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HYPNOSIS, MEMORY, AND FRONTAL EXECUTIVE FUNCTIONING[1]

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Abstract: According to the dissociated-control hypothesis forwarded by Woody and Bowers (1994), the effects of hypnosis are consistent with attenuated frontal lobe functioning. The present study was designed to compare the performance of participants with high and low hypnotic ability on a variety of memory tasks thought to be sensitive to frontal lobe functioning, as well as some control memory tasks not considered to be sensitive to such functioning. Results generally indicated that participants with high hypnotic ability have more difficulty with tasks sensitive to frontal lobe functioning, including free recall, proactive interference, and source amnesia tasks, both within and outside of the context of hypnosis. These differences, which were not found for nonfrontal tasks, are generally supportive of the dissociated control theory of hypnotic responding.

In times past, it was widely assumed that the ''trance'' associated with hypnosis was a form of artificial sleep and that somnabulists would have no posthypnotic recollection of the events that occurred while they were ''asleep'' (Evans, 1988). However, the present consensus is that posthypnotic amnesia is only experienced as the result of direct suggestions to that effect and that spontaneous amnesia is neither an interesting nor essential feature of high hypnotic ability (Davidson & Bowers, 1991; Kihlstrom & Schacter, 1995).

Most available theories of hypnotic responding do not posit any real underlying changes in cognitive control processes during hypnosis. According to these views, any unsuggested effects of hypnosis on

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memory (Furneaux, 1946; Hammer, Evans, & Bartlett, 1963) can be best accounted for by demand, context, and expectation effects (Kihlstrom, 1992; Kirsch, 1997; Spanos, 1986).

In contrast, according to the theory of dissociated control (Woody & Bowers, 1994), hypnosis alters the actual underlying control of behavior and not just attributions about control. That is, hypnosis results in a relative weakening of the executive level of cognitive control responsible for the initiation and monitoring of behavior. According to Woody and Bowers, the unsuggested effects of hypnosis on memory bear a strong resemblance to what Shallice (1988) and others (Shimamura, 1995) have termed *frontal amnesia*.

The present study was designed to be a strong test of the dissociated control explanation of hypnotic amnesia. The notion that the unsuggested effects of hypnosis on memory resemble the symptoms of frontal amnesia suggests that hypnotized participants should have difficulty with the sorts of memory tasks that are used to distinguish frontal amnesia from other amnesic syndromes (i.e., temporal-lobe problems). Shimamura (1995) has described a variety of such memory tests. What follows is a brief review of Shimamura's battery of frontal memory tasks and a brief summary of relevant research in hypnosis and memory to date.

Free Recall

Patients with frontal lobe lesions show impaired free recall for lists of unrelated words (Gershberg & Shimamura, 1991). Shimamura (1995) has proposed that the impairment in free recall observed in frontal lobe patients is due to the demands that such a task places on internally generated memory strategies and effortful search and retrieval processes (Baddeley, 1986). Interestingly enough, Kihlstrom (1980) reported that hypnotized participants take significantly more trials to learn a list of unrelated words than do control participants.

Proactive Interference

Patients with frontal lobe lesions have difficulty ignoring irrelevant information (Milner, 1982; Perret, 1974). There are a number of memory tasks designed to assess the impact of prior learning in the learning of new information, and the term *proactive interference* is used to describe the negative effects that prior learning can have on new learning. Shimamura (1995) has reported that patients with frontal lobe damage show impairment on tests of memory that require participants to inhibit previously learned responses in an AB-AC paired-associate learning task.

There has only been one reported study of proactive-interference effects following a hypnotic induction. Dillon and Spanos (1983) administered a Brown-Peterson memory task designed to induce proactive interference. They reported that an amnesia suggestion

did not prevent previously learned material from interfering with newly presented material and that hypnotized participants showed no more proactive interference than unhypnotized participants. Given that the Brown-Peterson task is quite different from the proactive-interference task employed by Shimamura (1995), the effects of hypnosis on performance on such tasks merit further exploration.

Word Fluency

The word-fluency test is well established as a measure of left frontal lobe functioning, in contrast to which the design-fluency task is a less well-established measure of right frontal lobe functioning (Shimamura, 1995). Patients with left frontal lobe damage demonstrate marked impairment on the word-fluency test (Janowsky, Shimamura, Kritchevsky, & Squire, 1989). Gruzelier and Warren (1993) have reported that hypnotized participants show a reduction in word generation to letter categories, results that are broadly consistent with the hypothesis that hypnotized participants have a difficulty in word finding that is similar to the anomia observed in patients with left frontal damage.

Temporal Organization

Milner (1971) reported that frontal lobe patients exhibit deficits in the temporal organization of memory. Using a word-sequencing task, Shimamura, Janowsky, and Squire (1990) have also demonstrated impaired memory for temporal order in patients with frontal lobe lesions. Participants were presented with a list of 15 words, one at a time, and then were asked to reconstruct the correct list order from a random display of the stimulus words. Patients with frontal lobe lesions exhibited significant impairment on this task as compared to control participants (Shimamura et al., 1990).

