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Editorial

Hypnosis and cognitive neuroscience: Bridging the gap

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Controversy and disagreement lie at the heart of scientific advance and hypnosis has had its fair share of detractors, given its chequered history in some areas of medicine and long standing association with mysticism and stage hypnotism (Raz and Shapiro, 2002). Nevertheless, despite some understandable scepticism, hypnosis's compelling behavioural and experiential phenomena continued to provide a small number of neuroscientists with a rich paradigm for understanding the nature of hypnosis and using it to manipulate aspects of phenomenological consciousness (Spiegel et al.,1982; Kihlstrom, 1987; Crawford and Gruzelier, 1992; Kirsch and Lynn, 1995; Oakley, 1999; Kosslyn et al., 2000; Raz et al., 2002; Barnier and McConkey, 2003).

Recently, however, hypnosis has begun to attract renewed interest from cognitive and social neuroscientists interested in using hypnosis and hypnotic suggestion to test predictions about normal cognitive functioning (Jamieson, 2007; Oakley and Halligan, 2009; Terhune and Kadosh, 2012; Del Casale et al., 2012; Priftis et al., 2011; Connors, 2012; Hoeft et al., 2012).

This renewed interest was partly facilitated by the growing acceptance of consciousness as a legitimate field of enquiry for cognitive neuroscience (Marcel and Bisiach, 1988; Velmans, 1996) but also critically, by the findings from neurophysiological tools (Hinterberger et al., 2011) and in particular the widespread availability of functional-imaging techniques (Raz and Shapiro, 2002; Oakley and Halligan, 2009). In tandem with improvements in experimental design and subject screening, these studies are now making inroads into the functional anatomy of hypnosis (Jamieson, 2007) as well as paving the way for its use as an experimental tool for neuroscience research (Oakley, 2006). In particular these studies have begun to address the sceptic's concern regarding the subjective reality and comparability of hypnotically suggested phenomena previously dependent on the subjects' largely unverifiable report and behaviour (Raz and Campbell, 2011; Terhune and Kadosh, 2012).

As one indication of the progress made, the cover of this special issue brings together one of the very first and one of the most recent ways of demonstrating objectively the power of suggestion. The foreground contains Chevreul's pendulum while the background provides a representation of brain activations seen following hypnotic suggestion during functional magnetic resonance imaging (fMRI). The pendulum effect was described in 1833 by the French chemist Michel-Eugene Chevreul in an open letter to the physicist André Ampère (Chevreul, 1833; Spitz, 1977). The effect involves amplifying small, unconscious (ideomotor) movements of the hand, arm and body of the individual holding the pendulum. The origin and direction of the movement is determined by the content of the concurrent suggestions provided by another person, by environmental cues and/or by implicit expectancies (via autosuggestion) on the part of the person holding the pendulum, who experiences the movement as occurring 'all by itself'. This ideomotor response captured by the Chevreul pendulum effect is a classic hypnotic phenomenon responsible for the apparently spontaneous movements experienced in the context of water divining, automatic writing, the use of ouija boards and table turning in séances. It is also a good example of 'cold control' – described by Dienes and Hutton (2013). The background image on the cover features approximate surface projections of activated voxels revealed by fMRI during hypnotically suggested heat pain (Derbyshire et al., 2004), superimposed on a glass brain. These activations were similar to those produced by an actual painful heat stimulus but different from those seen when the hypnotised subject was instructed to imagine the same pain experience.

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In addition to demonstrating the future potential for this growing field, the contributors to this special issue illustrate how methodological and theoretical advances can return novel and experimentally verifiable insights relevant to neuroscience in general and the neuroscience of consciousness in particular. Moreover, the special issue includes several new and provocative contributions from a range of established and up and coming researchers that cannot be gained from any other source.

