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HYPNOSIS AS A TOOL IN RESEARCH: EXPERIMENTAL PSYCHOPATHOLOGY

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Abstract

Hypnosis is interesting in its own right and has been demonstrated to be a useful facilitator of psychological therapies. It is also increasingly employed as a tool in research, particularly in association with modern neuroimaging techniques. This paper reviews some of these 'instrumental' uses of hypnosis in relation to conversion disorder (paralysis), malingering, chronic pain and disorders of volition and motor control. In addition to their relevance to models of normal psychological functioning, the findings have significant implications for the understanding and treatment of a range of clinical conditions. They also serve to underline the subjective 'reality' of the experiences that accompany hypnotic phenomena. It is concluded that hypnosis has a significant role to play in mainstream psychological, neuropsychological and clinically related research. Copyright © 2006 British Society of Experimental & Clinical Hypnosis. Published by John Wiley & Sons, Ltd.

Key words: chronic pain, hypnosis, malingering, motor control, neuroimaging, research

Introduction

An important distinction in hypnosis research is between those studies that are intended to explore the nature of hypnosis itself and those that use hypnosis as a tool for exploring other psychological processes and phenomena. Reyher formalized this distinction as being between 'intrinsic' and 'instrumental' hypnosis research respectively (Reyher, 1962; Barnier and McConkey, 2003). This review focuses primarily on the second of these types of research, which has seen a resurgence of interest over the past few years, especially in the context of neuroimaging techniques. For example, hypnosis has been used recently to explore memory (Barnier, 2002; Cox and Barnier, 2003); visual Stroop effects (Raz, Shapiro, Fan and Posner, 2002; Macleod and Sheehan, 2003; Egner, Jamieson and Gruzelier, 2005; Raz, Fan and Posner, 2005); functional blindness (Bryant and McConkey, 1999) auditory hallucinations (Szechtman, Woody, Bowers and Nahmias, 1998); colour processing (Kosslyn, Thompson, Costantini-Ferrando, Alpert and Spiegel, 2000); pain (Rainville, Duncan, Price, Carrier and Bushnell, 1997; Hofbauer, Rainville, Duncan. and Bushnell, 2001; Derbyshire, Whalley, Stenger and Oakley, 2004; Schultz-Stubner, Krings, Meister, Rex, Thron and Rossaint, 2004; Raij, Numminen, Narvarnen, Hiltunen and Hari, 2005); voluntary motor control (Halligan, Athwal, Oakley and Frackowiak, 2000; Blakemore Oakley and Frith, 2003; Haggard, Cartledge, Dafydd and Oakley, 2004); malingering (Ward, Oakley, Frackowiak and Halligan, 2003); phantom limb pain (Willoch, Rosen, Tolle, Oye, Wester, Berner, Schwaiger and Bartenstein, 2000;

Rosen, Willoch, Bartenstein, Berner and Rosjo, 2001); and phantom limb movements (Ersland, Rosen, Lundervold, Smievoll, Tillung, Sundberg and Hugdahl, 1996). Research of this sort not only helps us to understand how our brains normally work in creating these types of experience but can also give us insights into some of the more perplexing symptoms that are seen in clinical settings. This brief review focuses on some recent studies that have investigated the second of these, the area of experimental psychopathology or neuropathological simulation.

Experimental psychopathology: functional modelling of neurological conditions

There is a growing and productive literature that employs hypnosis to create a temporary functional disturbance of quasi-neurological functions that in turn provides an experimental model for understanding similar conditions such as conversion disorders, chronic pain conditions and disorders of volition and motor control that are encountered clinically. There is growing evidence that the resulting changes in subjective experience and behaviour may be instrumental in informing and revising our views about both aetiology and treatment as the hypnotically-induced changes are in many ways phenomenologically and neurophysiologically similar to those of individuals with the corresponding clinical symptoms. The review that follows focuses on recent collaborative work between the Hypnosis Unit and the Centre for Cognitive Neuroscience at University College London and the Universities of Pittsburgh and Cardiff.

