Hypnotic suggestion and cognitive neuroscience

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The growing acceptance of consciousness as a legitimate field of enquiry and the availability of functional imaging has rekindled research interest in the use of hypnosis and suggestion to manipulate subjective experience and to gain insights into healthy and pathological cognitive functioning. Current research forms two strands. The first comprises studies exploring the cognitive and neural nature of hypnosis itself. The second employs hypnosis to explore known psychological processes using specifically targeted suggestions. An extension of this second approach involves using hypnotic suggestion to create clinically informed analogues of established structural and functional neuropsychological disorders. With functional imaging, this type of experimental neuropsychopathology offers a productive means of investigating brain activity involved in many symptom-based disorders and their related phenomenology.

Introduction

Over the past decade, research involving hypnosis has made an important and unique contribution to the refinement and development of cognitive neuroscience [1–3]. The advent of sophisticated functional neuroimaging in particular has made it possible to localize task-related, regionally specific brain activity associated with hypnosis as a mental state and the combination of hypnosis with suggestion (hypnotic suggestion) [4,5]. Here, we outline relevant findings and review recent evidence of how hypnosis and suggestion provide a powerful tool for exploring normal and pathological psychological processes and conditions.

Hypnosis and suggestion

It is helpful first to draw a distinction between 'hypnosis' and the effects of suggestion. Operationally, 'hypnosis' refers to a change in baseline mental activity after an induction procedure and typically experienced at the subjective level as an increase in absorption, focused attention, disattention to extraneous stimuli and a reduction in spontaneous thought [5]. Hypnotic induction procedures comprise a set of verbal instructions that facilitate this particular mental state. Typical 'hypnotic' phenomena, such as alterations in sensory experience and motor control, amnesia and the adoption of false beliefs about the self and the environment, require specific suggestions. There is good evidence, however, that subjects can respond to suggestions of this sort without the need to employ formal

induction procedures. Indeed, the best predictor of the suggestibility of an individual in hypnosis is their responsiveness to the same suggestions outside hypnosis [6]. Nevertheless, hypnotic induction procedures can increase responsiveness to suggestion, particularly if expectancy has been raised by explicitly labelling the procedure 'hypnosis' [7]. Also, the effect of hypnotic suggestion can be more evident at the level of brain activation. Derbyshire *et al.* [8], for example, showed that the same suggestions to increase or decrease fibromyalgia pain using functional magnetic resonance imaging (fMRI) produced greater changes in activation in pain-related brain areas when participants were hypnotised compared to when they were not, despite much less marked difference in reported subjective pain modulation between the two conditions. For the aforementioned reasons, most studies reported here involve highly hypnotizable individuals, selected on the basis of one or more of the standardised scales of hypnotic susceptibility [9], and employ a formal hypnotic induction procedure.

A second important distinction within hypnosis research [10] concerns studies attempting to elucidate the neuro-cognitive nature of hypnosis (intrinsic studies) and those that use hypnotic suggestion as a means (instrumental studies) of exploring a range of psychological phenomena (such as memory, perception, pain, hallucination or voluntary control of action), including more recent attempts to develop hypnotic analogues for neurological and psychiatric conditions ([10–12].

Functional anatomy of hypnosis (*Intrinsic research*)

Although there have been some notable attempts to draw together neuropsychological and phenomenological evidence for hypnosis as an 'altered state of consciousness', with particular emphasis on the roles of anterior cingulate and dorsolateral frontal cortical areas [13], relatively little is known from a cognitive neuroscience perspective about the underlying processes involved in hypnotic experience in the absence of suggestion – so-called 'neutral hypnosis'. Using positron emission tomography (PET), Rainville *et al.* [14] compared a no-hypnosis baseline condition with a hypnosis condition that produced a co-ordinated pattern of activity involving brainstem, thalamus, anterior cingulate cortex, right inferior frontal gyrus and right inferior parietal lobule. These activations were interpreted as evidence that mental absorption (measured independently) is an experiential correlate of executive attentional networks and central to the production of the hypnotic