It has been demonstrated, more often than not, that highly hypnotizable participants are likely to recall in a more disorganized fashion following suggestions for amnesia (Bertrand & Spanos, 1986; Geiselman, Bjork, & Fishman, 1983; Kihlstrom & Wilson, 1984; Radtke & Spanos, 1981; Radtke, Spanos, Malva, & Stam, 1986; Schwartz, 1980; Spanos & Bodorik, 1977; Spanos & D'Eon, 1980; Spanos, Radtke-Bodorik, & Stam, 1980). The evidence for temporal disorganization in hypnosis in the absence of specific suggestions for amnesia is also mixed. However, in contrast to Kihlstrom and Evans (1979), Radtke et al. (1986) and Schwartz (1980) have reported that even prior to receiving suggestions for amnesia, hypnotized participants are significantly less sequential in their recall of their hypnotic experiences than are nonhypnotized control participants. Indeed, Radtke et al. pointed out that the effects of hypnosis on temporal organization might not be due to suggested amnesia.

Source Amnesia

Source amnesia occurs when one can remember factual information but not when or where the information was either originally or last encountered. Source-error effects are usually associated with impairment in frontal lobe functioning (Moscovitch, 1994; Shimamura, 1995). For example, Janowsky, Shimamura, and Squire (1989b) asked patients with frontal lobe lesions and control participants to learn a set of 20 obscure trivia facts (e.g., the name of the dog on the Cracker Jacks box is ''Bingo''). After a 6- to 8-day retention interval, participants were tested for recall of both the facts learned during the previous session (e.g., what is the name of the dog on the Cracker Jacks box?) and for 20 new facts, as well as for their knowledge of the source of the information. Janowsky et al. (1989b) reported that patients with frontal lobe lesions were able to recall as many of the previously learned facts as normal controls. However, Janowsky et al. (1989b) also reported that patients with frontal lesions tended to make two kinds of source errors: (a) errors in which they falsely reported that an ''old'' fact learned in the first session was most recently encountered at some time prior to the first session; and (b) errors in which they incorrectly reported that a recently ''new'' fact was encountered during the first learning session. According to these criteria, source memory was impaired in patients with frontal lobe lesions, even though their recall of the ''old'' facts was as good as that of control participants.

There are considerable data regarding source amnesia following specific suggestions for amnesia (Cooper, 1966; Evans & Thorn, 1966; Gheorgui, 1967). In these experiments, during hypnosis participants are generally asked several questions, the answers to which they do not usually know (e.g., an amethyst is a blue or purple gemstone. What color does it turn when exposed to heat?). Participants are told the correct answer to the questions, and then posthypnotic amnesia is usually suggested in the standard way. After participants are tested for their memory of the content of the hypnosis session (standard recall amnesia), the same questions are asked again. Like frontal lobe patients, hypnotized participants often respond with the correct answer to the question, even though they are unable to specify how they know the answer (Evans, 1979; Evans & Thorn, 1966). Indeed, Evans (1979, 1988) concluded that some spontaneous source amnesia is a genuine effect of hypnosis and not simply an artifact of the demand characteristics of the situation.

Metamemory and Cognitive Estimation

When people are asked to remember, they can be either more or less sure that the information is available and/or accurate. At one extreme, people with anomic deficits will often report that the information is ''on the tip of the tongue'' even though they cannot access it (Shimamura,

1995). At the other extreme, patients with Korsakoff's Syndrome can report confabulations as certain memories (Lezak, 1995). Patients of both types could be said to be suffering from a deficit in metamemory, that is, a deficit in knowledge of what they know and/or a deficit in the ability to initiate and monitor strategies that can be used to access memories (Metcalfe & Shimamura, 1994).

Janowsky, Shimamura, and Squire (1989a) have reported that patients with frontal lobe lesions exhibit metamemory deficits when they are asked to make judgments about what they know. For example, in one test, participants were given 24 sentences to learn (e.g., Patty's garden was full of marigolds). After a delay, cued recall was assessed for the last word in each sentence (e.g., Patty's garden was full of _____). If participants could not recall the correct answer, they were asked to rate on a four-point scale how likely they would be to recognize the answer from a number of alternatives. The ''feeling of knowing'' (FOK) judgments were then correlated with performance on a subsequent recognition task using a multiple-choice format test. Janowsky et al. (1989a) reported that frontal lobe patients were significantly more impaired in FOK accuracy as compared to controls, even though the frontal lobe patients performed as well as the controls on the recall and recognition tasks.

Shimamura (1995) has speculated that the inaccuracy of the FOK judgments of frontal lobe patients might be related to the deficits this population exhibits on other retrieval tasks. For example, others have reported that participants with frontal lobe lesions often give wildly inaccurate responses to questions involving cognitive estimation, such as ''How tall is the average English woman?'' (Shallice & Evans, 1978), and can have difficulty estimating the price of objects (Smith & Milner, 1984). Although there are no reports in the hypnosis literature of hypnotized participants demonstrating difficulties in cognitive estimation as demonstrated in frontal lobe patients, there is evidence of hypnotized participants' difficulties with cognitive estimation of the introspective (metacognitive) sort (Woody & Bowers, 1994; Schwartz, 1980).

To some extent, hypnotic subjects do respond as if they show a metamemory deficit. For example, Kihlstrom (1980) has demonstrated that hypnotized amnesic participants can recall target words if they are given an appropriate cue word. In addition, Kihlstrom (1980) reported an experiment in which participants learned a categorized word list and were then given a suggestion to be amnesic for all of the words. Participants with high hypnotic ability demonstrated fairly dense amnesia, until given a category-instances test (CIT). On the CIT, the participants were asked to generate 15 instances of each of several categories. Half of the categories were categories from the previous learning task (critical) and half were new categories (neutral).

