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Belief, delusion, hypnosis, and the right dorsolateral prefrontal cortex: A transcranial magnetic stimulation study☆

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ABSTRACT

According to the Two-Factor theory of delusional belief (see e.g. Coltheart at al., 2011), there exists a cognitive system dedicated to the generation, evaluation, and acceptance or rejection of beliefs. Studies of the neuropsychology of delusion provide evidence that this system is neurally realized in right dorsolateral prefrontal cortex (rDLPFC).

Furthermore, we have shown that convincing analogues of many specific delusional beliefs can be created in nonclinical subjects by hypnotic suggestion and we think of hypnosis as having the effect of temporarily interfering with the operation of the belief system, which allows acceptance of the delusional suggestions. If the belief system does depend on rDLPFC, then disrupting the activity of that region of the brain by the application of repetitive transcranial magnetic stimulation (rTMS) will increase hypnotizability. Dienes and Hutton (2013) have reported such an experiment except that it was *left* DLPFC to which rTMS was applied. An effect on a subjective measure of hypnotizability was observed, but whether there was an effect on an objective measure could not be determined.

We report two experiments. The first was an exact replication of the Dienes and Hutton experiment; here we found no effect of rTMS to lDLPFC on any hypnotic measure. Our second experiment used rTMS applied to *right* rather then left DLPFC. This right-sided stimulation enhanced hypnotizability (when hypnotic response was measured objectively), as predicted by our hypothesis.

These results imply a role for rDLPFC in the cognitive process of belief evaluation, as is proposed in our two-factor theory of delusion. They are also consistent with a conception of the acceptance of a hypnotic suggestion as involving suspension of disbelief.

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1. Introduction

In this paper we are concerned with the explanation of belief formation – that is, how beliefs are generated, evaluated, and adopted or rejected – and in particular with the neuropsychology of these belief processes. We approach this topic from two angles. The first is the study of delusional beliefs in clinical patients. The second is the use of hypnotic procedures to manipulate belief formation in healthy subjects.

With respect to delusional belief, a distinction can be drawn between polythematic delusion and monothematic delusion (see e.g. Coltheart, 2013; Davies, Coltheart, Langdon, & Breen, 2001; Radden, 2011). A polythematic delusional condition is one in which the deluded person has a variety of different and unrelated delusional beliefs; a monothematic delusional condition is one where the deluded person has only a single delusional belief or at most a small set of delusional beliefs all related to a single theme. Our Two-Factor theory of delusion, described below, has been primarily concerned with monothematic delusions.

There are numerous distinct forms of monothematic delusion. They include Cotard delusion ("I am dead"), Capgras delusion ("My wife has been replaced by an impostor", Fregoli delusion ("People I know are following me around, but in disguise so that I can't recognize them"), somatoparaphrenia ("This is not my arm, it is my aunt's" – the patient here is referring to her own arm), erotomania aka de Clérambault's syndrome (" a famous person X is in love with me but keeps this a secret"), mirrored-self misidentification ("When I look into a mirror, the person I see is not me, but a stranger who looks like me"), alien control delusion ("other people can control the movements of my body against my will") and various others: for reviews of these monothematic delusions see Davies et al. (2001), Coltheart (2007) and Coltheart, Langdon, and McKay (2011).

With respect to the use of hypnotic procedures to influence belief formation in healthy subjects, we have over the past few years shown that features of some of these forms of monothematic delusional belief can be induced in high-hypnotizable subjects by appropriate hypnotic suggestions. We have demonstrated this for the mirrored-self misidentification delusion (Barnier et al., 2008), somatoparaphrenia (Rahmanovic, Barnier, Cox, Langdon, & Coltheart, 2012), erotomania (Attewell, Cox, Barnier, & Langdon, 2012), Fregoli delusion (Cox, Elliott, & Barnier, 2013) and alien control delusion (Cox & Barnier, 2010). We have argued (e.g. Connors, Barnier, Coltheart, Cox, & Langdon, 2012; Connors, Cox, Barnier, Langdon, & Coltheart, 2012, 2013; Cox & Barnier, 2010a, 2010b; for an overview of this work see; Connors, 2015) that in these studies of hypnotically-induced delusional beliefs, simply being in the hypnotic state by itself impairs belief evaluation, a view that is consistent with prior observations on hypnosis, such as that people tend to accept ideas during hypnosis that they would normally reject in an ordinary, everyday state of consciousness (Shor, 1959) and that a hypnotic induction reduces the ability of high-hypnotizable subjects to distinguish between suggested and real events (Bryant & Mallard, 2003; see also; Barnier et al., 2008).

1.1. The two-factor theory of delusional belief

What could give rise in clinical patients to the kinds of monothematic delusions we have described above – how might these be explained? A Two-Factor theory of monothematic delusion was proposed by Langdon and Coltheart (2000) and Davies et al. (2001), and subsequently elaborated by e.g. Coltheart (2007) and Coltheart et al. (2011). According to this theory, to account for any kind of monothematic delusion we just need to discover the answer to two questions. The first is: what brought the delusional thought to mind in the first place? The second is: why was this thought then adopted as a belief, rather than being dismissed from consideration as it should have been (because of its implausibility, and because of the strength of the evidence against it)?

The development of this Two-Factor theory was provoked by seminal work on the Capgras delusion by Ellis, Young, Quayle, and de Pauw (1997). It was known that when subjects are viewing photographs of faces, autonomic responses (as indicated by changes in skin conductance) are normally much larger when the faces are familiar than when they are unfamiliar. This difference was shown by Ellis and colleagues to be present also in nondelusional psychiatric patients but absent in patients with Capgras delusion, a finding confirmed by Hirstein and Ramachandran (1997) and Brighetti, Bonifacci, Borlimi, and Ottaviani (2007). Hence in Capgras delusion patients, the autonomic response to the face of a familiar person such as a spouse, is the response to be expected if that face were the face of a stranger: which, plausibly, prompts the idea that the person being looked at *is* a stranger.

But this disconnection between the face recognition system and the autonomic nervous system cannot be the complete explanation of the Capgras delusion, because it has been shown by Tranel, Damasio, and Damasio (1995) that patients with damage to ventromedial frontal cortex also do not show greater autonomic responsivity to familiar compared to unfamiliar faces: and yet these patients were not delusional. Proponents of the Two-Factor theory therefore argue that there must be some additional impairment in patients with Capgras delusion. A disconnection between the face recognition system and the autonomic nervous system is responsible for the content of the Capgras delusion; a second impairment is responsible for the maintenance of this content as a belief. That is, the normal processes of belief evaluation and belief acceptance or rejection are impaired in patients with Capgras delusion: that is the second factor.

The various kinds of monothematic delusional beliefs differ from each other with respect to the content of the belief. It follows that Factor 1 must be different for each kind of monothematic delusional belief, since it is Factor 1 that is responsible for the content of the belief. For example, the specific content of the Capgras delusional belief is a consequence of the failure of autonomic response to familiar faces. It is therefore necessary for proponents of the Two-Factor theory to identify, for each type of monothematic delusion, what neuropsychological impairment is present that is plausibly connected to the specific content of that particular delusional belief; and we have made proposals regarding this

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