Conversion disorder and malingering

In neurology clinics a significant number of patients report symptoms that seem likely to have a neurological cause – partial blindness, deafness, paralyses, unusual movements, seizures, losses of skin sensation and so on, but no physical or neurological cause can be found (Akagi and House, 2001; Stone and Zeman, 2001). Medically unexplained symptoms such as these were initially described as ‘hysterical’ and, more recently, as conversion disorder symptoms. The similarity between these symptoms and the phenomena produced by suggestion in hypnosis has been noted many times (Charcot, 1888; Janet, 1907; Bliss, 1984; Kihlstrom, 1994; Oakley, 1999). In particular both hypnotic phenomena and conversion disorder symptoms are reported by the people who have them as being ‘real’ or ‘involuntary’, and yet medical and neurological examinations show the relevant nerves and muscles to be in good working order. These similarities raise the possibility that both are created in the same way by the brain.

An intriguing report of a Positron Emission Tomography (PET) study by Marshall, Halligan, Fink, Wade and Frackowiak (1997) provided the starting point for an ongoing series of experimental studies investigating the use of hypnotic limb paralysis as an experimental analogue for conversion disorder paralysis (see also Athwal, Halligan, Fink, Marshall and Frackowiak, 2001). Their investigation involved a 45-year-old, right-handed woman with a diagnosis of conversion disorder, who presented with a flaccid paralysis of her left leg. When she was asked to move her paralysed limb the scanner revealed activations of brain areas (premotor cortex and cerebellum) that would normally be activated by an individual preparing to make that movement. This was taken to be indicative of a genuine attempt to move the limb as requested and thus to be consistent with her diagnosis. However, the activation of contralateral motor areas, in particular the primary sensorimotor cortex, that accompanied an actual movement of her right leg

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failed to materialize for her left leg along with the absence of the movement itself. Instead there was increased activity in two other areas, the right anterior cingulate cortex and right orbitofrontal cortex, which the authors interpreted as evidence for an unconscious inhibition of the intended voluntary movement corresponding to the activation of these two brain areas.

Halligan, Athwal, Oakley and Frackowiak (2000a), again using PET, repeated as closely as possible the earlier Marshall et al. (1997) study but with a 25-year-old, right-handed male participant with a hypnotically suggested left leg paralysis. The pattern of brain activations during attempted left leg movements following the paralysis suggestion for this hypnotized participant were the same as those described for the conversion disorder patient. The conclusion drawn by Halligan et al. (2000a) on the basis of these two studies was that the paralyses in both instances appeared to be the product of brain areas involved in the inhibition of voluntary attempts at movement, that the brain mechanisms underlying the conversion disorder symptoms and the hypnotic paralysis were the same and consequently that 'hypnotic phenomena provide a versatile and testable model for understanding and treating conversion hysteria symptoms'. The implications of this conclusion for the treatment of conversion disorder symptoms have been explored elsewhere (Oakley, 2001).

Whilst these two studies have produced converging evidence that provides promising support for the use of hypnosis as an experimental tool in exploring conversion disorder symptoms they also raise some questions. The first is that they both involved single cases and consequently generalizations from them should be approached with caution. Second, and more pressingly, though the experimenters interpreted their data as supporting the view that the patient in the Marshall et al. (1997) study and the participant in the Halligan et al. (2000a) study were genuinely experiencing an involuntary paralysis, other commentators argued that this did not exclude the possibility that inhibition of movement was voluntarily generated (Terao and Collinson, 2000). That is, the reason why the observed patterns of brain activation were so similar could be because in both cases the individuals concerned were 'malingering', or 'faking' their paralysis. Terao and Collinson (2000) supported their argument by noting that Spence, Crimlisk, Cope, Ron and Grasby (2000) in another PET neuroimaging study had found a different pattern of brain activation (hypoactivity of left dorsolateral prefrontal cortex) during attempted movement in three patients with conversion disorder (in this case weakness of the upper limb) compared to the activations seen in the conversion disorder patient in the Marshall et al. (1997) and the hypnotically paralysed participant in the Halligan et al. (2000a) study. While it was possible to counter these arguments and to account for the differences in activation seen between the two sets of studies (Halligan, Oakley, Athwal and Frackowiak, 2000b) it was evident that the question of the subjective 'genuineness' of these 'paralyses' required a more robust demonstration before proceeding further with the use of hypnotic paralysis as an experimental analogue of conversion paralysis.