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experience. Similarly, a recent study (Q. Deeley, *et al.* unpublished) specifically explored the 'default mode' (the normal resting state) of brain activation during hypnosis and found a different pattern of brain activity with a decrease in spontaneous conceptual thought compared to the no-hypnosis conditions [4,5]. This study used hypnosis as a means of systematically modulating sustained attention and stimulus-independent thought (a non-default activity) without engaging a specific goal-directed cognitive activity under low demand stimulus conditions. Although further research is clearly needed, both preliminary sets of findings are indicative of a distinct 'default mode' or neural signature associated with hypnosis together with increases in mental absorption and reduction in spontaneous conceptual thought commonly reported by hypnotised individuals. In a similar way, Fingelkurts *et al.* [15], using EEG measurements with a hypnotic virtuoso subject, found alterations in local and remote functional connectivity between brain areas during neutral hypnosis, which were replicated in the same subject one year later. These changes imply a distinct hypnotic 'state' in which normal patterns of communication between separate cognitive systems are perturbed. In particular, they identified the weakening of remote functional connections as a possible correlate for some of the unusual experiences that subjects commonly report in hypnosis such as timelessness and detachment from self. Converging evidence comes from the finding that administration of a hypnotic induction procedure is associated with spontaneous increases in errors in a word and colour conflict test (the Stroop effect) in highly hypnotizable individuals [16]. The associated increase in activity in anterior cingulate cortex in the absence of compensatory changes in left frontal cortical areas has been interpreted as evidence that hypnosis acts to decouple the normal relationship between conflict monitoring and cognitive control [16].

Collectively, these studies raise not only the possibility of identifying distinct patterns of brain activations attributable to hypnosis (including anterior cingulate cortex and frontal cortical areas) but also indicate that these patterns comprise familiar components that can be found in many other cognitive tasks. In other words, a principled understanding of hypnosis is possible without the implication of arcane or esoteric processes that has arguably slowed the uptake of 'hypnosis' as a cognitive tool for illuminating interesting scientific questions about memory, perception, attention and volition.

Functional modulation of cognitive performance with hypnotic suggestion (instrumental research)

Hypnosis and suggestion offer a direct means of studying a wide range of cognitive processes. One compelling line of research exploring attention and attentional conflict has involved the suppression of the Stroop effect using a hypnotic suggestion that disrupted lexical processing [17,18] and the elimination of the flanker compatibility effect by hypnotic suggestions that increased focal attention [19]. In the case of the Stroop studies, the suppression of attentional conflict was associated with reduced activity in anterior cingulate cortex and in visual cortical areas possibly related to word recognition [20]. Congruent with

changes in visual cortical functioning seen in Stroop performance due to suggestion, Kosslyn *et al.* [21] reported modulation of activity in colour processing (fusiform) areas of visual cortex after direct hypnotic suggestions to perceive a coloured stimulus as grey-scale or to experience grey-scale stimuli in colour. Also related to colour perception, a recent study reporting the successful creation of grapheme-colour synaesthesia in non-synaesthetes by hypnotic suggestion [22] used the outcome to support the view that the unusual cross-modal interactions found in synaesthesia could be the product of disinhibition between brain areas rather than hyperconnectivity.

The Stroop studies relied in large part on the effectiveness of hypnotic suggestion to produce alterations in long established automatic linguistic processing. There is also consistent, albeit less formal, evidence that hypnotic suggestion can affect performance relating to the use of numerical information. The classic 'missing number seven' phenomenon, for instance, where it is suggested that the number seven 'no longer exists', produces disturbances to the processes of counting and calculation. Although we are unaware of systematic studies, there are clear opportunities for using hypnotic suggestion not only to create, and reverse, tailored forms of dyscalculia as a way of exploring models of number processing but also to investigate other cognitive developmental conditions such as dysgraphia, dyslexia and dyspraxia.

