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Hypnosis in the right hemisphere

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ABSTRACT

Speculations about the neural substrates of hypnosis have often focused on the right hemisphere (RH), implying that RH damage should impair hypnotic responsiveness more than left-hemisphere (LH) damage. The present study examined the performance of a patient who suffered a stroke destroying most of his LH, on slightly modified versions of two hypnotizability scales. This patient was at least modestly hypnotizable, as indicated in particular by the arm rigidity and age regression items, suggesting that hypnosis can be mediated by the RH alone – provided that the language capacities normally found in the LH remain available. A further study of 16 patients with unilateral strokes of the LH or RH found no substantial differences in hypnotizability between the two groups. Future neuropsychological studies of hypnosis might explore the dorsal/ventral or anterior/posterior dichotomies, with special emphasis on the role of prefrontal cortex.

1. Introduction

Of all the speculations concerning the neural substrates of hypnosis and hypnotizability, perhaps the most popular have been those that implicate the right cerebral hemisphere (for reviews, see Barabasz and Barabasz, 2008; Kihlstrom, in press). Bakan (1969) was apparently the first to propose that hypnosis was mediated by the right hemisphere (RH), based on an identification of hypnosis with the creative, intuitive, nonanalytic, and holistic processing often held to characterize RH function (e.g., Hellige, 1993; but see Efron, 1990), in contrast to the logical, sequential, and analytic processing associated with the LH. Of course, a strong interpretation of the RH hypothesis is untenable (Jasiukaitis et al., 1997), if for no other reason than that the comprehension of hypnotic suggestions requires linguistic skills normally associated with the LH.

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Nevertheless, over the succeeding years, the idea that the nondominant, typically right, hemisphere is somehow specialized for hypnosis has been extremely attractive to both researchers and theorists (for a comprehensive review, see Crawford and Gruzelier, 1992).

Evidence for RH involvement in hypnosis has come mostly from studies employing behavioral or psychophysiological paradigms (for a comprehensive review, see Kihlstrom, in press). For example, Bakan himself reported that hypnotizable subjects showed more reflective eye movements to the left, ostensibly indicating greater RH activation, than insusceptible subjects (Bakan, 1969), while other investigators found that hypnosis diminished the right-ear (i.e., LH) advantage frequently found in dichotic listening tasks (Frumkin et al., 1978; Spellacy and Wilkinson, 1987). Hypnotizability has been associated with autokinetic movements to the left (Graham and Pernicano, 1979). In one study, subjects who sat on the right side of a room (thus placing the hypnotist in their left visual half-field, projecting into the right cerebral hemisphere) were more hypnotizable than those who sat on the left (Sackeim et al., 1979), while in another study right-handed subjects given motor suggestions were more responsive on the left side of their body – i.e., the side controlled by the RH (Sackeim, 1982). Hypnotizability has been correlated with performance on "gestalt closure" tasks that seem to capitalize on the holistic information-processing capacities of the RH (Crawford, 1981); and the induction of hypnosis, particularly in hypnotizable subjects, enhanced performance on behavioral tasks that ostensibly capitalized on "RH" functions (Bakan, 1970; Crawford, 1986). On the other hand, many of these observations have proved difficult to confirm and extend (e.g., Bakan, 1970; Cranney and McConkey, 1980; Gur and Gur, 1974; Monteiro and Zimbardo, 1987; Otto-Salaj et al., 1992; Stam et al., 1981; Wallace and Persanyi, 1989).

A similar fate befell psychophysiological and brain-imaging studies of hypnosis, hypnotizability, and laterality. Some investigators reported that hypnosis produced a shift from LH to RH activation, as measured by the EEG (Edmonston and Moskovitz, 1990; MacLeod-Morgan and Lack, 1982), while Gruzelier and his colleagues found lateral asymmetries in EDR activity suggesting an inhibition of the LH (Gruzelier et al., 1984; Gruzelier and Brow, 1985). At the same time, both earlier (Morgan et al., 1971, 1974) and later (Graffin et al., 1995) studies failed to produce congruent results. A pioneering PET study by Crawford and her colleagues found that hypnotizable subjects showed dramatic increases in regional cerebral blood flow in the RH following hypnotic induction (Crawford et al., 1993). However, more recent studies have indicated broader patterns of activation involving both cerebral hemispheres (Maquet et al., 1999; Rainville et al., 1999).