Kihlstrom (1980) demonstrated that despite their amnesia for the target words, amnesic participants were able to recall the words in the context of the CIT.

In a similar study, participants were asked to rate their confidence that each of the items (old and new) had appeared on their lists. Waking control participants made a perfect discrimination between old and new items. In contrast, hypnotized participants found it more difficult to distinguish between old and new material, being less confident that old material had been learned previously and more confident that they had previously encountered the new material (Kihlstrom, 1985).

Finally, Dywan and Bowers (1983), as well as others (e.g., Orne, Soskis, Dinges, & Orne, 1984; Sheehan, 1988), have demonstrated that using hypnosis to ''refresh'' memory for previously learned material leads to performance changes that suggest deficits in metamemory. These include a more lax report criterion for reporting mental content as a memory (Dywan, 1995) and high confidence about erroneous memories.

Summary and Hypotheses

Thus, there appears to be a reasonable fit between the evidence from the hypnosis literature and the frontal memory literature described by Shimamura (1995). The purpose of the present study was to directly compare the performance of hypnotized participants to the performance of control participants on the tasks noted by Shimamura as tapping diminished frontal functioning. According to Woody and Bowers (1994), hypnotized participants should show many of the subtle impairments in memory performance that have been observed in patients with frontal lobe damage. Thus, participants with high and low hypnotic ability were compared on performance on memory tasks suggested by Shimamura as being sensitive to frontal lobe functioning, together with some associated nonfrontal memory tasks. In addition, this was done both within and outside of the context of hypnosis. It was anticipated that the hypnotic context (including a hypnotic induction) would enhance any differences on the frontal memory tasks between those high versus low in hypnotic ability.

Participants

Participants at the University of Waterloo were selected on the basis of being initially tested in a large group session, using the Harvard Group Scale of Hypnotic Susceptibility, Form A (Shor & Orne, 1962), followed by a second assessment conducted in smaller groups of 2 to 10 people, using a group adaptation of the Waterloo-Stanford Group Scale of Hypnotic Susceptibility, Form C (WSGC; Bowers, 1998). Thirty participants with high hypnotic ability were recruited from those who scored nine or above and passed the amnesia item on both scales. Thirty participants with low hypnotic ability were recruited from

among those who scored four or below on both scales. A research assistant carried out the selection of the participants to ensure that the experimenter was blind to each participant's hypnotic ability.

Procedure

Participants were telephoned and either asked to participate in a study of hypnosis and memory (hypnosis condition) or a study of memory and individual differences (nonhypnotic-context condition). Across two sessions, participants completed the battery in one of four possible counterbalanced orders. However, all participants began and ended the first session with the source amnesia task and began and ended the second session with the metamemory task. In addition, the order of tasks was arranged such that participants were not asked to perform two memorization tasks in a row. Participants in the nonhypnotic condition were not informed about the relevance of their hypnotic ability until the end of the second session. Participants in the hypnosis condition received a standard hypnotic induction at the outset of each session, whereas participants in the nonhypnotic condition were simply introduced to the source amnesia task as the first test.

Tests

Free recall. The task was closely based on the Rey Auditory Verbal Learning Test (Lezak, 1995). Participants were aurally presented with a list of 15 unrelated words and asked to recall as many words as possible following the presentation. Five successive study-test trials were presented, with the same 15 words presented in a different order for each study trial. The list of words was read to each participant at the rate of one word per second, followed by an oral test of free recall that continued for thirty seconds. Participants' responses were recorded on audiotape. The measure of interest was the number of words recalled on the fifth learning trial.

Proactive interference (AC1). The stimuli consisted of two lists of 12 paired associates (e.g., RIVER-POND, LION-HUNTER) (Shimamura, Janowsky, & Squire, 1991). Across the two lists, the cue words were the same (i.e., the first word in each pair), whereas the response words (i.e., the second word in each pair) were different. Three study-test trials of each paired-associate (AB) list were administered. Participants were shown the word pairs one at a time and instructed to read the word pairs out loud and to try to remember them as pairs so that they could later report the second word when presented with the first. After each study trial, participants were visually presented with the cue words and asked to report the word associated with each cue word.

Following the three study-test trials for the first (AB) pairs of words, a second set of three study-test trials (AC) was administered. Participants were explicitly informed that the second list involved the same cue words but different test words. Otherwise, the instructions and procedures for the second list were the same. Finally, in order to determine if interference effects were due to problems in list discrimination, participants were given a final cued-recall test in which each cue word was presented and both of the response words were requested, a ''modified-modified free recall'' (MMFR) test (Barnes & Underwood, 1959). Participants' responses were audio taped throughout this task. The measure of interest was the number of errors on the first test trial for the second (AC) list. It is important to note that the AB1 and MMFR trials do not discriminate frontal lobe patients from normal controls. Patients with frontal lobe damage are characterized by normal performance on the AB1 and MMFR trials and poor performance, as compared to normals, only on the AC1 trials (Shimamura, 1995).

Word fluency. Participants were given 60 seconds per category to say as many words as possible beginning with the letters F, A, and S (Lezak, 1995). Participants' responses were audio taped, and performance was measured using three indices: (1) total number of words produced for the three letters; (2) number of errors, i.e., the number of times the participant failed to follow instructions; and (3) number of perseverative responses.