The doubts expressed over the 'genuineness' of the limb paralysis in Marshall et al. (1997) and Halligan et al. (2000a) raise much broader issues. Conversion disorder patients have frequently been accused of 'malingering'; that is, intentionally feigning symptoms to avoid responsibilities or to gain compensation. Similarly those who do not believe in the subjective reality of hypnotic phenomena may accuse hypnotized people of deliberately faking their responses, in order perhaps to please the hypnotist or to avoid the social embarrassment at not behaving as they were expected to. Ward, Oakley, Frackowiak and Halligan (2003) went on to explore this issue directly using neuroimaging (PET) techniques with 12 highly hypnotizable student volunteers with scores of at least 8 out of 12

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on the Harvard Group Scale of Hypnotic Susceptibility: Form A (HGSHS:A; Shor and Orne, 1962). For half of each scanning session they had a hypnotically suggested paralysis in their left legs and for the rest of the time, with both legs normal, they were asked to feign a left leg paralysis in return for a financial reward if they could do so convincingly. Participants were hypnotized throughout both halves of the session and the order of the paralysis/ feigning conditions was counterbalanced across subjects. In fact the subjects proved to be very good at their task and repeated neurological examinations did not enable an independent observer blind to the testing condition to tell reliably whether the subjects had a hypnotic paralysis or were feigning paralysis. However, there were clear differences in brain activity in the two conditions. With the hypnotic paralysis there were activations in the right orbitofrontal cortex, right cerebellum, left thalamus and left putamen that were not seen when they were feigning the paralysis. In contrast the feigned paralysis condition was selectively associated with activity in the left ventrolateral prefrontal cortex and some right posterior cortical structures. It is important to note that one of the brain areas associated with the hypnotically induced paralysis in this study, the right orbitofrontal cortex, was also one of the areas identified in the single case of hypnotic paralysis reported by Halligan et al. (2000a) and in the conversion disorder patient studied by Marshall et al. (1997). This supports the view that the paralyses reported in these two earlier studies were not the products of faking or malingering (Oakley, Ward, Halligan and Frackowiak, 2003). In more general terms the data from Ward et al. (2003) clearly indicated that the hypnotic paralysis was produced by different brain processes to the feigned paralysis and supported the participants' claim to be experiencing a 'real' inability to move their left leg when it was hypnotically paralysed. They said they genuinely were trying to move their legs in the hypnotic paralysis condition but nothing happened – the results from the scanner were consistent with their claims. Further collaborative work is currently underway to scan a larger number of participants with hypnotically induced limb paralysis and to compare them with conversion disorder patients who also show limb paralyses, to investigate further the earlier observation that the brain processes in the two cases are the same.

'Functional' pain

The results described in the previous section are of intrinsic interest in relation to motor control and intentionality, as well as for the light they shed on the underpinnings of hypnotically generated experiences. They also have potentially profound implications for the way we perceive the experiences of at least some of those individuals who claim to have an apparently disabling neurological problem for which no physiological explanation can be found. They may well be 'genuinely' experiencing their inability to move or to see or hear normally even though their sensory and motor systems are intact. Moreover, by analogy with hypnotic phenomena, the symptoms they experience may be produced by mechanisms that are similar in some way to those of hypnotic suggestion.

These possibilities have been explored further in the context of the equally puzzling phenomenon of so-called 'functional' pain. That is, pain that seems to be experienced in the absence of any external or internal stimulus, nerve damage or other pathological change. There are many examples of clinical pain where there seems to be no current physical cause, such as atypical facial pain, some low back pain or pains that may persist, or recur, in the neck and shoulders long after the tissue damage caused by whiplash injuries has healed. The possibility of a physical explanation is notoriously difficult to exclude but when all other avenues have been exhausted these types of pain are often

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dismissed as being simply 'imaginary' or, perhaps even more damaging for the patient, that they are intentionally feigned or malingered conditions. An important question that needs to be addressed in trying to understand conditions such as these is whether it is possible to have a 'real' experience of pain that is truly 'functional'. If this should prove to be the case, the next question is whether it is fair to dismiss such pains as simply being a product of an overly active imagination.