By contrast, there is a long history of memory research based on the reversible post-hypnotic memory loss that can be produced by suggestion [23]. More recently, the focus has been on the selective and reversible loss of autobiographical memory and the preservation of implicit memory in post-hypnotic amnesia for autobiographical events [24–26], differences between directed forgetting and post-hypnotic amnesia [27] and the creation of a robust and repeatable laboratory analogue for the experience of déjà vu [28]. In a similar way, hypnosis has been employed as means of exploring ironic processes in thought suppression [29]. In particular, it has been found that hypnotised individuals demonstrate a greater capacity for thought suppression and do not show the usual paradoxical after-effects such as rebound, which has been interpreted as reflecting an increased ability in hypnosis to manage cognitive load [23,30]. A recent neuroimaging study by Mendelsohn *et al.* [31], using a well established, reversible hypnotic suggestion to suppress episodic memories (posthypnotic amnesia), reported alterations in brain areas responsible for long-term retrieval (occipital, temporal and prefrontal cortex). The findings in the posthypnotic amnesia condition were seen as evidence for the active inhibition of retrieval during pre-retrieval monitoring.

Studies with particular relevance to trauma-related memory processes have incorporated hypnotic suggestions to create analogues of emotional numbing and peri-traumatic dissociation. Hypnotically induced emotional numbing [32] has been used to suppress affective responses to emotion-laden autobiographical memories without influencing the ability to recall the memories themselves [33], all of which supports the relative independence of the two processes. Exploring the relationship between peri-traumatic dissociation and flashback memories, Holmes *et al.*

[34] used hypnotic suggestion to produce increased subjective dissociation during viewing of a traumatic film. The theoretically predicted increase in memory flashbacks was not found and, when taken with other converging evidence, challenges the assumption of a simple link between the experience of dissociation at the time of trauma and subsequent proneness to flashback experiences.

A defining feature of most hypnotically suggested effects is the report of subjective involuntariness [35]. This is typically demonstrated when hypnotic suggestion is used to create ideo-motor responses; in which the hypnotised person's own movements are experienced as occurring 'all by themselves' (anarchic control) or as the result of some external agency (alien control). In a recent study, Haggard *et al.* [36] used hypnotically suggested involuntary finger movement to investigate the relationship between the experience of volition and the subjective estimation of time of movement. The participants reported their hypnotically suggested involuntary movement and a comparable passive movement as occurring closer in time to the actual movement than for voluntary finger movements. This indicates that the normally experienced anticipatory underestimation of timing for voluntary movements does not depend on the central motor preparatory phase, as this is retained in ideomotor movement, but on the subjective awareness of an impending movement that underlies the experience of intentionality, which is removed by the ideo-motor suggestion. In a related experiment, Blakemore *et al.* [37] investigated the brain processes underlying feelings of passivity or alien control produced by the hypnotic suggestion that the participant's hand was being moved up and down by means of a pulley. Subjective ratings of involuntariness for the suggested passive movement and a comparable truly passive movement, in which the hand was actually moved by a pulley, were identical. Both the voluntary movements and the hypnotically suggested passive movements were associated with activity in brain areas associated with left-sided movement production, reflecting the fact that they were actively produced movements. The suggested passive movements, however, were also accompanied by greater activation in bilateral cerebellum and parietal cortex – also seen in the truly passive movement condition and associated with feelings of passivity and external agency. The findings are consistent with the 'forward model' account of motor control [37] and indicate that the hypnotic suggestion of passivity either prevented the generation of an effective forward model for the hand movement or interfered with the normal suppression of feedback information associated with voluntary action.

Hypnotic analgesia suggestions are effective in alleviating both clinical and experimental pain [38] and can selectively influence different aspects of pain experience. When suggestions were given in hypnosis to increase or decrease the affective component of pain produced by an unvarying heat stimulus without affecting its perceived intensity, the subjectively reported changes were accompanied by corresponding changes in activity in anterior cingulate cortex, whereas activation in other areas of the pain matrix were unaffected [39]. A follow-up study [40] using the same experimental procedure showed the converse effect with

activity in primary somatosensory areas varying selectively in parallel with suggestions of changing pain intensity. Similarly, it is possible to demonstrate selective effects of hypnotic suggestion on components of phantom limb pain [41]. Suggested movements of the normally cramped and immobile fingers of a phantom arm [42] have been shown not only to produce the subjective experience of movement, with accompanying activation of contralateral somatosensory cortex, but also with a reduction in the associated pain. In a related study [43] in which the suggested movements of the phantom limb were to comfortable or uncomfortable positions, the movement was again accompanied by activity in contralateral somatosensory cortex and where the position was painful there was activation of pain related areas (thalamus, anterior cingulate, posterior cingulate and lateral prefrontal cortex). These observations clearly provide converging evidence for cognitive models that emphasize the contribution of different neurocognitive pathways in the affective and sensory components of pain, in addition to the role of feedback and control in the experience of pain.