Given all this activity, it is somewhat remarkable that, to our knowledge, no investigator has ever addressed the RH hypothesis by testing patients with lateralized brain injury. Some investigators have administered neuropsychological tests, including assessments of lateralized function, to hypnotized or hypnotizable subjects (Gruzelier and Warren, 1993; Query et al., 1983), but these subjects were neurologically intact. Laidlaw (1993) assessed hypnotizability in a group of neurological patients who had suffered closed head injuries, but did not specifically consider laterality. Relatedly, Persinger and his colleagues (Healey et al., 1996; Tiller and Persinger, 1994) found that the brief application of a weak pulsed magnetic field over the right temporal lobe, inducing activity resembling complex partial epileptic-like seizures, increased hypnotizability in neurologically intact subjects. The present study sought to contribute to neuropsychological investigations of hypnosis by examining hypnotic susceptibility in patients with clearly lateralized brain damage secondary to stroke.

2. Case study: patient GK

2.1. *Case description*

At the time of testing (1994), GK was a 63-year-old right-handed male who had suffered a LH stroke in 1977, resulting in global aphasia, alexia, and agraphia, as well as a dense right homonymous hemianopia, right hemiplegia, and right hemisensory loss. An MRI scan showed a massive infarction involving the distribution of all three major cerebral arteries supplying the LH. The lesion resulted in virtually complete destruction of the cortex of all four cerebral lobes of the LH as well as the underlying white matter. The RH appeared to be normal.

Following his discharge from the hospital, GK showed continuous improvement of his language and gestural abilities, reaching a plateau after about 2 years in recovery. At the time of testing, more than 15 years after his stroke, his speech and language abilities were consistent with Broca's (expressive) aphasia. His spontaneous speech was effortful, nonfluent, and slightly dysarthric; his speech output was a grammatical but meaningful, with the omission of functors and simplified sentence structure. His auditory comprehension was excellent for conversational speech, disrupted only when he was dealing with complex sentences. GK walked with a leg brace, and his only other physical limitation was a right hemisensory loss, and a right hemiplegia restricting use of his right arm. Despite these impairments, he lived alone, tended to his daily affairs without any apparent difficulty, and pursued his hobby of building model automobiles and airplanes.

Because GK's language abilities were relatively well preserved, he was almost unique among those patients who have lost so much of their LH late in life. Accordingly, he was studied by investigators who were interested in hemispheric contributions to various aspects of cognitive and behavioral function (Polster and Rapcsak, 1994; Rapcsak et al., 1991, 1993).

2.2. *Methods and results*

In the course of events, GK agreed to participate in a study of hypnosis. For this purpose, he was individually administered modified versions of the 12-item Stanford Hypnotic Susceptibility Scale: Form A (SHSS:A; Weitzenhoffer and Hilgard, 1959), followed by the 12-item Stanford Form C (SHSS:C; Weitzenhoffer and Hilgard, 1962). In return for his participation, GK received an honorarium of $25 plus reimbursement of his travel expenses for each of two sessions lasting approximately 75 min in length.

In view of GK's right hemiplegia, the Postural Sway item (#1) of SHSS:A was replaced by the corresponding "Head Falling Forward" item (#1) of the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A; Shor and Orne, 1962, 1963). The Arm Immobilization item (#4) was shifted from the right to the left side, and the Hands Moving Together suggestion (#7) was omitted entirely. Two items, Posthypnotic Suggestion and Posthypnotic Amnesia, proved difficult to assess due to GK's physical and verbal-expressive limitations. Still, GK clearly passed nine out of the possible 11 items, which would ordinarily indicate relatively high hypnotizability (Register and Kihlstrom, 1986).

In contrast to his relatively high score on SHSS:A, however, GK clearly passed only four out of a possible 10 items on a modification of the more demanding SHSS:C. As on SHSS:A, lateralized items of the SHSS:C (#1, Hand Lowering; #5, Arm Rigidity; and #8, Arm Immobilization) were shifted as appropriate; Hands Moving Apart (#2) was eliminated. In view of GK's expressive aphasia, the Dream (#6) item was also eliminated, leaving 10 items in the scale. For the same reason, a recognition test was added to the usual recall test of posthypnotic amnesia (Kihlstrom and Shor, 1978).