Whalley and Oakley (2003) have recently shown that in hypnosis people are able to have an experience of pain, similar to that produced by a very hot stimulus, in response to appropriate suggestions. Derbyshire et al. (2004) then looked at the brain activity associated with hypnotically produced pain using functional Magnetic Resonance Imaging (fMRI) and compared it to both physically induced and imagined pain. Eight highly hypnotizable participants (scoring 8 or higher out of 12 on the HGSHA:A) were hypnotized and then were scanned when they were (a) receiving a painful heat stimulus to their right hand, (b) were experiencing a hypnotically suggested pain in their right hand or (c) were imagining the same painful heat as clearly as they could. The physical heat pain was delivered by a thermal probe, attached to the palm of the right hand, that reached 48.5° Celsius (C) when activated. The thermal probe remained in place and the participants remained hypnotized in all three conditions. To create the physically induced and hypnotically induced pain conditions the participants were informed that a single tap to their foot signalled the onset of the painful (48.5°C) heat stimulus and a double tap signalled a return to comfortable heat (37.0°C). The painful heat stimulus was in reality only delivered on half of the occasions that a single tap signal was given however and for the remainder the probe did not rise above 37.0°C. The single tap thus acted as a suggestion for the experience of painful heat on those trials when the thermal probe was not activated. For the imagined pain condition participants were aware that the heat probe would remain at a comfortable temperature throughout and would not be activated to its painful level but they were asked to imagine the heat pain as clearly as possible in response to a single tap and its termination on a double tap signal.

The major experimental finding of this study was that the hypnotically induced pain condition produced widespread activity in brain areas traditionally associated with the experience of pain (see Figure 1). In particular there were significant activations in the thalamus, anterior cingulate cortex, insula, prefrontal cortex and parietal cortex, producing a very similar overall pattern to that of the actual heat pain itself. The imagined pain condition by contrast produced activity in very few of the brain's pain areas. Though the participants were not aware in which trials the painful heat stimulus was omitted, subjective pain ratings did vary between hypnotically induced and physically induced pain trials. For hypnotically induced pain the average rating was 2.8 (out of 10: range 1–9) and for physically induced pain it was 5.7 (range 3–10). In both conditions, however, there was a direct relationship between the intensity of the pain report and the degree of activation of pain areas. It would appear that though hypnotically induced (functional) pain may be subjectively less intense than physically induced pain it is accompanied by the same patterns of brain activity. Moreover, the level of subjective intensity of the pain irrespective of whether it is hypnotically or physically induced bears a close relationship to the levels of brain activity associated with it.

It seems therefore that it is not only possible to produce a completely 'functional' pain experience using hypnotic suggestion but that it is a 'real' experience of pain in that it involves activation of the same brain areas as a physically produced pain. It is also clear that this type of functional pain is not the same as a simply imagined pain. We take this to mean that people who complain of chronic clinical pain that does not seem to have a

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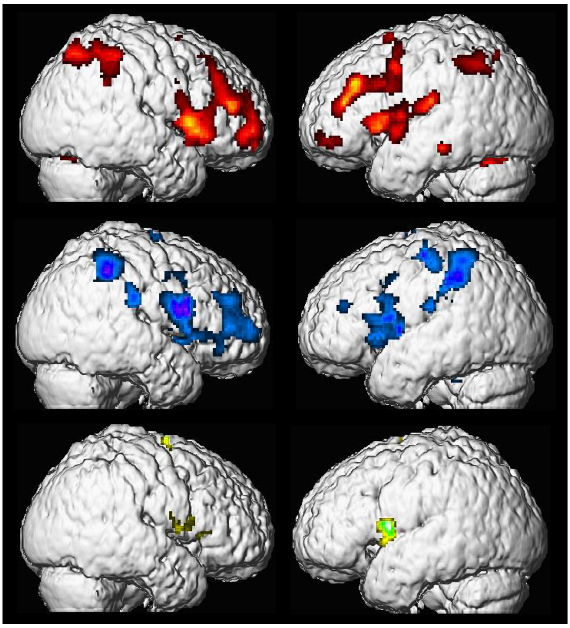

Figure 1. Surface reconstructions of brain activations during physically induced pain (top), hypnotically induced pain (middle) and imagined pain (bottom).