Word-sequencing task. Fifteen common one- or two-syllable words were selected according to the same criteria as for the free-recall task and printed individually on 4×6 inch index cards. The words were presented visually at the rate of 3 seconds per word, and participants were instructed to read each word aloud and try to remember the order in which the words appeared. Immediately following the study phase, participants were instructed to place the words in the same sequence in which they had just been presented. The measure of interest was the Spearman rank correlation between the actual study order and the order in which the participant placed the cards during the organization task (perfect score $= +1.0$).

Source amnesia. Thirty difficult general-information questions were employed that were designed to tap participants' knowledge about obscure facts across a variety of topics including literature, movies and music, geography, sports, and history (e.g., what is the name of the town through which Lady Godiva supposedly made her famous ride?) (Janowsky et al., 1989b). For each participant, one set of 15 facts was presented in the study phase and the remaining 15 facts were used in the test phase as foils. Ten easy factual questions were also included in the test phase (e.g., what is the name of a dried grape?) to ensure that

some correctly answered questions had clearly been learned from a source outside the experimental situation.

At the beginning of the study phase, participants were presented with the questions in the form of ''facts'' (e.g., the name of the town through which Lady Godiva supposedly made her famous ride is Coventry). No instructions were given to try to learn and remember the material. Participants were asked to read each fact aloud and place it in one of five categories (literature, movies and music, geography, sports, and history).

At the end of the experimental session—after the participant had completed a number of intervening tasks—both source recall and recognition memory were tested. The facts were now presented in the form of aural questions (e.g., what was the name of the town through which Lady Godiva made her famous ride?). The participant was tested on 40 facts: the 15 facts that had previously been presented, 15 new difficult (baseline) questions that had not been previously presented, and 10 new easy facts. No reference to the study phase was made. Rather, participants were simply asked to answer some general-information questions (Janowsky et al., 1989b).

When participants correctly answered a question, they were asked to recollect when they had last encountered that information (can you tell me the last time you encountered that information?). When participants incorrectly answered a question, they were asked if they had ever encountered the information before. If a participant answered in the affirmative, then she or he was asked when the last time was that the information had been encountered. Thus, even if a participant failed to recall the information learned earlier in the session, she or he might identify that time as the most recent time that the information was encountered. Participants' responses were audio taped throughout this task.

In addition to retrieval of the 15 facts from the study phase, two types of error were recorded. An ''omission'' was recorded if the participant reported that the information was learned from an outside source when it had in fact been presented during the study phase. A ''commission'' was recorded if the participant reported that the information was learned in the study phase when it had, in fact, not been previously presented.

Cognitive estimation. Shallice and Evans (1978) constructed a list of 15 questions for which the correct approach (or strategy) for answering the question is not immediately apparent (e.g., how tall is the average Canadian woman?). However, once an appropriate strategy is hit upon, participants do not require any kind of specialist knowledge to provide a reasonable answer. A 14-item version of the task slightly adapted for University of Waterloo participants was employed.

The questions were presented aurally and participants were given 30 seconds to answer each question. Participants' responses were audio taped. The measure of interest was the extremeness of a response (Shallice & Evans, 1978), which could be either greater than or less than the average answer. Any answer given that was greater or less than the average response for that question by two standard deviations or more was considered to be extreme. The number of extreme responses was summed for each participant.

Metamemory. The procedure was a slightly modified version of the task described in Shimamura and Squire (1986). Twenty-four simple sentences were printed individually on index cards (e.g., ''At the museum we saw some ancient relics made of clay''). At the outset of the experimental session, participants were presented with the 24 sentences for study. They were asked to read each sentence aloud and to study the sentences so that they could remember them later. Twelve of the 24 sentences were presented once during the study phase and 12 of the sentences were presented twice during the study phase, for a total of 36 sentence presentations per participant. Sentences were presented in a random order across participants. At the end of the experimental session, after several intervening tasks, participants were asked to recall or guess a missing word in each of 36 sentences (24 sentences from the study phase and 12 new sentences that had not been previously studied). Participants were encouraged to guess if they were uncertain. Also, they were correctly informed that they might not have previously seen some of the test items (Janowsky et al., 1989a).

Immediately following the recall phase, participants were asked to make feeling-of-knowing (FOK) judgments for all nonrecalled deleted words (including both errors of omission and commission). For each nonrecalled item, as well as for each of the 8 new items, participants rated their FOK on a 4-point scale (high, medium, low, pure guess). More specifically, participants were shown each sentence and asked to judge the likeliness that they would be able to recognize the missing word if some choices were given. After placing the nonrecalled sentences and 12 new sentences into one of the four FOK categories, participants were asked to rank order the sentences within each rating category according to their FOK. Thus, at the end of this phase, all of the sentences were ranked, from the one judged as having the highest FOK to the one judged as having the lowest FOK (Janowsky et al., 1989a).

Following the FOK phase, participants were given a seven-alternative, forced-choice recognition test for all 24 study sentences and the 12 new sentences. The measure of interest for determining the accuracy of the FOK judgments was the within-subject correlation between the FOK ranking and recognition performance for the sentences that

had been presented at the beginning of the session (Janowsky et al., 1989a).

RESULTS

For each task, outliers were removed at two standard deviations from the mean. This resulted in data from approximately 5 people being removed from each analysis. There was a comparable contribution of highs and lows to outliers.

