BRAIN AND COGNITION **34,** 189–206 (1997)
ARTICLE NO. BR970873

Confabulation, Memory Deficits, and Frontal Dysfunction

Marcia K. Johnson

Princeton University

and

Margaret O'Connor and James Cantor

Memory Disorders Research Center, Boston University

This paper explores potential cognitive deficits underlying confabulation of a patient, G.S., following an anterior communicating artery aneurysm. G.S.'s performance on tasks assessing memory for temporal duration, temporal order, and speaker identification is examined as is his recollection of autobiographical events. We compare G.S. with three nonconfabulating patients matched with him for age, education, and neuropsychological measures of memory and frontal deficits and with three age- and education-matched control subjects. Like frontal control patients, G.S. underestimated temporal durations and showed poor source monitoring (speaker identification). In addition, G.S. showed an even more pronounced deficit in recall of autobiographical memories and relatively more detailed reports of laboratory-induced memories for imagined events. We suggest that this configuration of deficits rather than any single factor accounts for G.S.'s tendency to confabulate. © 1997 Academic Press

Brain damage sometimes produces an intriguing phenomenon called ''confabulation'' (e.g., Berlyne, 1972; Talland, 1961). The term *confabulation* is used inconsistently in the literature, as noted by Whitlock (1981); however, a general working definition is ''false statements that are not made to deceive, are typically more coherent than thoughts produced during delirium, and do not reflect underlying psychopathology'' (Johnson, 1991, p. 187, see also Kerns, 1986; Talland, 1961, Whitlock, 1981). Confabulations range from small distortions on laboratory tasks (e.g., Kopelman, 1987) to strik-

This report was funded in part by NINCDS Program Project Grant NS 26985, by funds from the Department of Veterans Affairs Medical Research Service, by NIAAA Grant AA-00187, and by NIA Grant AG09744. Correspondence concerning this article should be addressed to Marcia K. Johnson, Department of Psychology, Princeton University, Princeton, NJ 08544–1010 (e-mail: mkj@clarity.princeton.edu), or Margaret O'Connor, Memory Disorders Research Center, Boston Veterans Affairs Medical Center, 150 South Huntington Ave., Boston, MA 02130. We thank Mark D'Esposito and two anonymous reviewers for helpful comments on an earlier draft of the manuscript.

0278-2626/97 $25.00

ingly bizarre stories that patients tell in describing their personal histories (e.g., Damasio, Graff-Radford, Eslinger, Damasio, & Kassell, 1985; Stuss, Alexander, Lieberman, & Levine, 1978).

Various theories about the nature of the cognitive disruption underlying confabulation have been suggested. One idea is that confabulation helps fill in the gaps of memory that arise from amnesia (e.g., Barbizet, 1963; Berlyne, 1972; Bonhoffer, 1904; Wyke & Warrington, 1960). Although this idea is intuitively appealing, it cannot be the whole story because confabulation is not a typical response in normal subjects' failures to remember, and amnesia is not a sufficient condition for confabulation (Johnson, 1991; Kapur & Coughlan, 1980). Another suggestion is that confabulation arises from a deficit in temporal discrimination whereby memories become detached from their appropriate temporal contexts (Talland, 1965). According to this view, the confabulating patient accesses veridical memories but the chronology of these events is disturbed. Such displacements alone would not easily account for the bizarre, unrealistic stories told by some confabulating patients [e.g., the patient who claimed to have been a ''space pirate'' (Damasio et al., 1985)]. In addition to the potential role of memory deficits and disruptions of temporal information, confabulation typically occurs in the context of executive deficits such as perseveration, poor self-monitoring, and difficulty with self-initiated processes (e.g., Baddeley & Wilson, 1986; Shapiro, Alexander, Gardner, & Mercer, 1981).