physical cause may nevertheless be genuinely experiencing ‘real’ pain and not pain that is merely ‘imaginary’. Again these observations have important implications for how we understand the origin of some painful conditions and how we should treat people who complain of them. The results also have implications for the wording we use to deliver suggestions in hypnosis. If we wish to create subjectively ‘real’ perceptual or motor changes in experimental settings or to take advantage of ‘virtual reality’ experiences in our clinical work it is important that we do not ask our participants or clients to ‘imagine’ the desired change but that we use language that emphasizes ‘experiencing’ and ‘being there’ (Walters and Oakley, 2003). It is interesting in this context that Szechtman et al. (1998) found in their PET study of auditory hallucinations that both physically presented and hypnotically suggested speech sounds activated areas of the right anterior cingulate cortex but instructing their hypnotized participants to imagine ‘as vividly as possible’ the same speech sounds did not. The greater subjective ‘reality’ of the hypnotically induced experience compared to the imagined one is underlined by the fact that the participants’ subjective ratings of externality and clarity of the speech sounds correlated strongly with the degree of activation of the right anterior cingulate cortex for the hypnotically suggested speech sounds. Szechtman et al. (1998) concluded that, as in schizoprenia, activation of the right anterior cingulate cortex during the experiencing of self-generated speech sounds in response to hypnotic suggestion identifies these sounds as being externally rather than internally generated.

Disorders of volition and motor control

When one of our limbs moves we are normally clear in our minds as to whether we made that movement ourselves, whether it occurred all by itself or was the result of some exter-

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nal force acting upon it. There are a number of clinical conditions, however, in which these helpful distinctions break down and the sense of agency becomes impaired (Spence, 2002). Injuries to medial frontal regions of the brain and damage to the corpus callosum (the large fibre tract linking the two hemispheres together), for instance, can create a condition known as anarchic (or alien) limb (Marchetti and Della Salla, 1998). In this condition the individual's experience of the affected limb is that it 'has a mind of its own' and that it carries out acts that may be against the individual's own wishes. The hand opposite a medial prefrontal lesion, such as might be caused by a stroke, may for example pick up an object that the individual has no apparent use for, and the 'normal' hand may then be used to restrain the activities of its 'anarchic' counterpart. This is the phenomenon made famous by Peter Sellers' performance in the film *Dr Strangelove*. It is important for this diagnosis of anarchic limb that the patient retains a sense of it still being their own limb despite its 'uncontrollable' behaviour. A similar phenomenon is also commonly created in hypnosis in one type of ideomotor responding, where the suggestion is given that a movement, of a finger say, will 'happen all by itself'. In clinical hypnosis settings this type of suggestion is often used with the intention of accessing from an individual information that is currently held by them in an 'unconscious' form.

A similar, but distinct, condition associated with schizophrenia, right parietal lobe lesions and focal epilepsy is that of 'alien control' or feelings of passivity. In this condition the individual again retains the sense of the affected limb belonging to them but its movements are attributed not to the limb itself but to an external agency. It is as though some force external to themselves is responsible for its actions. Mellors (1970) gives the following classic account by a schizophrenic patient of her experiences of alien control:

> 'When I reach my hand for the comb it is my hand and arm which move, and my fingers pick up the pen, but I don't control them . . . I am just a puppet who is manipulated by cosmic strings. When the strings are pulled my body moves and I cannot prevent it.' (p. 36)

The phenomenon of alien control is also commonly created in hypnosis as another form of ideomotor response, typified by arm levitation procedures in which it is suggested to the participant that their hand and arm will be 'lifted up by a balloon inflated with helium that is attached by a string to your wrist'. The resultant arm movement is attributed by the participant to an external agency, the balloon.

Haggard et al. (2004) used hypnosis to produce an involuntary finger movement as an experimental analogue ('anarchic digit') of the clinical condition of anarchic limb in order to investigate the relationship between the experience of volition and the subjective estimation of time of movement. Their study was a continuation of earlier cognitive neuropsychological work that involved participants being asked to indicate when they become aware of one of their own motor movements. An important finding of these studies has been that the participant typically estimates that the movement occurs earlier in time when it is a voluntary movement compared to when the same movement is made involuntarily, such as when it is the result of brain stimulation (Haggard, Clark and Kalogeras, 2002). This suggests that the processes that precede motor acts that are experienced a being voluntary include an unconscious planning stage that leads to an anticipatory awareness of the impending movement, and that the involvement of these two processes is reflected in an underestimation by the individual concerned of the time at which the movement actually occurs. Movements that are produced reflexively or by an external agency, on the other hand, lack the central planning stage, are not accompanied