In the opening paper Kihlstrom (2013), a pioneer in the neuroscience of hypnosis, provides the inexperienced reader with an excellent overview of the area. He reminds us how, despite being a "late comer", hypnosis played a significant role in the "consciousness revolution" within psychology and cognitive science (Hilgard, 1987), and in particular rekindling interest in, and acceptance of, research in unconscious mental processing (Kihlstrom, 1987, 2007). The paper then reviews neuroscience research in hypnosis which can broadly be divided into two main approaches depending on the primary focus of interest. The first more 'intrinsic' approach is directed at providing a better understanding of the neuro–cognitive nature of hypnosis itself and of hypnotic phenomena in general (see also Posner and Rothbart, 2010). Central to the intrinsic approach is the focus on understanding the behavioural, experiential and neuro-cognitive nature of hypnosis and hypnotically suggested subjective changes. Relevant research here includes studies exploring the neural correlates of individual differences in hypnotisability, alterations in neural activity accompanying the induction of hypnosis and the neural correlates of response to individual hypnotic suggestions, including hemispheric differences. More recently, several studies have attempted to characterise the neural signature of hypnosis by exploring alterations observed in the normal resting default mode state of brain activity following hypnotic induction procedures in the absence of suggested changes in experience (McGeown et al., 2009; Deeley et al., 2012).

The second approach reviewed by Kihlstrom (2013) under the heading 'Hypnosis as an experimental medium' looks at 'instrumental' studies that employ targeted hypnotic suggestion as a research tool to investigate a range of normal psychological processes, such as motor control, pain perception, memory and automaticity in the Stroop task, as well as abnormal processes seen in schizophrenia, delusions and conversion disorder. As Kihlstrom points out however, there is considerable overlap between the two approaches. Intrinsic studies whose primary intent is to explore suggested hypnotic phenomena such as changes in colour perception or hypnotic analgesia, for example, can equally help to elucidate the general mechanisms underlying colour vision and pain perception. Conversely, despite the primary focus of instrumental studies, many also shed light on the cognitive and biological substrates underlying hypnosis and the suggested hypnotic phenomena they rely on. While still relatively small, the instrumental approach has established historical precedence. Charcot, Janet, and Freud all employed hypnosis for the study of hysteria and dissociative disorders (Bell et al., 2011). A recent and promising extension of this approach involves using hypnotic suggestion to create "clinically informed analogues" of established structural and functional neuropsychological disorders with the intention of uncovering the underlying cognitive processes implicated in these clinical conditions (Oakley and Halligan, 2009; Connors, 2012).

The next three studies in this special issue [Cardeña et al. (2013); Dienes and Hutton (2013); Kihlstrom (2013)] and the review by Mazzoni et al. (in this issue) that follows are geared towards exploring hypnosis and hypnotic suggestibility. That is, they are primarily 'intrinsic' in intent. The final five papers all involve hypnotically suggested phenomena but are less easy to categorise. The studies by Deeley et al. (2013); Cojan et al. (2013) and Burgmer et al. (2013) all derive from an 'instrumental' interest in parallels between hypnotic and conversion disorder paralysis but focus on the nature of hypnotic paralysis as part of that interest in the 'intrinsic' question. Similarly, the final two papers, Valentini et al. (2013) and Lifshitz et al. (2013) derive from more general interests in pain perception and 'automatic' cognitive processes respectively but equally help elucidate the hypnotic phenomena they employ.

From a cognitive neuroscience perspective, relatively little is known about the underlying processes involved in the hypnotic trance state itself. To remedy this, the paper by Cardeña et al. (2013) is a good example of an intrinsic study that considers the neurophysiological basis of hypnosis in the absence of explicit suggestions (referred to as 'neutral' hypnosis). Drawing on a meticulous analysis of experiential and physiological data, and paying close attention to temporal state fluctuations, this study provides new and intriguing data that throw light on the nature of the spontaneous but trait dependent changes that occur in neutral hypnosis over time and across hypnotisability levels.

According to the "cold control" theory of hypnosis (Barnier et al., 2008) hypnotic responses comprise an intention to perform a motor or cognitive action, while the subject is unaware of the intention. In other words, if one intends to lift one's arm it will rise; but if one is unaware of the intention, the arm will appear to lift by itself, producing the classic phenomenology of the hypnotic arm levitation response. Using repetitive transcranial magnetic stimulation (rTMS), Dienes and Hutton (2013) selectively disrupt dorsolateral prefrontal cortex (DLPFC) processing on the hypothesis that, as the DLPFC is a key region involved in higher order thoughts related to performing action, it should be easier to respond to a hypnotic suggestion if it is made harder for subjects to be aware of the intention to perform an action. The results show that that the subjective rating of hypnotic suggestibility was higher after stimulation of the DLPFC and lend support to theories postulating that diminished frontal cortex functioning is related to hypnotic response.