Johnson (1991) suggested that disruptions in these and other cognitive mechanisms that produce various forms of confabulation could be characterized within a general reality monitoring framework. Within this framework, confabulation could arise for a number of reasons: disruptions in motivation, judgment, retrieval, or encoded qualities of memory. For example, disrupted motivation or deficits in judgment processes could result in reliance on lax criteria in determining the veracity of an event. Disrupted retrieval would impede access to supporting or disconfirming information relevant to identifying the source of a target event. Changes in the qualities of encodings could produce memories for real events with less perceptual or contextual detail or memories for imagined events with more detail, reducing the discriminability between them. Such possibilities are not mutually exclusive and it is likely that two or more factors might act together to produce confabulation. For example, a bizarre confabulation could be produced by a memory of a past fantasy, dream, TV program, and so on, if the patient could not encode or retrieve contextual information and could not retrieve or evaluate semantic knowledge that would disconfirm the veridicality of the memory. Similarly, perceptual vividness might provide a basis for estimating temporal information—vivid memories seem recent and faded memories seem more remote (Whitty & Lewin, 1960). Atypically vivid or atypically impoverished memories might then be temporally displaced, especially if the patient also suffers deficits in retrieval of relevant autobiographical or semantic information. In general, a reality monitoring or source monitoring analysis suggests that different types of confabulation (e.g., differing in plausibility) would result from different combinations of cognitive deficits (Johnson, Hashtroudi, & Lindsay, 1993).

Although a number of factors have been identified that are undoubtedly central to understanding confabulation (e.g., disruptions of memory, temporal confusion, deficits in self-initiated processes), it will take a more detailed analysis of the cognitive performance of confabulating patients to identify the cognitive profile(s) associated with confabulation (cf. Dalla Barba, 1993b). For example, confabulation is often associated with damage to frontal brain regions (e.g., Baddeley & Wilson, 1986; Johnson, 1991; Kapur & Coughlan, 1980; Moscovitch, 1989; Stuss et al., 1978). Furthermore, frontal brain regions are critical for retrieval, temporal discrimination, and self-monitoring (e.g., Baddeley & Wilson, 1986; Milner, Petrides, & Smith, 1985; Stuss & Benson, 1986); however, not all ''frontal syndrome'' patients confabulate (Stuss & Benson, 1986). In other words, standard diagnostic tests for frontal symptoms do not alone differentiate between frontal patients who confabulate and those who do not. This observation suggests that our understanding of confabulation might be increased by identifying confabulating and nonconfabulating patients who resemble one another on some neuropsychological tasks (e.g., memory, attention and other executive functions) and comparing them on additional tasks designed to assess the more specific cognitive factors that have been proposed to underlie confabulation. The present study took this approach by comparing G.S., a confabulating patient, with three patients who resemble him on standard measures of memory and frontal system functions but who do not confabulate. The study also included three age- and education-matched control subjects. Of interest were differences between the frontal control patients and the normal controls and any additional deficits, or unique pattern of deficits, that G.S. might show.

The protocol consisted of cognitive tasks designed to assess some of the factors, described above, that have figured importantly in theoretical accounts of confabulation. We assessed temporal memory (both duration and order judgments), source memory (temporal order and speaker identification), and qualitative characteristics of autobiographical recall for both actual and imagined events. Finally, for G.S., we compared his report of a clearly confabulated event with his report of an actual event that occurred within the same time frame. The specific questions of interest were whether G.S. showed unusual source deficits relative to other patients or particular difficulties with retrieval of complex memories, or whether he would demonstrate unusual qualitative characteristics on reports of actual or imagined complex events.

SUBJECTS

Patient G.S.

G.S. is a 48-year-old, right-handed, retired police officer with 14 years of education, who presented with confusion and headaches on 1/26/92, at which time a CT scan was significant

TABLE 1
Demographic and Neuropsychological Measures

Measure	Patient G.S.	Frontal controls (mean)
Age	48	50
Education (years)	14	14
WAIS-R	94	100
WMS-R Attention	95	97
WMS-R Delayed memory	95	92
WCST (categories)	0	2.33
WCST (perseverations)	73%	28%
Trailmaking B	170 sec, 1 error	241 sec, 5 errors
Stroop test	80 sec, 4 errors	130 sec, 4 errors
Verbal fluency (FAS)	9th percentile	39th percentile

for subarachnoid hemorrhage. Angiography revealed a large anterior communicating artery aneurysm and surgical intervention took place the following day. Postoperative CT scan revealed bifrontal medial lesions. G.S. spent 2 weeks in the hospital and was discharged to a rehabilitation facility. During the course of rehabilitation he developed hydrocephalus requiring shunt placement. Subsequently, he was transferred back to the rehabilitation hospital where his recovery was characterized by slow, but steady progress. Neuropsychological evaluation was conducted 4 months following surgical intervention (Table 1) and the experimental tasks were conducted approximately 5 months postonset. He showed pronounced deficits on neuropsychological tests assessing frontal functions (Wisconsin Card Sort Task, Trailmaking B, verbal fluency). G.S. was not amnesic by standard criteria since he scored 95 on both the attention and delayed memory subtests of the WMS-R (Kixmiller, O'Connor, & Cermak, 1994).

