Hypnosis and hemispheric asymmetry

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**Abstract**

Participants of low and high hypnotic susceptibility were tested on a temporal order judgement task, both with and without hypnosis. Judgements were made of the order of presentation of light flashes appearing in first one hemi-field then the other. There were differences in the inter-stimulus intervals required accurately to report the order, depending upon which hemi-field led. This asymmetry was most marked in hypnotically susceptible participants and reversed when they were hypnotised. This implies not only that brain activity changes in hypnosis, but also that there is a difference in brain function between people of low and high hypnotic susceptibility. The latter exhibited a faster-acting left hemisphere in the waking state, but faster right when hypnotised.

**1. Introduction**

For much of the latter part of the 20th Century hypnosis research and theory were influenced by the fact that typical ‘hypnotic’ phenomena are subjective, and hence unverifiable. Even observable behaviour, such as a participant’s arm gradually lifting following suggestions that it was getting lighter, could in principle be faked since it was not possible for a researcher to know whether the action was ‘real’ or a deliberate attempt at deception (Orne, 1979). ‘Real’ in this context can be treated as meaning ‘believed in by the participant’. Thus, Wagstaff (1981, 1986) proposed that a person being given hypnotic suggestions would attempt to use strategies to imagine those suggestions vividly, then (wrongly) attribute the experience to ‘being hypnotised’. He proposed that not all were able to perform this self-deception, so they might proceed to act-out the suggestions through simple compliance to the perceived wishes of the experimenter.

The advent of functional-imaging techniques has clarified the reality issue somewhat. For example, hypnotically-induced experiences in both hearing (Szechtman, Woody, Bowers, & Nahmias, 1998) and vision (Kosslyn, Thompson, Costantini-Ferrando, Alpert, & Spiegel, 2000) appear to have neural correlates that are more akin to those of real experiences than to imagining. Blakemore, Oakley, and Frith (2003) compared neural activity associated with either hypnotically-induced movement (of a finger, rather than a whole arm) or with deliberate, voluntary movement. The hypnotic movement (experienced as ‘happening by itself’) produced more parietal activity, as would be expected had the movement genuinely been caused by an external agent. These findings all imply that a successful hypnotic participant is able to generate experiences that go beyond simple imagination, although they do not explain how this is achieved.

From early on (e.g., Crawford et al., 1998) scanning studies have implicated the anterior cingulate cortex (ACC) as playing a significant role in hypnosis, suggesting that the process involves an unusual deployment of attentional resources. Also, changes in gamma-band EEG during hypnosis have been interpreted as revealing a reduction in connectivity between brain regions (Fingelkurts, Fingelkurts, Kalio, & Revonsuo, 2007). Overall, results can be described as supporting a long-standing description of hypnosis: that it involves an abandonment of reality testing. In line with this, many researchers have
concluded that highly susceptible participants (commonly known as ‘Highs’, while the unresponsive are termed ‘Lows’) achieve their experiences by being adept at focusing attention strategically and keeping some key material out of attention (e.g., Barber, Spanos, & Chaves, 1974; Crawford & Gruzelier, 1992; Hilgard, 1977).

The distinction between Highs and Lows invites enquiry into how or why they differ. Apart from their responsiveness to hypnosis, there are no very obvious differences between the two groups and, because correlations between susceptibility and other variables are low, Highs and Lows have to be selected by screening with hypnotic susceptibility tests. Nevertheless, it is tempting to speculate that there may be subtle neural differences between those who can achieve hypnotic effects and those who cannot, differences that may be detectable without recourse to hypnosis. A recently reported diffusion tensor imaging study (Dennis, Gabrieli, Whitfield-Gabrieli, Haas, Spiegel, & Hoeft, unpublished 2008 conference poster) showed that hypnotic Highs have greater functional connectivity between dorsal ACC and the left dorso-lateral prefrontal cortex. The authors speculate that this may facilitate the alteration of sensory and motor functions in hypnosis, but do not comment upon the possibility of behavioural differences outside hypnosis. The studies of Gruzelier and colleagues (see Gruzelier (2006) for a review) lend support to the idea that Highs have a particular asymmetry in brain function, showing that in hypnosis left hemispheric activity is reduced, leaving the right to predominate. These shifts were demonstrated behaviourally in a haptic shape-discrimination task. Outside hypnosis, the right hand (left hemisphere) advantage in this task was more marked in Highs, but hypnosis brought about a left hand improvement which was correlated with depth of hypnosis.