Again, the evidence emerging from these studies is that hypnosis (in this case combined with suggestion) produces its effects through controllable functional changes within neurocognitive systems normally involved in mediating the psychological processes under investigation. In this way, hypnotic suggestion also influences aspects of 'phenomenological awareness', which in turn can provide insights about the structure and biological basis of normal cognitive processes. Recent studies have also exploited the potential that hypnotic suggestion offers for understanding clinical conditions.

Experimental neuropsychopathology (instrumental research)
According to Zvolensky *et al.* [44], the term 'experimental psychopathology' was first used in the 1950s to describe laboratory based attempts to develop viable clinical models of behavioural dysfunction. Experimental psychopathology attempts to elucidate the cognitive processes that contribute, either in whole or in part, to the aetiology, exacerbation or maintenance of abnormal behaviour [44]. Although not intended to produce exact replications of the psychological disorder, the approach focused on a small number of key symptoms with the aim of identifying core impairments, understood in terms of (functional) deficits to known normal cognitive processes. Experimental neuropsychopathology can be seen as productively extending this well established approach to include conditions from mainstream cognitive neuropsychology [45].

Like transcranial magnetic stimulation (TMS), the use of hypnotic suggestion as an experimental tool provides for the creation of clinically informed analogues (virtual patients rather than virtual lesions) delivered through intact cognitive neural systems, and enables cognitive neuroscientists to selectively manipulate components of known information processing processes with a view to assessing their impact on cognitive output. If disorders of psychological function are defined by reference to 'normal' information-processing systems [46], then credible reversible psychological disturbances produced in hypnosis (hypnotic analogues) can be

readily understood in terms of perturbations to pre- and post-hypnotic 'normal' informational processing. The instrumental use of hypnotic suggestion thus provides a powerful methodological approach for cognitive neuroscience to establish both the causal relevance of the specific brain areas activated during the symptom presentation while comparing those activations in the same subject when performing the task normally.

The use of hypnotic clinical analogues (virtual patients) which depends on establishing a match between the features of the clinical and hypnotic conditions is theoretically and clinically relevant given that many 'functional somatic syndromes' such as chronic fatigue syndrome, irritable bowel syndrome, migraine headache and various pain complaints that make up a large part of clinical practice [47] are often defined solely or largely in terms of their symptoms [48]. Indeed, most psychiatric conditions are defined in terms of their subjectively reported presentations [48] and even in neurology referrals, between 30% and 60% of outpatients present with symptoms that cannot be wholly or even partially explained by objectively identifiable pathology [47,49].

Several studies, have demonstrated the feasibility of generating subjectively compelling hypnotic analogues for established functional disorders. Hypnotically suggested blindness, for example, is a striking phenomenon with a long history that provides evidence of congruence with its functional clinical equivalent in conversion disorder [23,50]. In particular, this hypnotic analogue has been used to show preservation of implicit processing as evidenced by above chance performance in visual discrimination tasks, priming effects in homophone and word-stem completion tasks and the influence of social factors over performance [23,51,52]. Neuroanatomical [31] and behavioural observations [25] have been used to identify post-hypnotic memory loss as a viable analogue for functional amnesia. Similarly, Derbyshire *et al.* [53] have used hypnotically suggested pain in normal, pain-free individuals to create an unequivocal analogue of functional pain. What they found was that the hypnotic pain experience was associated with widespread activation in classic pain areas (thalamus, anterior cingulate cortex, insula, prefrontal cortex and parietal cortex), similar to that seen with a comparable physically induced pain and proportionate to the level of subjective pain reported. Interestingly, this activation pattern was not seen when participants were asked to imagine the same pain experience in hypnosis (Figure 1). A similar pattern of results has also been reported with hypnotically induced auditory hallucinations when compared to listening to recorded speech or to imagining the same auditory experience [54].