G.S. had a number of erroneous ideas about his personal life to which he clung despite attempts to dissuade him. His fabrications were generally plausible and many involved autobiographical events that were embellished. A particularly salient confabulation was G.S.'s account of the origin of his medical condition; he believed that he had fallen and hit his head while standing outside talking to a friend (see Appendix A), when, in fact, his aneurysm ruptured following an argument with his daughter. His wife stated that he had been in an upstairs apartment fixing the bathtub when he suddenly collapsed. Family members did not believe that G.S. had a previous head injury such as that described in his confabulation. G.S. also demonstrated temporal disorientation for recent and remote events. He grossly underestimated the duration of passing time and insisted that family members were changing the dates on his calendar in an attempt to ''trick him.'' On many occasions he would speak of week- or month-old events as having occurred the previous day. He believed that his divorce from his previous wife occurred 4 rather than 12 years previously, and that he had moved 2 months rather than 2 years prior to the evaluation. G.S. also had difficulty determining the chronology of personal and public events even when he clearly recognized them.

Talland (1961) suggested that there are two distinct confabulatory phenomena: distortion of true events (e.g., displacements of events in time), which he called *confabulation,* and fantastic and incongruous memories, which he called *fabrication.* Others have distinguished between *reactive* and *spontaneous* or *fantastic* confabulation (Berlyne, 1972; Stuss et al., 1978; Whitlock, 1981; Kopelman, 1987). Reactive confabulation tends to embellish true memories and to be plausible; spontaneous confabulation tends to be more bizarre, implausible, or fantastic. Such classifications are not clear-cut, of course. Realistic confabulations may reflect the intrusion of ideas derived from fantasy sources (daydreams, TV, movies, novels) and fantastic fabrications might draw on essentially accurate but ''displaced'' memories of premorbid imaginations and dreams (Johnson, 1991). In any event, G.S. does not fit neatly into either the confabulation/fabrication dichotomy or the reactive/spontaneous dichotomy. He confabulated both in response to questions and spontaneously, but none of his confabulations would be classified as bizarre or fantastic.

Frontal Patient Control Group

Three patients (two men and one woman) were included to compare G.S.'s performance on experimental cognitive measures with patients with similar neuropsychological profiles. One patient underwent surgical repair of an anterior communicating artery aneurysm; the other two patients suffered strokes in left frontal brain regions. All three frontal control patients had evidence of left frontal lesions on CT scan. Neuropsychological assessments were conducted an average of 4.7 months postonset (3, 2, and 9 months) and the experimental tasks were conducted approximately 8.5 months postonset (4.5, 5, and 16 months). Subjects were matched with G.S. on age, education, and neuropsychological measures including density of memory disorder, overall intellectual ability, and performance on tasks of frontal/executive functions (Table 1). Patients and G.S. were not matched with respect to neuroanatomical lesion. Based on clinical observation, none of the frontal control patients demonstrated confabulatory tendencies at any time postonset. In contrast, confabulation was clinically observed in G.S. throughout the period of this study and for as long as 2 years postonset. Thus, differences between G.S. and frontal controls in tendency to confabulate were not a consequence of differences in the stage of recovery at which they were observed.

Normal Control Group

Three male normal control subjects formed a control group matched with patient G.S. with respect to age (mean = 51) and education (mean = 14.5). (One control subject was unable to participate in one session and was replaced for that session by a fourth male control subject similar in age and education.)

TEMPORAL DURATION ESTIMATION TASK

Materials and Procedure

The experimenter announced the beginning of each trial. Then random letters of the alphabet appeared on a Macintosh computer screen for 1 sec each. The subject was required to press a button at each occurrence. At the end of a randomly selected interval of time, the computer screen flashed to indicate the end of the trial, and the experimenter asked the subject to estimate the duration of the interval from the beginning of the trial to the light flash (cf., Williams, Medwedeff, & Haban, 1989). There were 20 such trials, 4 each at 10-, 30-, 90-, and 120-sec-long intervals. Before beginning each trial, the subjects were reminded that they would be asked to estimate the duration of the task they were about to perform.