The hemispheric effects highlight another difference that awaits full explanation; not only is there a difference between Lows and Highs, but also between the conditions of waking and hypnosis. (Note: ‘waking’ is frequently used to distinguish from hypnotised, but does not imply that the latter is akin to sleep.) One approach to the issue would be to claim that there is no waking/hypnosis difference. This position is based on the fact that people pass almost as many susceptibility test items when simply asked to imagine what is suggested, as they do when the suggestions are delivered in a formal hypnosis session (Kirsch, 1997; Kirsch & Braffman, 2001). It is not intended in this paper to address the questions of whether a hypnotic induction actually affects any changes, nor whether asking a High to imagine is tantamount to performing hypnosis. Instead, based on the non-controversial observation that Highs are able to switch from interacting with a veridically perceived world to having vivid, but unreal experiences, two questions are asked. First, is the switch associated with a distinctive change in brain behaviour, and second, does their normal brain state differ from that of Lows? For convenience, ‘hypnosis’ and allied terms will continue to be used, but the parsimonious reader may prefer to interpret them as mere labels for any situation in which suggestive people can achieve the effects traditionally described as ‘hypnotic’.

The findings discussed earlier suggest that Highs may have more flexibility within the left hemisphere than do Lows, perhaps leading to more effective processing in this hemisphere during the waking state, but permitting some degree of disconnection during hypnosis. It would be valuable to be able to test this suggestion with a simple technique, rather than resorting to scanning or EEG technologies, but with a more sensitive task than sorting objects by feel, as used in the Gruzelier (2006) study. The task that was chosen uses temporal order judgements (TOJ).

In a typical TOJ study two visual items are presented, one in each hemi-field, with some small inter-stimulus interval (ISI) between the presentations; the participant is required to decide which item was presented first. Whether it is the left or the right event that leads, the sizes of ISI required to detect the order are generally broadly similar, although with a tendency for a shorter ISI when the left visual field (LVF) leads (Stelmach & Herdman, 1991). However, the task has been used in situations leading to a greater difference in ISIs. It has been shown, for example, that neglect patients have a marked asymmetry, requiring a much longer lead time when the first event occurs in the contra-lesional hemi-field (Rorden, Mattingley, Karnath, & Driver, 1997). Additionally, the task appears to be able to identify children with reduced ability for sustained attention (as with ADHD) who prove to be relatively slow at detecting items appearing in the LVF (Dobler, Anker, Gilmore, Atkinson, & Manly, 2005). Thus, this form of TOJ task appears to be sufficiently sensitive to detect hemispheric asymmetries, and moreover, being simple enough for children to perform, lends itself to use within hypnosis, where a highly complex task might be undesirable.

It was hypothesised that, in the waking state, when the leading stimulus occurred in the right hemi-field, highly hypnotisable participants would demonstrate their putative left hemisphere advantage by being more successful than Lows at making TOJs. However, if hypnosis resulted in the Highs reducing left hemisphere activity, their right-leading superiority would then be reduced.

2. Method

After giving informed consent, students attending an Open University Summer School were screened, using a standard hypnotic susceptibility test (Waterloo-Stanford Group Scale C; Bowers, 1998). Ten high scorers and 10 low were selected to participate in the study; all were right handed.

Stimuli were presented using two red light emitting diodes (LEDs) mounted on a pair of spectacle frames. One LED was placed on each outer edge of the frame, such that it was visible only with the adjacent eye. Positioning was near the outer corner of the eye, so that each LED delivered a stimulus to the corresponding hemi-field. Stimuli comprised 1 ms flashes of the LEDs, presented sequentially, either left–right or right–left. The participant then responded by pressing a left- or right-hand button, indicating that the left or right LED had flashed first. If the presentations appeared simultaneous the participant pressed both buttons simultaneously. Following the response there was a 2 s delay before the next stimulus pair was
presented. The sequence (L–R or R–L) was selected randomly, although with a maximum of three successive presentations using the same sequence. The whole process was controlled with a PIC microcontroller, running software developed for the purpose.

Critical intervals (ISIs at which the order could just be detected) were determined using a staircase method. At the start of testing ISIs were set to 128 ms for both sequences (i.e., for L–R and R–L). Each time a correct response was given, the ISI for the corresponding sequence was reduced by a step size set separately for each sequence. Initially this step was set at 32 ms for both sequences. On an error the ISI for that sequence was returned to the previous successful value, and the step size was halved. Descent of the staircase did not recommence until there had been two successive correct responses. A further error response at this stage resulted in the ISI being increased by the step size. A simultaneous decision (both buttons) was treated as an error. The procedure continued until for both sequences the step had been reduced to 1 ms and there had been an increase of ISI following an error. The resultant ISI was taken to be the critical interval (CI) for the sequence.