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by anticipatory awareness and so are experienced as occurring much closer to the time of the actual physical movement. It remains unclear from this interpretation, however, whether the anticipatory underestimation of time of movement arises from the preparatory processes themselves or from the anticipatory awareness of an impending movement. What hypnosis uniquely is able to do through the creation of an ideomotor response that occurs 'all by itself' is to separate these two components. The ideomotor movement, as it is self-generated, must be the product of an unconscious planning process and thus has the preparatory stage in common with a 'voluntary' movement. However, because of the suggestion given, the ideomotor movement lacks the stage of anticipatory awareness and so is experienced as 'involuntary'. If the central planning stage is the important factor in producing anticipatory underestimation of the timing of the movement the ideomotor movement should continue to produce the time underestimation. On the other hand, if the crucial factor is the anticipatory awareness, the underestimation should be lost and the subjective timing of the ideomotor response should be the same as an externally generated, involuntary or passive movement.

Haggard et al. (2004) used an experimental procedure described by Libet, Gleason, Wright and Pearl (1983) in which a very fast running clock display was used to obtain accurate measurements of the time at which participants experienced the occurrence of their own movements. Throughout the testing procedure the participant's right index finger was held in place on top of a response key by a loop of fabric. Twelve right handed participants with HGSHS:A scores ranging from 9 to 11 were tested before, during and after hypnosis and were asked during all three stages to report the time that their right index finger moved when they voluntarily pushed down the response key (Voluntary Movement condition) or when the physically identical finger movement was produced by the key itself moving downwards (Passive Movement condition). In addition, during hypnosis the same time measurements were made for ideomotor finger movements (Involuntary Movement condition) following the suggestion that the same finger, resting on the response key, would 'make a clear distinct downward movement at about the same time intervals that it does when you move it yourself . . . but on these trials it will move all by itself. You will not know when it is going to move but you will be clearly aware of the movement when it occurs and you can report it in the usual way by calling out the number from the clock'.

In addition to the timing measures participants rated the subjective voluntariness of their movements on a 100 mm visual analogue scale (where 100 mm represents 'completely voluntary' and 0 mm 'completely involuntary/passive'). All experimental conditions were carried out in a counterbalanced order within and across subjects.

The results are summarized in Figure 2. Comparing hypnosis with no hypnosis conditions there were no effects of hypnosis per se on the estimated timing or the subjective involuntariness for either the Voluntary Movement or the Passive Movement conditions. That is, hypnosis itself did not interfere with the motor or temporal aspects of the task. The Passive movements, as expected, were rated as significantly less voluntary and as occurring significantly later in time than the Voluntary movements. Within hypnosis, the Involuntary Movement condition produced movements that were rated, despite being self-generated, as significantly less voluntary than the comparable movements in the Voluntary Movement condition. Consistent with this, time judgements for the Involuntary Movement condition in hypnosis were significantly different from those for Voluntary movements but were not significantly different from Passive movements.

These results indicate that the normally experienced anticipatory underestimation of timing for voluntary movements does not depend on the central preparatory phase, as

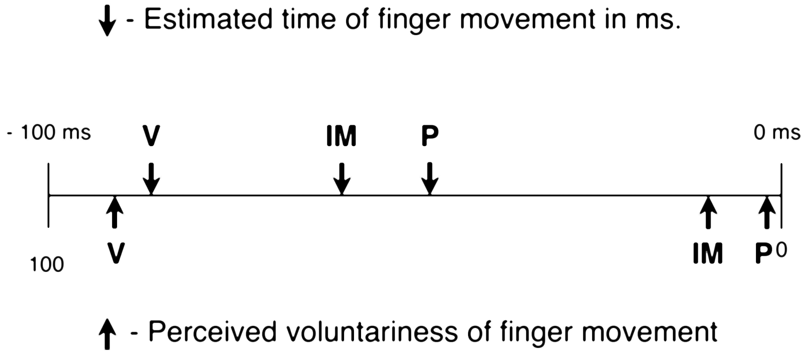

Figure 2. a) Estimated time of finger movements in milliseconds (top half of figure) where 0 ms is the actual time of movement as registered by the key press and negative values indicate underestimations of the time of finger movement as judged by the participants in the three conditions.
b) Perceived voluntariness of finger movements in the three conditions (bottom half of figure) on a scale of 0–100 where 0 indicates a feeling of complete involuntariness and 100 a feeling that the movement was completely voluntary. In both halves of the figure V refers to the Voluntary Movement condition, IM the Involuntary Movement condition and P the Passive Movement condition.