Hypotheses regarding the differential role of hemispheric processing in hypnosis have typically tended to implicate the right-hemisphere (RH) on the basis of its association with creative, intuitive, and holistic processing. Despite evidence of RH involvement in hypnosis from behavioural or psychophysiological paradigms, neuropsychological reports testing this hypothesis have been largely neglected. No study has addressed the RH hypothesis explicitly by testing patients with lateralized brain injury. In the small case series, Kihlstrom et al. (2013) do this by assessing the hypnotisability of patients with either left- or right-hemisphere lesions. Their findings show that it is possible for brain-injured individuals to experience hypnosis, and that their responses can be assessed without unduly compromising standardised procedures. Moreover, the results showed that unilateral RH damage following stroke does not impair hypnotic responding. Although based on modest sample sizes, the current study is valuable not only for evaluating the right-hemisphere hypothesis, but also showing that people with brain damage can be as hypnotically responsive as controls.

A key issue that remains unresolved and hence relevant when considering hypnosis from a neuro-cognitive perspective is what we mean by the term ‘hypnosis’. Typically this is reserved for the putative trance state produced by an induction procedure. While related, the targeted suggestion tends to be seen as a distinct process. This distinction is based on the well-established observation that subjects responsive to suggestions used in hypnotisability tests respond whether or not they have been exposed to a hypnotic induction procedure (e.g., Braffman and Kirsch, 1999). Several accounts of ‘hypnosis’ consequently tend to make ‘suggestion’ the defining feature such that hypnosis is defined by a subject’s responsiveness to specific sorts of suggestion irrespective of whether a formal hypnotic induction procedure is used (Green et al., 2005). The issue raised by these accounts is that if ‘hypnosis’ is defined primarily in terms of the effects of suggestion, it can question whether hypnosis necessarily involves a unique altered-state of consciousness (Kirsch and Lynn, 1995). This has led some in the hypnosis community to dismiss the issue of pursuing a “special-state” or “trance” on theoretical grounds, or pragmatically given the absence of a widely recognised or agreed behavioural marker (Lynn et al., 2007). In their review paper Mazzoni et al. (2013) tackle this controversy head on. Despite the upsurge in the number of neuroimaging studies, they argue that the stalemate over the altered-state issue persists, mainly due the confounding of hypnotic trance induction and suggestion in many studies. Although their findings are tentative, they conclude that appropriately controlled neuroimaging studies do support the existence of an identifiable hypnotic state. As neither the hypnotic induction procedure nor the cortical alterations it produces are necessary for the experience of ‘hypnotic’ suggestions, the substantive issue remaining is whether a trance state enhances the experience of those suggested effects and the related brain activity.

Patients with “functional” or “psychogenic” conversion disorders present symptoms, such as paralyses, that resemble those of neurological illnesses and for which no organic or neurological cause has been established (Fink et al., 2006). Such disorders are clinically challenging, as they can comprise between 30 and 40% of patients attending neurology outpatient clinics. Related to this, is one of most fascinating characteristics of hypnosis – namely the ability to produce marked alterations in volitional control. Highly hypnotically suggestible subjects report being unable to execute simple motor acts in response to specific suggestions. The similarities in reported experiences between conversions disorder patients and hypnotised subjects responding to suggestions of paralysis, raised the possibility that such symptoms were generated by the same kinds of cognitive and neural processes (Bell et al., 2011).

The potential for exploring this similarity was shown by Halligan et al. (2000) and others when successfully attempting to model conversion disorders (Ward et al., 2003; de Lange et al., 2007; Cojan et al., 2009a,b). Collectively these studies provide evidence of engagement of a range of prefrontal ‘executive’ inhibitory regions when attempting to move the paralysed limb. However, while earlier PET studies implicated orbitofrontal cortex (OFC) and anterior cingulate cortex (ACC) in involuntary inhibition of movement (Halligan et al., 2000; Marshall et al., 1997; Ward et al., 2003), subsequent fMRI studies attributed these activations to the main effects of hypnosis (Cojan et al., 2009b). Accordingly, it is not surprising that the special issue contains three different papers attempting to elucidate different but related aspects of the functional anatomy of suggested limb paralysis.