Results

The mean time estimates for each of the interval lengths are shown in Table 2. Scores are expressed as a ratio of perceived to actual time, so underestimation of time is reflected by scores less than one and overestimation of time is reflected by scores greater than one. As is clear from Table 2, normal

TABLE 2
Mean Ratios of Perceived/Actual Time

Time intervals (sec)	Patient G.S.	Frontal controls	Normal controls
10	1.44	.61	1.31
30	.58	.52	1.36
60	.61	.48	1.47
90	.63	.50	1.31
120	.58	.48	1.18

control subjects overestimated time at all durations whereas frontal control patients underestimated times, $F(1, 4) = 6.37$, $p < .06$. Although G.S. overestimated in his judgment of 10-sec intervals, he resembled frontal control patients in his tendency to underestimate all other time intervals.

TEMPORAL ORDER DISCRIMINATION TASK

Materials and Procedure

Subjects were presented with eight stimuli followed by a 30-min delay during which they participated in other tasks. Subsequently, a second list of eight stimuli was presented, followed by a 2-min delay filled with conversation and instructions. Subjects were then asked to (1) identify previously presented (target) items from a randomly ordered, 32-item list (16 target items and 16 distracters) and (2) identify the list from which each old item came (cf. Winograd, 1968). Subjects were tested four times for temporal order discrimination using four different sets of stimuli: sentences, faces, words, and abstract paintings. Sentence stimuli consisted of highly concrete, subject–predicate–object statements (e.g., *The artist painted a portrait*, *The dog ran through the park*). Face and single-word stimuli were random subsets of the items of the Warrington Recognition Memory Test (Warrington, 1984). Abstract painting stimuli were color slides obtained from various art museums and were projected into an approximately 2×3-ft image.

Results

The first four columns in Table 3 show data separately for each of the four types of stimulus materials. The old–new recognition measure is the

TABLE 3
Performance on Tasks of Temporal Order Discrimination

	Faces	Sentences	Words	Paintings	Multinomial analysis
Old/new recognition					*D*
Patient G.S.	.81	.84	.66	.69	.64
Frontal controls	.75	.73	.71	.80	.66
Normal controls	.81	.86	.79	.88	.84
Temporal discrimination					*d*
Patient G.S.	.86	.82	.57	.79	.60
Frontal controls	.67	.48	.57	.59	.13
Normal controls	.68	.66	.78	.68	.47

proportion correct (hits plus correct rejections). The temporal discrimination measure is the proportion of items correctly recognized as old that were attributed to the correct list. To obtain overall estimates of old–new recognition and temporal discrimination based on the maximum number of measures available, the data from the four tests were combined and analyzed with a multinomial approach described by Batchelder and Riefer (1990). This analysis is based on high-threshold simplifications of signal detection theory (Green and Swets, 1966) and yields estimates of old–new detection (D) and source (in this case temporal/list) discrimination (d).[1] These estimates are shown in the last column of Table 3. Chance performance for both D and d would be indicated by a value of zero. The multinomial analysis permits us to test the difference between groups by computing the statistic g^2, which is distributed like χ^2 (1). Both G.S. and frontal patients demonstrated significantly poorer old–new recognition (D) compared with normal controls, $g^2 = 6.18$ and 10.17, $p < .05$, respectively. In addition frontal controls were poorer than normal controls on the temporal order judgment, $g^2 = 8.76$, $p < .05$ (see also Milner et al., 1985; Shimamura, Janowsky, & Squire, 1990). In contrast, G.S. showed no deficit in temporal discrimination; his performance was significantly better than that of the frontal controls, $g^2 = 7.71$, and was not significantly different from that of the normal control group.

The results of the multinomial analysis suggest that G.S., like other frontal patients, had a deficit in recognition memory. He differed from frontal controls in that he did not show a temporal ordering deficit. G.S.'s temporal memory performance was not simply a function of his recognition rate. His temporal identification was better when his recognition was better (e.g., faces and sentences) and when it was worse (e.g., paintings) than that of the frontal control patients (Table 3).

IDENTIFICATION OF SPEAKER TASK

Materials and Procedure

A female experimenter and male experimenter alternately read 30 items. Subsequently, subjects were given an answer sheet with 30 target and 15 distracter items randomly intermixed and instructed to identify target items and to indicate which examiner had read each. In this type of task, an important cue for source monitoring is the physical difference (e.g., in appearance and voice) between speakers (e.g., Ferguson, Hashtroudi, & Johnson, 1992). This proce-

[1] The analyses used here were performed using a software package by Hu (1990); theoretical and computational details are described in detail in Batchelder and Riefer (1990); see also Johnson, Kounios, and Reeder (1994) for an abbreviated description. Briefly, the multinomial approach permits one to derive separate estimates of old–new discrimination and A–B source discrimination from an analysis of the frequencies with which responses (e.g., List A, List B, and New) are given to items from each category (List A, List B, and New). Of the several models described by Batchelder and Riefer, we used Model 4.