A series of 2 (hypnotic ability: high, low) $\times$ 2 (context: induction, no induction) ANOVAs was then performed on the data from the various frontal memory tasks. In general, across almost all of the tasks, there was an absence of significant Hypnotic Ability $\times$ Context interactions, indicating that differences associated with hypnotic ability generalized across both types of context. For a summary of these results, see Table 1.

Concerning the free-recall task, participants with high hypnotic ability recalled significantly fewer words on the criterial fifth learning trial, as compared to participants with low hypnotic ability. Across all learning trials, participants with high hypnotic ability also made more perseverative responses, compared to participants with low hypnotic ability. However, an analysis of the number of errors (i.e., words reported that were not on the list) committed across trials revealed no difference between the groups.

Considering next the proactive-interference task, there was no main effect of hypnotic ability on the number of errors made on the first study-test trial of the first set of pairs of words (AB). Likewise, there was no main effect of hypnotic ability on the final cued-recall task in which participants were asked to report both responses to the stem word (MMFR). However, on the chief measure from this test, errors on the first test trial for the second set (AC1), participants with high hypnotic ability clearly made more errors, compared to participants with low hypnotic ability.

For the word-fluency task, there was no significant difference between the groups on the total number of responses. Nonetheless, for perseverations the interaction between hypnotic ability and context approached significance, $p = .08$. The interaction appeared to be the result of participants with high hypnotic ability in the hypnosis condition producing more perseverations ($M = 0.60$, $SD = 0.74$), as compared both to participants with high hypnotic ability outside of the context of hypnosis ($M = 0.23$, $SD = 0.44$) and low hypnotizable counterparts in both conditions ($M = 0.21$, $SD = 0.42$).

Moving to the word-sequencing task, there was a significant main effect for hypnotic ability on the degree of matching between the actual

Table 1
Results of Hypnotic Ability (High, Low) × Context (Induction, No Induction) ANOVAs of the Frontal Memory Tasks

Task	Hypnotic Ability		*F*		Error	
	High	Low	HA	HA × C	*df*	MS
Free recall						
Trial 5 errors†						
M	13.18	13.79	5.36*	1.84	55	0.95
SD	1.04	0.94				
Perseverations†						
M	5.96	3.14	6.81*	0.94	55	15.89
SD	4.60	3.17				
Proactive interference						
AB1 errors						
M	1.12	0.98	1.15	1.13	56	0.38
SD	1.02	1.13				
AC1 errors†						
M	2.35	1.17	12.57**	1.84	56	1.60
SD	1.42	0.94				
MMFR errors						
M	0.72	0.41	2.72	1.13	55	0.49
SD	0.70	0.69				
Word fluency						
Perseverations†						
M	0.43	0.21	2.03	3.23	55	0.28
SD	0.63	0.42				
Word sequencing						
Spearman rank correlation†						
M	0.81	0.68	9.52**	0.49	56	0.03
SD	0.13	0.18				
Source amnesia						
Retrieval failures						
M	2.33	1.46	0.82	1.25	54	1.26
SD	1.73	1.32				
Source omission errors†						
M	2.33	1.46	4.23*	0.03	54	2.40
SD	1.73	1.32				
Total source errors†						
M	2.78	1.50	6.28*	0.43	55	3.73
SD	2.25	1.55				

(*continued*)

Table 1
(continued)

Task	Hypnotic Ability		*F*		Error	
	High	Low	HA	HA × C	*df*	MS
Metamemory task						
Recall						
M	3.38	3.63	0.17	0.56	56	0.15
SD	1.32	1.54				
Recognition						
M	1.00	1.11	0.14	0.42	56	0.18
SD	1.17	1.12				
Total metamemory errors†						
M	3.48	2.28	4.18*	1.46	56	5.01
SD	2.53	1.86				

Note. HA = hypnotic ability; C = Context; $^{*}p < .05$, $^{**}p < .01$; MMFR = modified-modified free recall; AC1 = proactive interference trial; AB1 = first study-test AB trial; †indicates a frontal task (all others are nonfrontal).

study order and the order in which the participant placed the stimulus cards (Spearman rank correlation). However, somewhat surprisingly, participants with high hypnotic ability performed *better* on this task than did participants with low hypnotic ability.

On the source-amnesia task, participants with high hypnotic ability made more total source errors, as compared to participants with low hypnotic ability. This difference was mainly due to errors of omission. Although there were no significant group differences on the number of errors of commission, participants with high hypnotic ability tended to make more errors of omission, as compared to participants with low hypnotic ability. It is important to note that an analysis of the number of simple retrieval failures, i.e., the number of the fifteen trivia facts categorized at the outset of the session that the participant failed to recall at the end of the session, revealed no significant effects.

The measure of interest for the cognitive-estimation task was the total number of extreme responses (Shallice & Evans, 1978). A Hypnotic Ability (high, low) × Context (induction, no induction) ANOVA of number of extreme responses failed to yield any significant main effects or interaction (and hence this task is omitted from Table 1).