Hypnotic phenomena can also involve temporary delusions about the self and the world [23] and, as described earlier, have included clinically relevant hypnotic analogues of delusions of alien and anarchic control [36,37]. More recently, interest in modelling other delusions [23] has been informed by Langdon and Coltheart's [55] two-factor account of their generation and maintenance. Individuals experiencing a clinically convincing hypnotic analogue of mirrored-self misidentification, for example, retain their delusional beliefs even when confronted with conflicting
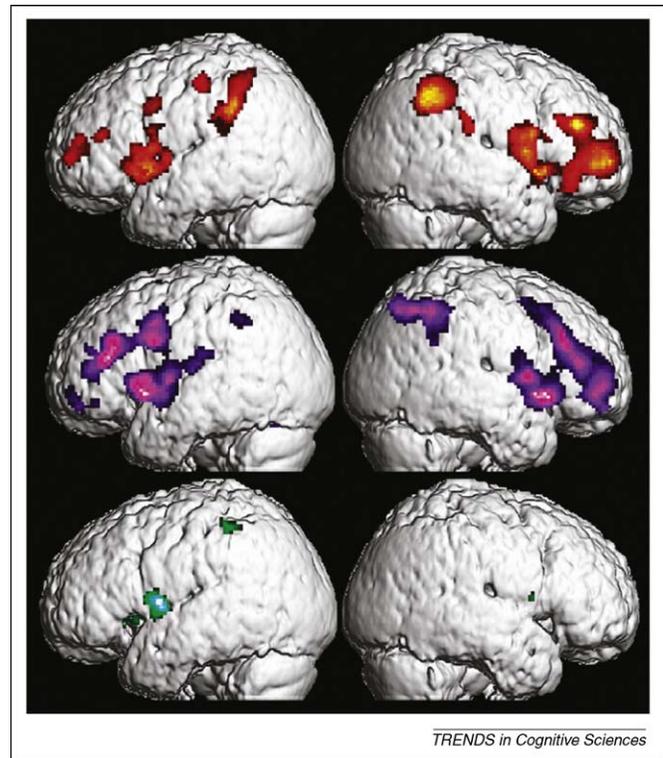

Figure 1. Hypnotically suggested, physically induced and imagined pain. Surface projections of brain areas activated in individuals experiencing hypnotically suggested heat pain (top), physically induced heat pain (middle) and imagined heat pain (bottom). The physical pain stimulus was delivered via a thermal probe that heated to 48.5 °C when activated, the hypnotic suggestion was that the thermal probe had been reactivated to the same painful level (when in fact it had not) and in the 'imagine' condition participants were asked to imagine the painful heat they had experienced from the probe as clearly as they could. Participants were hypnotised in all three conditions. This figure is based on data reported in Derbyshire *et al.* [53].

evidence [56]. Similarly, with a hypnotically suggested sex change, participants have been shown to persist in their delusional beliefs when directly challenged [57]. They also recall more from stories about individuals who correspond to their suggested sex, but are less likely than low-hypnotizable simulators to identify with those characters [58]. The same experimental approach could be extended productively to other hypnotically suggested delusional states that replicate clinically encountered conditions such as Capgras, Cotard, Frégoli and misidentification delusions, somatoparaphrenia and thought insertion.

Effective hypnotic analogues of clinical conditions require a clear understanding and specification of the phenomenological experience (i.e. what it is like to have the condition) to guide the hypnotic suggestions and ensure that the analogue faithfully replicates the relevant clinical symptoms. A second key requirement for a successful clinical analogue is the operation of a largely implicit reconstructive process by the subject, whereby verbally presented hypnotic suggestions are 'translated' into subjective experiences. The production of consistent outcomes within subjects through this reconstructive process assumes a translation based on a common set of, again largely implicit, 'expectations' regarding the appropriate symptom presentation for a suggested clinical condition. There is good evidence to suggest that individuals do, in fact, possess common or shared symptom-related expectations and that these can influence clinical

presentation and functional outcome. In one study, a large sample of subjects with no personal experience or knowledge of head injury, asked to imagine the post-concussional state, described a coherent cluster of symptoms virtually identical to the post-concussion syndrome reported by patients with head trauma [59]. Similarly, in a longitudinal study, patients with mild head injury who believed that their symptoms would have serious negative consequences in the longer term were found to be at heightened risk of experiencing enduring post-concussional symptoms [60].