TABLE 4
Performance on Speaker Identification Tasks

	Words	Sentences	Multinomial analysis
Old/new recognition			*D*
Patient G.S.	.60	.93	.70
Frontal controls	.72	.79	.68
Normal controls	.66	.86	.67
Speaker identification			*d*
Patient G.S.	.53	.67	.26
Frontal controls	.62	.67	.27
Normal controls	.73	.75	.53

dure was conducted twice, once with word lists consisting of low-imagery nouns (e.g., *humor, accent*) and once with unrelated sentences (e.g., *The president signed the treaty, The mermaid saved the sailor*).

Results

Table 4 shows recognition and speaker identification scores. Recognition scores are the proportion of items correctly identified as old and new (i.e., hits and correct rejections). Speaker identification scores are the proportion of items correctly identified as old and attributed to the correct source (e.g., Ferguson et al., 1992). As with the temporal discrimination data, the speaker identification data were analyzed with the Batchelder and Riefer (1990) multinomial approach (see last column in Table 4). Neither G.S. nor frontal control subjects differed from normal control subjects on old–new recognition (D). The frontal control patients demonstrated a significant deficit relative to control subjects on the speaker identification task (d), $g^2 = 4.14$, $p < .05$. G.S. demonstrated a similar speaker identification deficit as frontal control patients.

Discussion

G.S. demonstrated the same tendency to underestimate temporal duration intervals as other frontal control patients. His speaker identification ability was also similar to that of frontal controls; G.S. and frontal patient control subjects were impaired relative to normal control subjects even with recognition performance equated. In contrast, G.S.'s performance on the list discrimination task was superior to that of frontal control subjects and at a normal level. These results suggest that G.S. does not have dramatically greater deficits than other frontal patients. Hence, there was no evidence that this confabulatory patient was prone to exaggerated source monitoring deficits on either temporal or speaker aspects of source.

These findings point to several other significant issues. First, the fact that

G.S. was disrupted in person but not in list identification highlights the fact that ''source'' is based on various attributes that are useful to consider separately in any analysis (Johnson, Hashtroudi, & Lindsay, 1993). Second, the discrepancy between G.S.'s poor performance on tasks of temporal duration and his good performance on tasks of temporal ordering (list discrimination) is consistent with the idea that even seemingly simple memory features such as temporal information may involve a variety of attributes and/or processes (Johnson et al., 1993).

MEMORY CHARACTERISTICS OF COMPLEX AUTOBIOGRAPHICAL EVENTS

Materials and Procedure

Four questions used by Multhaup (1992) in a study of memory for autobiographical events constituted the stimuli of interest. Multhaup selected these questions from pilot work indicating that almost all older and younger adults were able to recount an experience for each of the questions. The questions were as follows: (1) *Tell me about something that happened to you when you were on a vacation.* (2) *Tell me about a time that you spent with a friend that you will always remember.* (3) *Tell me about a time that you moved out of a place that you had lived in.* (4) *Tell me what you did for Thanksgiving last year.* Subjects' responses were recorded, transcribed, and coded for categories of information, including references to actions, people, objects, emotions, places, and sensory detail (Table 6). Scoring criteria were based on those developed by Johnson and colleagues (Hashtroudi, Johnson, Vnek, & Ferguson, 1994; Johnson, Foley, Suengas, & Raye, 1988; Johnson, Kahan, & Raye, 1984; Multhaup, 1992). Two independent scorers coded the protocols and, in the relatively few cases in which scorers did not agree, the final code assigned was determined after consulting a third judge. Multhaup's data provide an opportunity to compare reports given by our subjects with those of a larger group of neurologically intact individuals. It is important to note that Multhaup reported information given spontaneously by subjects, whereas we included information elicited by further prompts (e.g., ''What did the house look like?'' ''About how long ago was that?''). The average number of prompts given were 2.5, 2.9, and 1.2 for G.S., frontal control, and normal control subjects, respectively.