Finally, turning to the metamemory task, there were no group differences for the number of words recalled during the recall phase nor for the number of recognition failures. For the FOK task, participants were considered to have committed an error of omission if they rated the confidence of their ability to recognize a word as ''low'' or a ''pure guess'' when they had, in fact, been presented with the sentence

in the study phase. Participants were considered to have committed an error of commission if they rated their confidence of their ability to recognize a word as ''high'' or ''medium,'' when they had, in fact, not been presented with the sentence in the study phase. In short, participants could either be under-confident about their ability to recognize the missing word that had previously been presented in the sentence during the study phase (omission) or over-confident about their ability to recognize the missing word from a sentence that had not previously been presented (commission). Participants made, on average, 1.89 omission errors ($SD = 1.58$) and 0.25 ($SD = 0.55$) commission errors in their FOK judgments. Because the average of the total number of errors of either type was quite low, errors of both types were summed for each participant to yield a total metamemory error score for each participant. The results of a Hypnotic Ability (high, low) $\times$ Context (induction, no induction) ANOVA of total metamemory errors revealed a significant main effect for hypnotic ability and no other significant main effect or interaction. Overall, participants with high hypnotic ability tended to make more metamemory errors, as compared to participants with low hypnotic ability.

Multivariate Analysis of Variance

The prevailing result of the ANOVA analyses of the frontal memory tasks was a main effect for hypnotic ability. Participants with high hypnotic ability appeared to have more difficulty with many of the frontal memory tasks both within and outside of the context of hypnosis. To more powerfully explore the possibility of an interaction between hypnotic ability and context, a MANOVA (2 levels of hypnotic ability $\times$ 2 contexts $\times$ 6 frontal memory tasks) was performed on the data (trimmed, as for the ANOVAs, at two *SD*s). The measures selected for inclusion in the analysis included the measures likely to be most sensitive to differences between participants, according to the results from the ANOVAs reported above. Thus, number of errors on the proactive-interference task (AC1), number of words recalled on the fifth free-recall trial, number of free-recall perseverations, word-sequencing score, total number of source errors, and total number of metamemory errors were entered into the analysis. The results revealed a significant main effect for hypnotic ability, $F(6, 37) = 7.09$, $p < .001$. However, despite the aggregation of measures, the hypnotic ability by context interaction was not found to approach significance, *Pillais'* $F(6, 37) = 0.87$, $p = .523$.

Intercorrelations Between Frontal Memory Measures

A table of intercorrelations of selected frontal memory measures for the entire data set (no trimming) is presented in Table 2. As for the MANOVA, the measures selected for inclusion in the table are those

Table 2
Intercorrelations of Selected Frontal Memory Tasks (N = 60)

Task	1	2	3	4	5	6
1 Proactive interference	–	−.42**	.30*	−.07	.56**	.48**
2 Free recall		–	.02	.27*	−.27*	−.30*
3 Perseverations (on free recall)			–	−.09	.14	.23
4 Word sequencing				–	−.07	−.24
5 Total source errors					–	.21
6 Metamemory errors						–

*$p < .05$, **$p < .01$.

that best discriminated between people with high versus low hypnotic ability, according to the results from the ANOVAs reported above. The tasks appeared to be modestly intercorrelated in the expected directions, with performance on the proactive-interference task (AC1) most clearly related to most of the other measures. The pattern of results was essentially the same when performed on the data set trimmed at two *SD*s for each measure.

Discriminant Function Analysis

As predicted, participants with high hypnotic ability appeared to perform somewhat poorly as compared to participants with low hypnotic ability on a number of the frontal memory tasks. It therefore became interesting to determine the degree to which performance on such tasks might be used to discriminate between participants with high and low hypnotic ability. The classification results of a stepwise discriminant analysis of the entire data set are presented in Table 3. Once again, the measures selected for inclusion in the analysis included the measures likely to be most sensitive to differences between participants, according to the results from the ANOVAs reported above.

Table 3
Classification Results of Stepwise Discriminant Analysis Used to Predict Hypnotic Ability from Performance on Frontal Memory Tasks (N = 60)

Actual Group Membership	Number of Cases	Predicted Group Membership	
		Highs	Lows
Highs	30	20 (66.7%)	10 (33.3%)
Lows	30	7 (23.3%)	23 (76.77%)

Note. Overall percent of cases correctly classified: 71.67%.

However, data from the word-sequencing task were not entered into this analysis because the results obtained from that measure were so contrary to what was predicted. Thus, the measures entered into the discriminant function analysis included number of AC1 errors on the proactive-interference task, number of words recalled on the fifth free-recall trial, number of perseverations on the free-recall task, total source-amnesia errors, and total metamemory errors. A subset of two predictors, number of AC1 errors and number of target words recalled on the fifth free-recall trial, correctly classifying 71.6% of all participants. Of those high in hypnotic ability, 66.7% were correctly classified, and the remaining 33.3% were incorrectly classified as lows. Of those low in hypnotizability, 76.7% were correctly classified, and the remaining 23.3% were incorrectly classified as highs. A corresponding analysis of the data set trimmed at two *SD*s on each measure produced similar results.

DISCUSSION

The principal result of this study is that participants with high hypnotic ability consistently performed less well on a variety of frontal memory tasks, compared to participants with low hypnotic ability. Most strikingly, participants with high hypnotic ability performed relatively poorly on the free-recall, proactive-interference, and source-amnesia tasks. Somewhat surprisingly, these differences were just as evident outside of the context of hypnosis as within it. In addition, participants with high hypnotic ability performed just as well as participants with low hypnotic ability on memory tasks not considered to be specifically affected by impaired frontal lobe functioning, including the AB1 and MMFR trials in the proactive-interference task, retrieval errors on the source-amnesia task, and recall and recognition failures on the metamemory task (Shimamura, 1995). Although the performances of participants with high and low hypnotic ability were well within the range of normality, the small but significant differences observed suggest a subtle association between hypnotic susceptibility and frontal lobe function.