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 ideomotor suggestion. If the movement preparatory phase of a self-generated movement is seen as a necessary precursor to a freely willed act it would seem that free will does not depend on conscious awareness. From the perspective of hypnosis studies these results support the view that in ideomotor responding a movement generated by normal voluntary motor control systems is not only reported as occurring involuntarily but is accompanied by a conscious experience that is close to that of a truly passive movement. It would be interesting to look at brain areas active during ideomotor movement compared to voluntary movement. We might expect to see activations in somatomotor cortical areas associated with execution of a motor response in both conditions but inhibition of frontal and midline areas associated with voluntary movement in the ideomotor movement condition.

The Haggard et al. (2004) study was concerned with the effect of the experience of intention on our estimate of the timing of a behavioural response. A related experiment by Blakemore et al. (2003) investigated the brain processes underlying feelings of passivity or alien control produced by ideomotor suggestions. In this study six highly hypnotizable male participants (HGSHS:A scores of 9 or more out of 12) were hypnotized throughout a PET scanning session whilst experiencing repetitive vertical movements of the left arm that were produced voluntarily (Active Movement condition), passively via the operation of a pulley system (Passive Movement condition) or by an ideomotor suggestion that consisted of telling the participant that the pulley would be used again to move the arm up and down when in fact the pulley was not activated (Deluded Passive Movement condition). The arm movements produced in response to suggestion in the last of these conditions correspond to clinical feelings of alien control – the arm movement in this case being falsely attributed to the action of the pulley. Participants rated the movements in the Passive and Deluded Passive conditions as significantly more

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involuntary (6.5 out of 7) than the Active movements (2.67). The Active Movement and Deluded Passive movement conditions were associated with significant activity in brain areas known to be associated with left-sided movement production (right sensorimotor cortex, premotor cortex, supplementary motor area and insula; bilateral basal ganglia and parietal operculum and left cerebellum) reflecting the fact that they were in reality actively produced movements. The Deluded Passive movements were also associated, however, with greater activation in bilateral cerebellum and parietal cortex, activations that were also seen in the Passive Movement condition. Similarly located activations have been seen in these same areas in other studies that have explored the neural correlates of passive movements. The hypnotically induced movements in the left hand and arm of these participants in the Passive Movement condition were thus accompanied by brain changes congruent with an associated feeling of passivity and external agency. This is consistent with a model of motor control (Miall and Wolpert, 1996) that proposes that self-produced movements are accompanied by a prediction of the likely sensory feedback that they will produce (the 'forward model'). Sensory feedback that matches the forward model can then be cancelled out as being of no further interest. If however a movement, say of a person's limb, is produced by the action of an external agency no forward model is available and the sensory feedback resulting from the movement is not cancelled, but remains active and the subjective feeling in relation to the movement is one of passivity or alien control. Similarly, in the case of the ideomotor movement it would appear that though the forward model may be generated the normal cancelling of the feedback from its execution does not occur. In this case this failure of feedback cancellation is a result of the suggestion that has been given and as a consequence the movement is experienced as 'passive'. Again the evidence is consistent with the view that ideomotor movement ('arm levitation' in this case) produced via voluntary muscle systems is genuinely experienced by the hypnotized person as an involuntary or passive event.

Conclusions

The three sets of studies briefly reviewed here illustrate the potential use of hypnosis as a powerful cognitive tool with which to explore in a controlled way psychological phenomena and processes that are of clinical and theoretical relevance outside the domain of hypnosis studies *per se*. They also serve to underline the view that hypnotic phenomena are experienced as subjectively 'real' events accompanied by significant brain changes. Moreover these changes are found in brain areas that would normally be expected to be active during these same experiences if they occurred spontaneously outside the hypnotic context. As researchers who are not familiar with hypnosis gain confidence in its strategic use in mainstream psychological and neuropsychological work we can expect to see a resurgence in its popularity as a practical tool. This may in turn lead to concerted research into the nature of hypnosis itself by individuals who have previously seen it as little more than a historical curiosity.

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