Results

The number of codes assigned per autobiographical report is given in Table 5. The first column is subjects' responses to the initial question. The second column includes additional information elicited in response to further prompts. In an analysis comparing frontal control patients with normal controls, there was a main effect reflecting the benefit of prompts, $F(1, 4) = 23.53$, $p < .01$. Although the frontal control patients recalled, on average, less detail, the difference between frontal and normal control patients was not significant, perhaps because of the small *n* tested, nor was the group × prompt interaction significant, both $F\text{s}(1, 4) < 1.00$. As is clear from Table 5, G.S. had extremely impoverished autobiographical memories compared with other frontal patients. G.S.'s detail scores, expressed as *z* scores on the

TABLE 5
Mean Number of Codes Assigned to Each Autobiographical Report

	Responses to initial question	Responses with prompts
Patient G.S.	2.50	11.75
Frontal patients	16.83	36.00
Normal patients	30.58	42.67

distribution of frontal control scores, were −1.89 (3rd percentile) and −1.40 (8th percentile) for unprompted and prompted recall, respectively.

For each subject, the proportion of each type of code assigned to the protocols was computed. These data are given in Table 6 along with Multhaup's (1992) data for young (mean age = 22 years) and older (mean age = 81 years) subjects. Our normal and frontal control subjects produced reports that were about half as long as those produced by Multhaup's subjects. Nonetheless, they produced similar distributions of types of information as Multhaup's young and elderly adults (see Table 6). This suggests that the memories of these frontal patients had the same general qualitative characteristics as those of normal control subjects; that is, although the reports were generally impoverished, they did not appear to be selectively impoverished in any particular feature. With respect to G.S., in addition to his previously noted difficulty in reporting specific memories, the absence of temporal detail in

TABLE 6
Percentage of Codes of Each Type Assigned to Autobiographical Reports

	Multhaup data		Normal	Frontal	Patient
Condition	Young (N = 24)	Older (N = 24)	group (N = 3)	group (N = 3)	G.S. (N = 1)
Actions	18	22	20	21	20
Fact/background	19	21	21	20	10
People	9	11	11	13	20
Places	10	9	9	16	10
Temporal	8	9	12	14	0
Objects	7	6	8	5	10
Evaluations	5	5	4	2	10
Emotions	3	4	2	1	0
Reasons	4	3	2	2	0
Thoughts	1	2	1	1	0
Sensory/perceptual	5	2	1	0	0
Spatial	3	2	3	1	0
Online[a]	7	4	6	3	20
Total	99	100	100	99	100

[a] Refers to comments about processing (e.g., ''I don't remember . . .'').

TABLE 7
Average Detail Scores for Real and Imagined Events

	Real event	Imagined event
Patient G.S.	4.20	5.47
Frontal controls	3.93	2.61
Normal controls	6.32	6.34

his report is perhaps worth noting; however, the proportion of his report that was coded into the first four categories (action, fact/background, people, and places) looks fairly typical, although, of course, in absolute number of details in these categories he was clearly impaired.

MINIEVENTS PROCEDURE (SIMULATED AUTOBIOGRAPHICAL EVENTS)

Materials and Procedure

A ''minievents'' procedure for simulating autobiographical events was used. Subjects participated in some events and imagined participating in other events (e.g., Suengas & Johnson, 1988). The next day, they were asked to describe their memories for these events. Descriptions were rated by the experimenter for qualitative information, such as amount of perceptual and contextual detail. Typically, subjects' descriptions of actual events include more perceptual and contextual detail than their descriptions of imagined events (Hashtroudi, Johnson, & Chrosniak, 1990). Of interest was whether G.S. and other frontal patients would show this typical pattern. Subjects imagined five events (e.g., making a paper snowflake, having tea with a friend), guided by an experimenter reading from a prepared script. For each of five real events, the examiners provided appropriate props (e.g., wooden boards, a hammer, and nails) for each assigned task (e.g., hammering a nail). All subjects performed the activities in the same order. Real and imagined events were randomly intermixed and 24 hr later, the examiner contacted the subject by telephone, named each event, and asked the subject to describe the event.