The use of hypnotic clinical analogues (virtual patients) assumes not only a match between the features of the clinical and hypnotic conditions but more crucially a putative common link to the underlying neurocognitive processes. Halligan *et al*. [11] used PET to explore hypnotically suggested left leg paralysis as an analogue for conversion ('hysterical') paralysis. In addition to the striking clinical parallels, lateralised brain activity associated with the paralysis suggestion during attempted movement (right anterior cingulate cortex and right orbitofrontal cortex) was similar to that reported earlier by the same researchers [61] in a clinical conversion patient with comparable leg paralysis, suggesting a commonality in underlying mechanisms [62]. A follow-up study [63] confirmed the involvement of right orbitofrontal cortex in hypnotically suggested left leg paralysis but not when participants were instructed in hypnosis to intentionally simulate the same symptom. In the latter case, distinctive activations were found in left ventrolateral prefrontal cortex.

Unlike clinical studies, hypnosis offers considerable experimental control over the type and spatio-temporal characteristics of the impairments produced. Although, historically this approach has tended to focus on specific psychiatric and functional disorders there is no reason why, given the wealth of clinical phenomenology and neurological findings, it could not be productively extended

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Box 1. Possible directions for future research

The nature of hypnosis
As noted, there is still comparatively little 'intrinsic' research using modern neuroimaging techniques that attempts to characterize the nature of hypnosis itself in the absence of specific suggestions. In particular, future work needs to address the question of whether there is a distinctive baseline state or 'default mode' for hypnosis that is different from comparable non-hypnosis resting states. This is important not only for understanding hypnosis but also is of practical relevance particularly in 'instrumental' neuroimaging studies in which the choice of a rest condition to compare with an active experimental condition based on hypnotic suggestion could crucially affect the result. It is also important to consider the effects of different hypnotic induction procedures (the majority of studies currently use so-called 'relaxation' inductions) to disentangle the effects of a particular induction procedure from core attributes of hypnosis, both in terms of brain states and their cognitive and/or subjective accompaniments.

The nature of suggestion
There is also an opportunity for 'intrinsic' research to further explore the cognitive neuropsychology of hypnotic and non-hypnotic suggestion *per se*. One potentially useful extension would be to compare the mechanisms of hypnotic suggestion with other forms of suggestion such as placebo effects, under conditions in which the suggested effect is similar (e.g. analgesia).

Neurological and psychiatric conditions
We have presented examples of the use of hypnotic suggestion to create analogues of functional, quasi-neurological (conversion) disorders such as limb paralysis, 'hysterical' blindness and functional pain, and of psychiatric symptoms such as auditory hallucinations, delusions of misidentification and alien control. A similar approach could be profitably extended in future research to neuropsychological and psychiatric disorders commonly associated with brain injury. See supplementary material online for examples of possible future developments in this area that the authors have found to be productive.

TMS for intrinsic and instrumental hypnosis research
Another potential research avenue would be to assess the effects of producing transitory 'virtual lesions' using targeted TMS during hypnosis or hypnotically suggested effects in high performing hypnotic subjects. As brain areas thought to be involved in hypnosis are identified, it should be possible, for example, to modulate hypnotic responsiveness in predicted directions by selectively suppressing them using TMS. Similarly, given that credible clinical analogues of neuropsychological and neuropsychiatric conditions can be reliably generated using hypnotic suggestion, the use of targeted TMS could provide a powerful confirmatory method for establishing the causal involvement of specific brain areas thought to be activated in generating or maintaining these analogue conditions.