Participants were tested twice, once during hypnosis and once without. Half of each group (Lows and Highs) were tested first in hypnosis; the remainder began with the waking condition. Those who were going to be tested in hypnosis first were familiarised with the apparatus and nature of the task, before the hypnotic induction was commenced. The induction used instructions for progressive relaxation, followed by a period of guided visual imagery, during which the participant was asked to try to visualise being in a relaxing scene. Following the induction, participants were requested to open their eyes, put on the spectacles and commence the task. At its conclusion, hypnotised subjects were asked to close their eyes once more and relax briefly, before alerting instructions were given. In both conditions, participants were asked to keep their eyes looking forward while performing the task.

3. Results

Critical intervals were determined for participants of high and low susceptibility, and for left hemi-field leading (CLleft) and right hemi-field leading (CLright), this being repeated in waking and hypnotised conditions. Mean values are shown in Fig. 1.

The data were examined by analysis of variance (ANOVA). A 2(wake/hypnotised) × 2(left/right) × 2(high/low) ANOVA revealed a significant 3-way interaction: $F_{1,18} = 12.7, p = .002$. There was also a significant 2-way interaction between state and side: $F_{1,18} = 9.7, p = .006$. No other significant effects were observed, although the interaction between state and susceptibility approached significance ($p = .073$).

Two-way ANOVAs, examining the effects of state and side, were conducted for high- and low susceptibility participants separately. The following significant effects were found. In Lows there was an overall increase in CI in hypnosis: $F_{1,9} = 6.6, p = .03$. In Highs there was an interaction between state and side: $F_{1,9} = 26.1, p = .001$.

Planned, 1-tailed t tests were carried out, to examine the differences implicit in the initial hypotheses. For Highs, $CL_{right}$ increased significantly with hypnosis ($t = 3.07, df = 9, p = .007$) suggesting a reduction in left hemisphere processing speed during hypnosis. At the same time, right hemisphere processing became faster, with a significant reduction in $CL_{left}$ ($t = 3.54, df = 9, p = .003$). Prior to hypnosis, processing was significantly faster in the left hemisphere than the right ($t = 2.05, df = 9, p = .036$), but this was reversed in hypnosis ($t = 2.08, df = 9, p = .034$). In the waking state, Highs were slower than Lows at processing in the right hemisphere, as shown by a significant difference in $CL_{left}$ between the two groups ($t = 1.95, df = 18, p = .033$).

![Fig. 1. Mean critical intervals (ms) for left- and right-leading order judgements. Standard deviations shown in parentheses.](image-url)
4. Discussion

The suggestion that, in the absence of hypnosis, highly hypnotisable people would exhibit particularly effective left hemisphere processing has been supported; results show that critical intervals were shorter for right-leading stimuli than left in this group. In addition, the left-leading Cs were longer than the corresponding measure in the low hypnotisability group. However, with no main effect of group, the Highs cannot be said to have better processing ability; indeed, their apparently efficient left hemisphere does not actually process significantly faster than the Lows in either hemisphere. What Highs do appear to exhibit is greater hemispheric asymmetry and, moreover, they are able to reverse the asymmetry in hypnosis; Lows merely slow their processing overall in hypnosis.

The significant changes in processing speeds exhibited by Highs when hypnotised support the claim that hypnosis engenders a change in brain state. Against this position, it is recognised that the critical interval for TOJs can be shifted with changes in direction of attention (Stelmach & Herdman, 1991). It therefore remains possible that the shifts reported here are due to a simple change of attention, perhaps brought about by the visualisation procedures used in the induction (Gruzelier, 2006). However, the results also reveal a difference between Highs and Lows while in the waking state, providing good evidence for the claim that there are inherent differences between the brains of high and low susceptible people. If this difference is accepted as real it becomes more plausible to suppose that the change produced by hypnosis (in those able to experience it) is also of more significance than a simple change of attention.

It is curious that the enhancement in right hemisphere processing and corresponding reduction in the left hemisphere, exhibited by Highs during hypnosis, results in an asymmetry in the same direction as shown by Lows (with or without hypnosis). Clearly the Lows are unable to achieve hypnotic effects with this pattern of activity, so it seems likely that these effects are associated with the change, rather than asymmetry per se. It is not clear from these results which change is critical. With hypnosis, Lows exhibit negligible slowing in the left hemisphere, while Highs slow significantly: this may be the difference that is crucial to hypnosis. However, while Highs speed their right hemisphere processing when hypnotised, Lows actually slow theirs; this difference may equally well underlie the ability for hypnosis. One of the most consistent effects of hypnosis is its impact upon time perception, behaving as if an internal clock is slowed (Naish, 2003). With evidence that at least part of the timing process takes place in the right hemisphere (Lewis & Miall, 2006) it is plausible that it is the change in right hemisphere activity that brings this about. Moreover, Lows tend to produce the opposite timing effect, as if the clock has sped up (Naish, 2007); this may be linked to their opposite tendency to reduce right hemisphere activity.