Five items were common to both the Form A and the Form C. GK passed two of these on both occasions: the relatively easy Hand Lowering suggestion and the more difficult Arm Rigidity. He barely failed Arm Immobilization on SHSS:C, lifting his hand about three inches before the end of the 10-sec interval. On the Mosquito Hallucination item of SHSS:C (corresponding to the Fly Hallucination of SHSS:A), he appeared to be annoyed but did not make any swatting gesture. Perhaps this was due to his physical limitations, but in any event he was scored as failing the suggestion. On the test of posthypnotic amnesia, GK recalled nothing while the amnesia suggestion was in effect, but on the recognition test correctly identified seven suggestions, with no false positives; accordingly, he was scored as failing the amnesia item.

Interestingly, GK responded positively to the cognitively demanding Age Regression suggestion on SHSS:C. This was illustrated both by his verbal report of his name and age (nine), and by his handwriting sample. He wrote the year as 1939 (which was when he was 9 years old), and named and described his teacher.

In summary, GK's response in both hypnosis sessions indicated that he was at least somewhat hypnotizable. Although he did not pass a majority of the items on SHSS:C, which is generally considered the "gold standard" for the assessment of hypnotizability (Register and Kihlstrom, 1986), he did score relatively high on SHSS:A and responded positively to two of the more difficult suggestions – Arm Rigidity and Age Regression – on SHSS:C.

3. An exploratory study of stroke patients

Nothing about GK's performance would suggest that the special abilities associated with the RH offer any particular advantage, so far as hypnosis is concerned. At the same time, however special, GK was only one subject. Accordingly, we followed our study of GK with a pilot study of patients who had suffered unilateral brain damage as a result of a stroke.

3.1. *Patients*

The subjects in this study were 16 right-handed patients, 8 men and 8 women, averaging 56 years of age (SD = 16.40), members of a stroke survivor support group at a large university medical center who volunteered for a study of hypnosis. All signed a written informed consent to participate that was approved by the local institutional review board for the use of human subjects in research. All subjects were in the chronic stage of stroke: a minimum of 6 months had passed since the onset of their lesion.

Nine of these subjects (5 men, 4 women) had damage due to strokes affecting the left cerebral hemisphere (LH), and seven (3 men, 4 women) had damage due to strokes affecting the RH. All exhibited behavioral evidence of unilateral stroke, including contralateral hemiparesis or sensory impairment and/or speech and language dysfunction characteristic of LH stroke. None of the subjects exhibited frank unilateral spatial neglect or anosognosia and none had comprehension deficits that precluded understanding instructions. Clinically obtained neuroradiological images were available for the majority of subjects: they confirmed the presence of a unilateral stroke in 7/9 subjects with LH injury and in 4/7 subjects with RH injury. Table 1 shows the distribution of the lesions in the two groups. Most had lesions in the frontal, temporal, or parietal regions.

The patients' average score on the Mini-Mental Status Exam (MMSE; Folstein et al., 1975) was 25.75 (SD = 3.97), indicating essentially intact cognitive abilities. There was no difference in MMSE performance between the LH and RH groups ($t < 1$). In return for their participation, the patients received an honorarium of $25 plus reimbursement of their travel expenses for a single experimental session lasting 75 min.

3.2. *Method*

Following informed consent, each patient received an individual administration of the Arizona Motor Scale of Hypnotizability (AMSH), which consists of an induction of hypnosis accompanied by suggestions for 16 representative hypnotic experiences. The AMSH itself was derived from existing standardized tests of hypnotizability, such as SHSS:A and C and HGSHS:A. It is so named because it focuses mainly on ideomotor suggestions of two types: direct and challenge,

Table 1 – Radiological Findings in stroke patients.

N	Distribution of lesions
7 of 9 Patients with LH lesions	
3	Frontal-temporal-parietal (cortical and subcortical)
2	Temporal-parietal
1	Occipital-temporal
1	Posterior thalamus
4 of 7 Patients with RH lesions	
2	Frontal-temporal-parietal (cortical and subcortical)
1	Temporal-parietal
1	Occipital

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with less emphasis on cognitive items. Each of the 16 test suggestions (including one for eye closure administered during the hypnotic induction procedure itself) is scored dichotomously (pass/fail) on the basis of objective behavioral criteria, yielding scores that can range from 0 to 16 points. Normative information based on 100 college-student subjects, and the AMSH script, is available as an Internet resource (Kihlstrom, 2011). The AMSH was originally constructed to address a question concerning the multidimensional structure of hypnotizability: whether the direct and challenge suggestions constituted separate factors. It was employed in the present study because of the availability of contemporaneous norms, derived from the sample of 100 students described earlier.