Results

Subjects' descriptions of the 10 minievents were rated for details such as visual, auditory, sensory/motor, and location information. Mean ratings were combined to yield a composite or ''average detail'' score. The average detail scores for actual and imagined events are listed in Table 7. In an analysis comparing frontal controls and normal controls, the frontal patients reported less detail than did normal control subjects, $F(1, 4) = 48.94$, $p < .01$. The $F(1, 4)$ values for the main effect of type of item (real vs. imagined) and the interaction of group × item were 3.78 ($p < .12$) and 4.06 ($p < .11$), respectively. Although the difference between recall of actual and imagined events was minimal for our normal control subjects, most individuals report more details for actual than imagined events (Hashtroudi et al., 1990; Suengas & Johnson, 1988), as did our frontal controls. Most notable was G.S.'s

TABLE 8
Number of Codes of Various Types Assigned to G.S.'s Reports of His ''Fall'' and of an Anniversary Party

Response category	G.S. fall transcript	G.S. party transcript
Actions	11	8
Evaluations	0	0
Fact/background	7	10
Emotions	0	0
Objects	4	4
People	3	6
Places	5	3
Reasons	1	0
Sensory/Perceptual	1	1
Spatial	4	1
Temporal	6	4
Thoughts	0	0
Total	42	37

unusual pattern of recall. G.S. reported more details for imagined than for actual events. For actual events, G.S. gave descriptions with similar levels of detail as did frontal controls, $z = 0.27$ (61st percentile); for imagined events, G.S. gave more details than did frontal controls, $z = 4.21$ (99th percentile). G.S.'s reports for imagined events were more detailed than one would expect given his level of recall of actual events.

Qualitative characteristics of a confabulated memory. One of G.S.'s confabulations was compared with his report of a real event from the same period (see Appendix A). The confabulation chosen for study concerned G.S.'s erroneous belief that his memory problem was the result of hitting his head on a rock in his front yard. The comparison event was an anniversary party G.S. attended the night before his aneurysm ruptured. Reports were from approximately 3 months after these events. G.S.'s confabulation about his head injury and his memory for the anniversary party were scored as in the autobiographical study above. As shown in Table 8, the two reports included about the same number of codable pieces of information (42 and 37 for the fall and party, respectively). The party had somewhat more references to people (as might be expected) and the fall somewhat more spatial references, but, generally, the reports were quite similar. Two features of these reports are noteworthy. First, G.S.'s confabulation is as detailed and specific as his memory for a real event from the same time frame. Second, although the anniversary party was a real event, G.S.'s memory included some confabulated elements. He believed that he stayed at the party the whole time when he had left and returned, and he mistakenly believed that his wife's brother attempted ''to get a band going'' during the party.

Discussion

G.S.'s performance on the complex autobiographical memory tasks was interesting for several reasons. First, he demonstrated extremely poor recall for autobiographical events when cues were presented that elicited detailed memories from frontal control and, especially, normal control subjects. G.S.'s autobiographical recall was clearly impaired relative to frontal control subjects. These data suggest that G.S. has a pronounced difficulty in systematically self-generating a series of cues necessary to specify particular event memories (e.g., Reiser, 1986).

G.S.'s memory for details of complex real events experienced in the laboratory was poorer than that of normal control subjects and only slightly better than that of frontal controls. In contrast, his recall of imagined events was far better than that of frontal controls and almost at a normal level. Most significant was G.S.'s unusual pattern of recall which was characterized by greater clarity for imagined than for real events. Of course, we could not determine whether G.S. was recalling remembered information about the imagined events or generating the information at the time of the test. Nevertheless, the pattern was similar in the ''minievents'' procedure and in the comparison of G.S.'s confabulation with his memory for a real event from the same period. In both instances, G.S.'s accounts for imagined events had somewhat more detail and specificity than did his account of real events.

GENERAL DISCUSSION

To examine cognitive deficits contributing to confabulation, patient G.S. was matched with frontal patient control subjects according to level of mnemonic abilities and executive functions as assessed by standard neuropsychological tests. The aspect of his clinical presentation that clearly set him apart from these other patients was his tendency toward confabulation. One set of laboratory tasks focused on memory for specific features of relatively simple events. G.S. looked similar to the frontal control patients on the temporal duration task and, in fact, performed at the level of normal control subjects on the temporal order task. Also on the speaker identification tasks, G.S.'s deficits were no greater than those of frontal control patients. Thus there was no evidence that source monitoring failures as measured by either temporal order or speaker identification were disproportionately impaired in G.S. relative to nonconfabulating frontal control patients.