There has been some other recent interest in exploring the contribution of frontal lobe functioning to hypnotic ability, with mixed results. Aikins and Ray (2001) reported that 9 participants with high hypnotic ability performed better on the Wisconsin Card Sorting Test, widely considered to be a measure of frontal lobe functioning, as compared to 7 participants with low hypnotic ability; whereas Kallio, Revonsuo, Hämäläinen, Markela, and Gruzelier (2001) reported that participants with high hypnotic ability performed less well on a word-fluency test, another frontal lobe task, as compared to participants with low hypnotic ability. The present results are somewhat more consistent with

Kallio et al. than Aikins and Ray; however, neither of these other, relatively small-sample studies involved the administration of a battery of memory tasks.

The results of the present study are both broadly consistent with what one would expect from a dissociated control perspective and also somewhat inconsistent with it. It would appear that participants with high hypnotic ability have difficulty with many of the same kinds of tasks that frontal lobe patients are reported to have difficulty with, indicating relatively weak executive control of memory. Such a finding dovetails quite nicely with the dissociated control model of hypnotic responding first proposed by Bowers (1992).

However, it was anticipated that the hypnotic context, including provision of a hypnotic induction, would enhance any differences between those of high versus low hypnotic ability, as was indeed reported by Kallio et al. (2001); yet there was almost no evidence at all in the present study to support this idea. The lack of context by hypnotic ability interactions is surprising, given arguments and evidence presented by Woody, Bowers, and Oakman (1992) about the strong effect of a hypnotic context in many other studies. It also appears to clash with a strong state position about the nature of hypnosis (cf. Kirsch & Lynn, 1995). Experimental data reported by Ray (1997) and broader, conceptual arguments by Kirsch (1997) likewise indicate that a hypnotic induction may not be necessary for revealing differences due to hypnotic susceptibility.

However, alternatively it seems possible that asking hypnotized participants to complete a fairly extensive battery of demanding cognitive tasks, such as the memory tasks used in this study, is simply incompatible with maintaining a ''state'' of hypnosis. In order to perform this battery of complex cognitive tasks, participants may have ''alerted'' themselves from hypnosis. In this view, participants with high hypnotic ability who received an induction might be considered to have been completing the tasks under essentially the same conditions as participants who participated outside of the context of hypnosis. In contrast, it may be possible that participants in previous studies who completed only one memory task over a shorter duration were not similarly alerted over time and may have been completing the tasks while hypnotized. Such an explanation for state-related differences across studies may fit with the concept of changes in attentional and disattentional processes that occur during hypnosis, as proposed by Crawford (1994).

Another possibility is that, rather than capturing what is essential to describe a hypnotic state, altered frontal lobe functioning may be one of the baseline individual characteristics of people with high hypnotic ability that is necessary to attain this state. Finally, the absence of effects for hypnotic induction and for interactions of hypnotic ability with

hypnotic induction could possibly have been the result of omitting the middle range of hypnotic ability. Specifically, although people with high hypnotic ability may be comparably different from people with low hypnotic ability in and outside of the hypnotic state, the performance of moderately susceptible subjects may possibly be more affected by an induction.

Also contrary to expectations was the finding that on the word-sequencing task participants with high hypnotic ability performed better than those with low hypnotic ability. Specifically, the average correlation between the actual study order and the order in which the participant placed the cards during the organization task was higher for participants with high hypnotic ability as compared to participants with low hypnotic ability. This result seems quite inconsistent with what one would expect from the dissociated control perspective. However, it seems at least possible that in an undergraduate population, such a task is not difficult enough and/or measures something quite different from what it measures in a population of patients with frontal lobe damage.

In retrospect, when compared to the temporal recency judgment task of Milner, Corsi, and Leonard (1991), in which participants are shown a long series of stimuli, either words or pictures, and occasionally asked to make a judgment about which of two stimuli was presented more recently, the word-sequencing task used in this study may simply not have been a difficult enough interference task to find the subtle differences we were looking for. Using a task very similar to that of Milner, Corsi, and Leonard, in which participants are shown a long series of stimulus words and occasionally asked to make a judgment about which of two stimuli was presented more recently, Vongphrachanh (1998) has demonstrated that participants with high hypnotic ability tend to perform more poorly than participants with low hypnotic ability, especially when making judgments about items at moderate temporal distance from each other, i.e., when asked to judge the relative recency of two items which are neither extremely close nor extremely far apart in presentation.

Alternatively, there may be something about the word-sequencing task that makes it different from the other tasks, on which subjects with low hypnotic ability consistently did slightly better. Performance on the word-sequencing task involves the intentional encoding and recall of the order of the material presented. In contrast, the temporal disorganization of recall is usually observed in tasks involving free recall of the material encoded. These two types of tasks are quite different, and the differential effect observed in this study may reflect a distinction between the *ability* of highs and lows to recall temporal information (here higher in highs) versus their *spontaneous use* of temporal ordering as a strategy to facilitate free recall (lower in highs).

In addition, it seems quite possible that ''frontal executive control'' is not a monolithic entity and that different aspects of executive control may be differently associated with hypnotic susceptibility (e.g., the double dissociation of word-sequencing results with the other tasks). Although speculative, such a possibility should be examined in future studies.