The first paper by Deeley et al. (2013) describes an fMRI study involving eight subjects selected for high hypnotic suggestibility that examines the functional anatomy of upper limb movement during hypnosis, where subjects attempt to move following limb paralysis suggestions. Combining objective and subjective measures of movement in conjunction with measurements of brain activity the main finding was greater supplementary motor cortex (SMA) and ACC activation in the suggested paralysis condition relative to normal conditions. This is consistent with the role of SMA in motor intention and planning and the involvement of ACC, BA 24 in involuntary, as well as voluntary, inhibition of prepotent motor responses. The generalisability of these findings and specific contributions of SMA, and ACC to involuntary inhibition need to be assessed in future studies by measuring the neural correlates of both voluntary and involuntary inhibition in highly hypnotisable subjects across a variety of tasks requiring motor and non-motor inhibition.

Debate continues as to whether direct inhibition of motor systems is responsible for hypnotically induced paralysis and by extension motor conversion. Cojan et al. (2009a) provided an alternative account using a go – no go task to examine brain activation during movement preparation, execution, and inhibition in a group selected for high hypnotic suggestibility employing separate suggested and feigned paralysis conditions. This study found that highly hypnotically suggestible participants exhibited normal motor cortex activation during a movement preparation phase, but right ACC, bilateral OFC and extrastriate visual area increases during the paralysis condition which were interpreted as being indicative of state-related hypnosis changes rather than an inhibitory mechanism.

In this special issue Cojan et al. (2013) use a modified bimanual Go–No go task performed either as a normal baseline condition or during unilateral paralysis following a hypnotic suggestion to compare motor inhibition mechanisms during hypnosis. Given the high temporal resolution and proven effectiveness in Go–No go trials, they employed topographical electroencephalography (EEG) analysis rather than fMRI to investigate both the spatial organisation and temporal sequence of the neural processes involved in these different conditions. Although motor preparatory activations were similar in all conditions, their results unlike Deeley et al. (2013) suggest paralysis is not caused by direct motor inhibition, such as in voluntary suppression of actions, but rather differential enhancement of executive control systems mediated by right prefrontal areas.

The paper by Burgmer et al. (2013) provides yet another perspective on the neural substrates underlying voluntary and involuntary motor activation in hypnotic paralysis. Unlike the two previous papers, Burgmer et al. (2013) are concerned to differentiate movement observation (passive experimental condition) and imitation (active motor effort) following a left limb paralysis induced by hypnosis in control subjects. The passive condition was employed as a control given that activation of the motor network during movement observation is thought to be mediated by a mirror neuron system independent of voluntary factors in movement generation (Burgmer et al., 2006). The results showed that hypnotic paralysis during movement imitation induced hypo-activation of the contralateral sensorimotor cortex and ipsilateral cerebellum. Hyperactivation of ACC, middle frontal gyrus (MFG), and insula during the attempt to move under hypnotic paralysis was unrelated to the executive motor impairment and was interpreted as reflecting alteration in specific aspects of attention, conflict-detection and self-representation. Critically, hypnotic paralysis did not affect the function of the mirror neuron system, suggesting that early motor processes, such as intention to move or initiate movement are not disturbed in hypnotically suggested paralysis.

It is well-established that hypnotically suggested analgesia can offer significant reduction in awareness of both clinical and experimental pain (Montgomery et al., 2000). Over the past 20 years an extensive functional imaging literature has demonstrated that pain experience is mediated via activation of a network of cortical regions including the ACC, insula, prefrontal regions, and primary (S1) and secondary (S2) somatosensory cortices. In a landmark study, Derbyshire et al. (2004) helped identify brain areas directly involved in the generation of pain, using hypnotic suggestion to create an experience of pain in the absence of any noxious stimulus. In contrast to imagined pain, fMRI revealed significant changes during this hypnotically induced pain experience within the thalamus and ACC, insula, prefrontal, and parietal cortices (represented in the cover image of this Special Issue). These findings compare well with the activation patterns during pain from nociceptive sources and provide the first direct experimental evidence in humans linking specific neural activity with the immediate generation of a pain experience.