It is unlikely that a simple reduction in left hemisphere activity is all that is required to achieve hypnosis, since Lows also appear to achieve such a reduction. Similarly, it is unlikely that the greater connectivity claimed for Highs aids hypnosis simply by ceasing to be used (Dennis et al., 2008; Fingelkurts et al., 2007). While it is plausible that Highs cease assembling full, reality-checked representations of external stimuli, it is clear that they maintain contact with reality, for example, in monitoring and responding to the hypnotist’s directions. The reduction in left hemisphere activity may reflect the general reduction in attention to external stimuli, but the enhanced connectivity may be required to produce a system sufficiently versatile that selected external processes can continue to be monitored.

A possible explanation for the switch to right hemisphere processing is that it facilitates the generation of illusory experiences. There is evidence that the left hemisphere is involved in the processing of local detail, while the right is concerned with more global processing (Hans et al., 2002; Malinowski, Hubner, Keil, & Gruber, 2002). The formation of a sensory experience, in the absence of sensory input, must involve top-down processing which presumably begins at the global, conceptual level. It could be argued that to achieve this it would be necessary to cease basing conscious experience upon the (absent) bottom-up, fine detail of the left hemisphere, using instead the self-generated ‘big picture’ of the right.

Another interesting parallel to the above is to be found in posttraumatic stress disorder (PTSD). A number of studies have reported relatively greater right hemisphere activation in PTSD patients (e.g. Clark et al., 2003; Metzger et al., 2004). Indeed, Vasterling, Duke, Tomlin, Lowery, and Kaplan (2004) specifically link this asymmetry to a shift towards global processing. The parallel with hypnosis is in fact even closer, since there is strong evidence for a correlation between hypnotic susceptibility and vulnerability to PTSD; although the direction of causality remains unknown (Yard, DuHamel, & Galynker, 2008).

Another correlation exists between hypnotic susceptibility and scores on a scale of schizotypy (Gruzelier et al., 2004). There is abundant evidence for abnormal hemispheric asymmetries in schizophrenia, as shown, for example, by McCourt, Shpaner, Javitt, and Foxe (2008) who used a line bisection task. Like the TOJ task used in the current hypnosis study, line bisection has been used as a tool for detecting visual neglect. Healthy participants display a tendency to divide a line left of centre, but McCourt et al. reported that schizophrenia patients did not produce this bias, interpreting this as revealing a deficit in right hemisphere functioning. This is equivalent to the situation for Highs while waking, as revealed by TOJ. Caligiuri et al., 2005 used a range of tests of hemispheric function in patients, and from their results speculated that decreased arousal in the left hemisphere might result in reduced inhibition of the right (via the corpus callosum) and hence lead to right hemispheric dysfunction. This could equally be a speculation about the effects exhibited by Highs in hypnosis.
5. Conclusions

Those who are highly susceptible to hypnosis are able, by definition, to generate unusual experiences. These are achieved while in a state where their brains show a hemispheric asymmetry that is reversed from their normal, waking state. Moreover, their normal pattern of responding to the TOJ task differs from that of people who have low hypnotic susceptibility.

To take these findings further is speculative, but there are correlations between hypnotic susceptibility and two other conditions which produce anomalous experiences, schizophrenia and the 'flashbacks' of PTSD. It is tempting to suggest that abnormal hemispheric effects may play a part in all these examples of hallucination-like experiences. Until some of these speculations can be tested, perhaps the most useful application for these findings will prove to be in the selection of research participants. Generally, high-susceptibility volunteers are identified by rather lengthy screening using hypnotic induction and the administration of standard test batteries. The procedures would become far less protracted if initial selection could be based upon critical interval measurement in the waking state. At this stage the full profile of TOJ performance across all levels of hypnotic susceptibility is not known, as only Highs and Lows were tested. In the sample examined the Lows appeared to exhibit more variability, with 4 of the 10 participants showing a 'High-like' waking pattern (i.e., right hemi-field advantage). Only 2 of the 10 Highs showed a left hemi-field advantage. Thus, with this sample 70% would have been correctly assigned to their groups.

References