The pattern of results observed in this study seems relatively difficult to explain from the sociocognitive (Spanos, 1986), dissociated experience (Kihlstrom, 1992), or expectancy (Kirsch, 1997) theories of hypnosis. According to these perspectives, any unsuggested effects of hypnosis on memory are due to the more or less subtle demand characteristics of the situation. Thus, an explanation of these data would be that there was something about the experimental situation that tipped off some participants to the relevance of their hypnotic ability; as a result, participants in the nonhypnotic context performed in the same way as participants in the hypnotic context (Kirsch & Council, 1992). However, great care was taken to make sure that participants who participated in the experiment outside of the context of hypnosis remained unaware of the relevance of their hypnotic ability until the end of the second session. In addition, insofar as participants with high hypnotic ability were responding to the demands of the situation in the context of hypnosis, one would predict a pattern of poor performance on all memory tasks. Instead, those high and low in hypnotic ability did not differ in their performance on the various nonfrontal memory tasks that served as checks.

Researchers of different theoretical backgrounds have recently begun to speculate that the phenomena associated with hypnosis may be best understood by a cautious integration of the sociocognitive and dissociation accounts of hypnotic responding (Barber, 1999; Kihlstrom, 1997; Kirsch & Lynn, 1995; Woody & Sadler, 1998). For example, Barber argues that some individuals achieve high scores on standard scales of hypnotic ability by having a very positive ''set'' and high motivation, whereas others achieve high scores as the result of being very good at engaging in fantasy and imagination. In addition, he argues that some individuals achieve high scores on standard scales of hypnotic ability as the result of being prone to amnesic phenomena more generally. If there is in fact a substantial subgroup of individuals with high hypnotic ability who are prone to amnesic phenomena outside of the context of hypnosis, the lack of context effects in the present study appears to be somewhat less mysterious.

If these results are replicated in future research, an interesting challenge is to explore what other individual difference variables might distinguish people with high hypnotic ability who demonstrate amnesic (or dissociative) phenomena or altered frontal lobe functioning outside of the context of hypnosis from those with high or moderate hypnotic ability who do not.

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Hypnose, Gedächtnis und die Funktion der frontalen Exekutive

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Zusammenfassung: Nach der von Woody und Bowers (1994) vorgebrachten Hypothese der dissoziierten Kontrolle entsprechen die Auswirkungen von Hypnose einer abgeschwächten Funktion des Frontallappens. Die vorliegende Studie wurde entwickelt, um die Leistung von Versuchspersonen mit hoher und niedriger Hypnosefähigkeit bei verschiedenen Gedächtnisaufgaben, die als sensitiv für eine solche Funktion gelten, sowie bei einigen Kontrollaufgaben, für die das nicht gilt, zu vergleichen. Die Ergebnisse deuten insgesamt darauf hin, dass Teilnehmer mit hoher Hypnosefähigkeit größere Schwierigkeiten bei Aufgaben haben, die sensitiv für die Funktion des Frontallappens sind, wie etwa freier Abruf, proaktive Interferenz und Quellenamnesieaufgaben. Dies gilt sowohl innerhalb als auch außerhalb des hypnotischen Kontext. Diese Unterschiede, welche nicht bei nichtfrontalen Aufgaben auftraten, stützen allgemein die Theorie der dissoziierten Kontrolle des hypnotischen Verhaltens.

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Hypnose, mémoire, et fonctionnement décisionnel du lobe frontal

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Résumé: Selon l'hypothèse de la commande dissociée formulée par Woody et Bowers (1994), les effets de l'hypnose correspondent au fonctionnement atténué du lobe frontal. Cette étude a été conçue pour comparer la performance de participants aux capacités hypnotiques élevées et basses dans une variété de tâches faisant appel à la mémoire et au fonctionnement du lobe frontal, ainsi que quelques tâches de commande de mémoire considérées comme non sensibles à un tel fonctionnement. Les résultats ont montré que les participants ayant des capacités hypnotiques élevées ont eu plus de difficulté avec des tâches faisant appel au lobe frontal, y compris le «rappel libre», «l' interférence proactive», et des tâches d'amnésie, tant en dedans qu'en dehors du contexte de l'hypnose. Ces différences, qui n'ont pas été trouvées pour des tâches non frontales, sont généralement le support de la théorie de commande dissociée de la réponse hypnotique.

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Hipnosis, memoria, y funcionamiento ejecutivo frontal

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Resumen: Según la hipótesis de control disociado propuesta por Woody y Bowers (1994), los efectos de la hipnosis son consistentes con un funcionamiento disminuido del lóbulo frontal. Diseñamos este estudio para comparar el desempeño de participantes con alta y baja capacidad hipnótica en una

variedad de pruebas de memoria sensibles al funcionamiento del lóbulo frontal, así como en pruebas de memoria no sensibles a tal funcionamiento. Los resultados generalmente indicaron que los participantes con alta capacidad hipnótica tuvieron más dificultad con pruebas sensibles al funcionamiento del lóbulo frontal, incluyendo pruebas de recuerdo libre, interferencia proactiva, y amnesia del origen del recuerdo, tanto dentro como fuera del contexto hipnótico. Estas diferencias, que no encontramos en pruebas no frontales, apoyan en general la teoría de control disociado de la respuesta hipnótica.

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