Many of the AMSH suggestions are lateralized, targeting either the left or the right arm or hand: as with GK, these suggestions were modified to take account of the patients' hemiplegia. As before, three suggestions involving bilateral movements were eliminated entirely: for purposes of comparison, scores on these items, and occasional missing data, were estimated by regression based on the combined set of patient and student data.

3.3. *Results*

The AMSH was first scored according to the standard criteria established in the published scales from which it was derived. Table 2 shows the number of items passed, according to these standard criteria. Despite differences in age, not to mention neurological status, the average AMSH score for the stroke patients was only slightly lower than that of the normative group of college students ($t < 1$).

It is conventional to classify hypnotic suggestions into two major categories: "Ideomotor" suggestions, as their name implies, involve suggestions for bodily movements (e.g., the subject's head is falling forward); "cognitive" suggestions focus on changes in perception and memory (e.g., for age regression) – which, of course, may also have consequences for behavior (Kihlstrom, 2008). Ideomotor suggestions, in turn, come in two major types: "direct" suggestions facilitate motor activity, as when it is suggested that the subject's outstretched hand is growing heavy and falling; "challenge" suggestions inhibit motor activity, as when it is suggested that the subject's arm is rigid, and he cannot bend it. Excluding the direct suggestion for eye closure, which is administered during the hypnotic induction procedure itself (pass rate: 89% for students, 94% for patients), AMSH contains six direct suggestions, six challenge suggestions, and three cognitive suggestions. Table 2 also shows mean scores on these subscales. There were no significant differences between the patients and the students on any of these subscales: Direct, $t(114) = 1.01$, n.s.; Challenge and Cognitive, both $t < 1$.

Table 2 – Hypnotizability scale performance – standard scoring.

Variable	Group	M	SD
Comparing patients and students			
Total score[a]	Patients	8.25	2.74
	Students	8.56	3.63
6 Direct suggestions	Patients	4.06	1.06
	Students	4.47	1.55
6 Challenge suggestions	Patients	2.19	1.60
	Students	2.04	1.78
3 Cognitive suggestions	Patients	1.06	.93
	Students	1.16	1.00
Comparing patients with RH and LH damage			
Total score[a]	Right	8.86	2.41
	Left	7.78	3.03
6 Direct suggestions	Right	4.57	.53
	Left	3.67	1.22
6 Challenge suggestions	Right	2.14	1.68
	Left	2.22	1.64
3 Cognitive Suggestions	Right	1.14	.90
	Left	1.00	1.00

a Includes eye closure suggestion administered during induction procedure (omitted from calculation of the direct suggestion subscale).

Table 2 also shows that the two groups of stroke patients did not differ significantly from each other, in terms of total scale score ($t < 1$), or any of the three types of items: Direct, $t(14) = 1.81$, $p < .10$; Challenge, $t < 1$; Cognitive, $t < 1$. Contrary to the laterality hypothesis, there was again a tendency for subjects with RH lesions to score *higher* than those with LH lesions.

3.4. *Alternative scoring*

Compared to direct suggestions, challenge suggestions are more complex, with a ternary structure: there is first a suggestion of an ideomotor effect (e.g., "Your arm is getting stiff"), then a suggestion of an inhibition of control (e.g., "You cannot bend it"); and finally a challenge to the of inhibition (e.g., "Go ahead, try to bend it"). Accordingly, as a rule, challenge suggestions are more difficult than direct suggestions; for different reasons, cognitive suggestions also tend to be more difficult than direct suggestions. In order to take account of differences in item difficulty, the AMSH items were rescored by adjusting the criteria for passing until the direct suggestion, challenge, and cognitive suggestions were of roughly equal difficulty, in terms of mean scores in the normative sample of college students. This had the effect of making the direct suggestions somewhat harder, and the challenge and cognitive suggestions somewhat easier. For example, the pass rate for the eye closure item in the student sample dropped from 89% under the standard scoring to 56%; for the patients, it fell from 94% to 69% (for details, see the normative study posted online).

Table 3 shows the mean scores on the overall scale, and on each of the subscales, rescored according to this alternative scoring method. The patients again scored slightly lower than the students, but the overall difference was not statistically significant: $t(114) = 1.19$, n.s. Interestingly, however, the difference was statistically significant for the direct suggestions: $t(114) = 3.53$; corresponding differences for the challenge and cognitive suggestions were not significant (both $ts < 1$).

Within the patient group, there was again a tendency for subjects in the RH group to score somewhat higher on the direct suggestions than those in the LH group [$t(14) = 1.78$,

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Table 3 – Hypnotizability scale performance – alternative scoring.