Differentiating hypnotic experiencing and imagining
There is some evidence that neurocognitive activations when experiencing a hypnotically suggested effect are qualitatively different from those when imagining the same experience (the examples we cited were of pain and auditory experiences). In particular, the hypnotic experience seems to create brain states closer to an actual experience, in addition to generating more 'as real' subjective reports than simply imagining it. If future studies confirm this qualitatively greater 'virtual reality' feature of the hypnotic experience over a wider range of examples there would be obvious theoretical implications but also practical ones – especially in clinical settings where hypnotic experiencing for instance could provide a viable substitute for *in vivo* therapeutic procedures.

Overriding 'automatic' processes
One of the most compelling recent effects in the studies we have reported is the apparent ability for hypnotic suggestions to override 'automatic' cognitive processes seen in the reduction of Stroop colour naming errors and overcoming attentional conflict in the flanker compatibility task. Future research could test current cognitive models by targeting other well established 'automatic' processes using specific hypnotic suggestions to selectively modulate phenomena such as perceptual implicit memory (as opposed to explicit memory), attentional blink, latent inhibition, repetition blindness, sensory gating and conceptual and perceptual priming.

Hypnosis as a neurocognitive rehabilitation tool
Given the extensive and growing knowledge of the cognitive architecture for many neuropsychological and neuropsychiatric disorders and the ability of hypnotic suggestion to reliably modulate performance at cognitive, behavioural and experiential levels, an underexploited opportunity remains for using hypnosis to make a meaningful contribution to neuropsychological interventions in the remediation of cognitive disorders. The potential for using targeted hypnotic suggestion as an adjunct to existing cognitive neuropsychological treatments (for those patients or subjects with the neural capacity to benefit) has yet to be fully realized. Possible examples include selective attenuation of the functional consequences of prosopagnosia, dyscalculia dysgraphia, dyspraxia visual neglect, memory dysfunctions and reading disorders. Such an approach might be particularly useful in the case of some monothematic delusions such as Capgras in which attempts to enhance the autonomic affective responsivity to familiar faces, and/or highlighting the evidence and consequences for holding such a delusion might prove helpful.

to more established clinical, neuropsychological and neuropsychiatric conditions traditionally associated with brain injury, such as aphasia, agnosia, alexia, visuospatial neglect, 'blindsight' hemianopia and dysexecutive disorders. There are clear similarities, for example between the phenomenology of hypnotically suggested blindness and clinical cases of 'blindsight' after lesions of the visual cortex [51,64] (see supplementary material online for examples of hypnotic analogues of prosopagnosia, hemianopia and visuospatial neglect). This is not, however, to assume that the same form of organic pathology seen in neuropsychological patients is functionally replicated in hypnosis. It could be that signs and symptoms can be generated by relevant 'top-down' processes recruited and amplified by the hypnotic procedures [56] to produce a clinically similar performance or experience. The possibility of a closer structural convergence should not be excluded, however, and it is interesting to note, for example, that the brain areas suppressed in response to hypnotic suggestions of loss of colour perception [21] correspond closely to the ventral occipital areas identified independently as being commonly involved in lesions producing achromatopsia [65].

Concluding remarks

Intrinsic studies have begun to reveal something of the nature of hypnosis, and the instrumental studies illustrate the potential of hypnotic suggestion as a powerful cognitive tool to explore in a controlled way selective phenomena directly relevant to cognitive and clinical neuroscience. The use of hypnotic analogues, however, requires clear specification of the phenomenological experience to facilitate and guide hypnotic suggestions to ensure that the clinical analogue faithfully reproduces the clinically established symptoms. Because many neuropsychological conditions (e.g. dyslexia, neglect, and so on) are formally defined at least for assessment purposes in terms of criterion test performances rather than relying on first person accounts, the need for more detailed information regarding the common phenomenological features characteristic of specific disorders is clearly important. We believe that, once generated, clinically relevant hypnotic analogues as clinically informed simulations will be increasingly used to investigate specific hypotheses regarding the underlying cognitive representations and mental processes. This, in turn, will allow for a more fine-grained revision of cognitive models with implications for informing clinical and ultimately therapeutic interventions. Box 1 outlines some areas in which we think future work on hypnosis and the use of hypnotic suggestion as a neurocognitive tool will prove particularly fruitful.

Supplementary data

Supplementary data associated with this article can be found at doi:10.1016/j.tics.2009.03.004.

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