It is well known that the perception of pain can be influenced by a number of cognitive manipulations such as attentional focussing (Bantick et al., 2002), meditation (Perlman et al., 2010), pain expectation and anticipation (Porro et al., 2002), placebo/nocebo experience (Kong et al., 2008) and, hypnotic suggestion (Derbyshire et al., 2009). The interesting study by Valentini et al. (2013) investigates evidence provided by previous reports (Rainville et al., 1997; Hofbauer et al., 2001) that hypnotic suggestion for changes in perceived intensity or affective valence of a painful stimulus could selectively influence subjective report and be mediated by different brain areas. In contrast to previous work, pain was created using pulsed laser stimulation rather than directly applied heat and EEG employed rather than positron emission tomography (PET). Valentini et al. (2013) found the expected modulation of affect and intensity dimensions of pain by hypnotic suggestion in highly hypnotically suggestible participants, but not in those classified as low in hypnotic suggestibility. However, the manipulation was more specific to subjective reports of pain unpleasantness (affect) than it was for reports of pain intensity. In addition modulatory suggestions were found to be more effective in increasing, compared to decreasing the targeted subjective experience. The EEG data was interpreted as being consistent with top–down influences underlying the modulatory effects of the hypnotic suggestion conditions.

The final intriguing paper by Lifshitz et al. (2013) builds on a series of reports that Raz and colleagues inspired over the past decade. This involves the use of hypnotic suggestion to control or manipulate automatic processes – using specific suggestions capable of producing effects difficult to fake, such as elimination of the Stroop effect. Collectively, these studies demonstrate the influence that suggestion can have over automatic processes. In this multifaceted study, the authors marshal an array of converging evidence that shows the capacity of suggestion to "derail" deeply ingrained automatic processes such as reading. In addition, they report preliminary data indicating that hypnotic suggestion can in highly responsive individuals override several effortful automatic processes including the audiovisual integration of the McGurk effect. In addition to reviewing published work, the authors suggest two new directions by providing pilot studies for natural extensions of the previous Stroop work. Collectively, these findings open up a promising future research vein that could serve to clarify underlying cognitive mechanisms and inform therapeutic applications of top–down control implied in hypnosis.

Although selective, the papers in the special issue make a strong case that the effects of hypnosis and hypnotic suggestion are more than capable of being harnessed by experimental methodologies and contributing to developments in cognitive and developmental neuroscience (Oakley and Halligan, 2009; Raz and Campbell, 2011). There is a wealth of experimental data on hypnosis that still awaits neuroscientific explanation.

For example, little primary research exists on the role of developmental factors in hypnotisability despite the finding that children are more hypnotisable than adults (Raz, 2012). From a cognitive neuroscience perspective, the use of effective hypnotic analogues for clinical conditions require better articulation of the phenomenological experience so that hypnotic suggestions can faithfully replicate the relevant clinical symptoms (Woody and Szechtman, 2011). The correspondences between hypnotically suggested phenomena and their neurological counterparts also provide research challenges for further development of practical clinical interventions such as the recently reported reduction of sensory extinction effects after stroke (Maravita et al., 2012). Finally, we simply do not know the reconstructive process whereby hypnotic suggestions (or suggestions per se) are cognitively processed and translated into subjective experiences. The production of consistent outcomes suggests the employment of a set of common, largely implicit, 'expectations' regarding the appropriate experience, role or symptom presentation. The nature of such experiences cannot be simply addressed by brain activity studies. In clinical training settings, the opportunity for practitioners to observe the creation (and removal) of neurological or functional neurological symptoms of ‘virtual patients’ in normal volunteers also provides potential theoretical and training value given the additional possibility for practitioners to experience these symptoms for themselves through hypnotic suggestion (Oakley and Halligan, 2009).

Although still “early days”, the bridge building studies reported in this special issue hopefully demonstrate the productive cross-talk between hypnosis and cognitive neuroscience (Raz and Shapiro, 2002) and serve as a progress report on the journey towards a genuine scientific cognitive neuroscience of hypnosis and suggestion.

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