Variable	Lesion	M	SD
Comparing patients and students			
Total score[a]	Patients	6.31	3.03
	Students	7.59	4.13
6 Direct suggestions	Patients	1.25	.68
	Students	2.96	1.91
6 Challenge suggestions	Patients	2.88	1.63
	Students	2.75	1.91
3 Cognitive suggestions	Patients	1.50	.96
	Students	1.32	1.00
Comparing patients with RH and LH damage			
Total score[a]	Right	7.14	2.34
	Left	5.67	3.46
6 Direct suggestions	Right	1.57	.53
	Left	1.00	.71
6 Challenge suggestions	Right	3.29	1.50
	Left	2.56	1.74
3 Cognitive suggestions	Right	1.57	.98
	Left	1.44	1.01

a Includes eye closure suggestion administered during induction procedure (omitted from calculation of the direct suggestion subscale).

$p < .10$]; the differences in total score, and on the challenge and cognitive suggestions, did not approach statistical significance (all $t < 1$).

4. Discussion

The RH hypothesis of hypnosis was based on early research that seemed to reveal dramatic differences in the capabilities of the two cerebral hemispheres. We now have a more nuanced view of the functional differences between the hemispheres (e.g., Efron, 1990), and we also appreciate the role typically performed by the LH in interpreting verbal suggestions from the hypnotist to the subject (Jasiukaitis et al., 1996). Even so, there are reasons for entertaining the hypothesis that the two hemispheres play different roles in hypnosis. For example, in a variant on Sperry's (1968) view of double consciousness, Gazzaniga (1985, 1988) has proposed that consciousness is closely tied to the linguistic abilities normally associated with the LH. Accordingly, it might be that the RH unconsciously generates responses to hypnotic suggestions, which are then represented consciously, and interpreted, by the LH.

Regardless of the rationale for the RH hypothesis, the present studies offer little or no evidence for it. RH damage due to stroke did not impair hypnotic responding. And while the performance of Patient GK indicated that the RH can support some degree of hypnotic responsiveness all by itself (provided that it possesses the requisite linguistic capacities), there was no evidence that the relative absence of a LH "disinhibited" RH functions, so as to make him more hypnotizable than normal. If anything, RH damage in the patients with unilateral stroke may have increased hypnotic responsiveness.

Although our sample was admittedly small, our failure to find significant differences between patients with RH and LH lesions was not an artifact of low power. With t values less than 1, or very close to 1, doubling or tripling the sample size would not make the differences we obtained statistically significant. The advantage of RH patients on the direct suggestions did approach statistical significance, and may warrant further investigation in a larger sample; but even this tentative result contradicts the RH hypothesis. The general lack of difference in hypnotizability between the patients and the students was unexpected. However, given the patients' scores on the MMSE it is possible that their strokes may not have been severe enough to significantly alter their hypnotizability.

As attractive as the RH hypothesis may have been, it is possible that hemispheric specialization is not the right framework for neurological studies of hypnosis. In fact, it has been argued that a dorsal-ventral dichotomy is a better framework than the right–left dichotomy for organizing neuropsychological research – with the dorsal system driven by expectations and processing action, and a ventral system driven by classification and processing perception (Borst et al., 2011). Alternatively, an anterior-posterior dichotomy might better characterize the alterations in executive functioning that seem to underlie the "dissociative" phenomena of hypnosis – involuntary movements, analgesia, amnesia, and the like. Perhaps the prefrontal cortex may play a special role in hypnosis (e.g., Farvolden and Woody, 2004; Halligan et al., 2000; Oakley and Halligan, 2009; Woody and McConkey, 2003). Lesions restricted to frontal cortex were notably absent in our sample of stroke patients.

Brain imaging, whether by fMRI or other techniques, appears to be the favored means of approaching the question of the neural correlates of hypnosis (Oakley, 2008). At the same time, opportunities to study hypnosis in brain-injured patients should not be neglected. Historically, cognitive neuroscience has advanced by integrating neuroimaging studies of intact subjects with neuropsychological studies of brain-injured patients. The present small study shows that it is possible for brain-injured individuals to experience hypnosis, and that their responses to hypnosis can be assessed without unduly compromising the standardized procedures that, historically, put hypnosis research on a firm empirical base. Future studies of stroke patients employing larger samples to explore the dorsal/ventral and anterior/posterior dichotomies, and their potential interactions with lesion laterality, may help identify the neural substrates of hypnosis.

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