although mirrored-self misidentification also involves a leap from not being able to recognise one's face in the mirror to the belief that the person in the mirror is a stranger, perhaps this inferential leap is not so great for hypnotised subjects. If I cannot recognise my own face, it seems reasonable for me to assume that the unrecognisable face is a stranger.

Yet another possibility is that our Factor 1 (paralysis) suggestion may be incomplete. That is, paralysis alone may not be sufficient to generate an initial "alien arm" thought (which Factor 2 then allows to be accepted uncritically as true). Instead, paralysis in the context of anosognosia may be necessary before somatoparaphrenia manifests, at least in the majority of cases (and despite the one reported case of somatoparaphrenia without anosognosia in the literature: Halligan et al., 1995). Although we included amnesia to prevent awareness of the hypnotic suggestion in the current study, amnesia is not analogous to anosognosia. This is because amnesia simply produces forgetting about the source of the suggestion, whereas an anosognosia suggestion would aim to capture denial about impairments to the targeted arm.

For the current study (the first of its kind to attempt to create a hypnotic analogue of somatoparaphrenia), we decided to adopt the more parsimonious hypothesis that Factor 1 in somatoparaphrenia is paralysis. The findings of this study do not completely rule out that this Factor 1 (paralysis) hypothesis is correct, even if anosognosia might also contribute to Factor 1 in some cases of somatoparaphrenia. This is because our operationalisation of Factor 2 in the current study may need to be revised. For example, if, as Connors et al. (in press) suggest, the hypnotic context can itself play the role of Factor 2 in disrupting belief evaluation, then we may need to consider what would happen if we present the Factor 1 paralysis suggestion alone; perhaps we will be just as successful in creating somatoparaphrenia as we were in this study's Fully Formed condition. Casting doubt on that proposal, however, is the current study's finding that our Factor 1 + Factor 2 suggestion was completely unsuccessful in creating somatoparaphrenia, whereas the combined Factor 1 + Factor 2 suggestion in the Connors et al. study was just as successful as the Factor 1 alone suggestion. Nevertheless, it may be that our particular Factor 2 suggestion interfered with subjects generating an alien arm thought. Recall that subjects were instructed to search for explanations for why their arm felt *paralysed* and to accept, as plausible, any thoughts or explanations that came to mind to account for the *paralysed arm*. Thus, although subjects were then instructed to forget what they had been told, they were still responding to a suggestion to generate explanations of feeling *they had a paralysed arm*; in other words, the thought of *their own arm* being unable to move may have been embedded in the causal explanations that initially came to mind. The implication here is that a less specific Factor 2 suggestion (e.g., "You will not know why the arm does not move and you will search for explanations to account for this; any explanations you come up with will seem plausible") might have been more successful.

CONCLUSIONS AND FUTURE DIRECTIONS

This first hypnotic study of somatoparaphrenia is important because it indicates that hypnosis can successfully recreate somatoparaphrenia for some high hypnotisable people. Specifically, both clinical cases of somatoparaphrenia and our subset of subjects display similarities in the way they describe their delusional belief, react to environmental stimuli and resist information that conflicts with their belief.

Future work can refine and test this analogue in various ways. For instance, in both the Fully Formed and Factor 1 + Factor 2 conditions, we can administer an anosognosia (rather than amnesia) suggestion that instructs subjects to deny that their own arm is impaired in any way. An anosognosia suggestion may help minimise the inferential leap from arm paralysis to the full-blown delusion. Indeed, Davies et al. (2002) suggested that patients with somatoparaphrenia may attribute ownership of a paralysed limb typically to others because they have the unusual experience of not being able to move their arm on command, yet do not realise that it is paralysed. Future work might also explore a Factor 1 paralysis suggestion alone and alternative Factor 2 suggestions, as discussed earlier, as well as examine fluctuations in belief during the suggested somatoparaphrenia delusion. For instance, some of our subjects fluctuated in their delusional conviction across the three challenges.

A number of theorists have noted that the hypnotic context places strong demands on experimental subjects. To address this issue of demand characteristics, future work should also implement Orne's (1962) "real-simulating" design to explore the demands associated with hypnotic somatoparaphrenia. This design includes the control condition of low hypnotisable subjects who are instructed to fake hypnosis where the hypnotist is blind to subjects' real or simulating status. If "reals" and "simulators" produce different patterns of behaviour, then we can infer that the responses under genuine hypnosis cannot be attributed solely to the demand characteristics associated with the hypnotic setting.

We conclude by acknowledging that there are differences between clinical and hypnotic delusions that should temper conclusions drawn from such work. Nevertheless, this study and studies like it are important because they provide a useful framework to test and refine theoretical perspectives and inform the design of psychological therapy for clinical delusions. Creating virtual patients in this way may also provide a valuable testing ground for exploring treatment possibilities.

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