A second set of tasks focused on qualitative characteristics of G.S.'s memory for complex, multifaceted events, some presented in the laboratory and some from his personal life. Here G.S. demonstrated unusual findings. G.S. showed poor memory for autobiographical events, as has been reported for other confabulating patients (e.g., Dalla Barba, 1993a, 1993b). Our results further indicate that for G.S., memory for autobiographical events was impoverished even relative to that of other frontal patients. Interestingly, G.S. had a clear, lucid, and generally accurate recall of the party that occurred the night before his aneurysm. There are at least two potentially interesting explanations for why recall of this event was so much better than recall of events in the autobiographical memory task (compare Tables 8 and 5). First, the retention intervals for appropriate target events in the autobiographical memory task were likely, on average, longer than the retention interval for the anniversary party. Second, the retrieval cues were much less specific in the autobiographical memory task than for the anniversary party. Perhaps G.S.'s recall of the party was detailed because the cue was quite specific—a particular anniversary party—whereas his recall of events in the autobiographical task was poor because the cues did not specify a particular, relatively unique event, but only a type of event (e.g., ''a time with a friend'' or a ''vacation''). To come up with an appropriate memory in this type of task, subjects must self-generate additional retrieval cues that will help activate more specific memories (e.g., Baddeley, 1982; Reiser, 1986). Consistent with the idea that these factors may be important are the results for the real events in the minievent study (Table 7). With a short retention interval (24 hr) and specific cues, G.S.'s memory for autobiographical events, though impaired relative to normals, was not worse than that of other frontal patients. Together, these results suggest that G.S.'s autobiographical memory deficit relative to frontal controls is more evident the longer the retention interval and the less specific the cue. These are exactly the conditions most likely to place the highest demands on self-initiated retrieval processes.

Another unusual aspect of G.S.'s performance was his relatively detailed recall of imagined events. His ''recall'' of details in his confabulated account of his injury rivaled his recall of details of the anniversary party, a real event from the same period. Similarly his recall of imagined events on the minievents procedure was as detailed—in fact, more so—than his recall of real events. G.S.'s tendency to recall more details of imagined events on this task (while the frontal control patients showed the more typical greater recall of real events) suggests that an imagined event does not necessarily have to be highly relevant to his concerns about his condition for G.S. to show an embellished report. One possibility is that, perhaps because of his impoverished recall of externally derived events, G.S. is more likely to rehearse or ruminate on self-generated information which may have an initial advantage in access (Johnson, 1983). The consequences of such reactivations would be to maintain the imagined details of the memory (Johnson & Chalfonte, 1994; Suengas & Johnson, 1988).

Our study of G.S. suggests that confabulation is based on a confluence of factors. Patient G.S. demonstrated a number of characteristics that could contribute to confabulation: (1) significant deficits in the systematic retrieval of autobiographical memories; (2) source monitoring deficits (i.e., underestimation of temporal duration and speaker identification deficits); and (3) a propensity toward detailed imaginations. Any one of these factors alone might not produce a clinically significant pattern of confabulation; however, these tendencies could interact, resulting in a situation where a patient has difficulty discriminating between fact and fiction. One might suppose that any detailed ''memory'' (whether real or invented) would stand out against a background of impoverished autobiographical memories. With poor source information, and with markedly impaired ability to retrieve additional confirming or disconfirming autobiographical memories, G.S. would not be able to reflect on other evidence in determining the authenticity of such memories. Consequently, he would be predisposed to accept them as real events.

There are a number of ways that reality monitoring can break down (Johnson, 1988, 1991, 1997). Other types of confabulation (e.g., more bizarre event memories, misidentifications of places or persons, or confabulations in conjunction with anosognosia) presumably result from other configurations of cognitive deficits that can lead to distorted memories and beliefs. Studies of individual patients (such as G.S.) help to elucidate the processes necessary in normal reality monitoring but any individual patient does not, of course, explicate the full range of factors and the interactions between factors involved in confabulation (Johnson, 1997). It bears repeating that G.S. and frontal control patients were matched according to neuropsychological performance on tests of general intelligence, frontal/executive functions, and memory. We did not match patients according to location of lesion. To date, the neural substrates of confabulation have not been clearly delineated. Confabulation occurs in conjunction with damage in the left, right, and bilateral frontal brain regions (DeLuca & Cicerone, 1991; Kapur & Coughlan, 1980; Joseph, 1986; Moscovitch, 1989). The exact relationship between location and extent of frontal lesions and confabulation remains to be specified (see also Fischer, Alexander, D'Esposito, & Otto, 1995). This effort will be facilitated, we believe, by larger group studies identifying intact and disrupted cognitive processes of patients who present with well-described neuroanatomic lesions and well-characterized confabulatory tendencies.

In summary, the current study attempted to identify a pattern of cognitive deficits associated with confabulation. There was evidence that a confabulating patient had difficulty on tasks measuring memory for temporal duration and speaker identification but that these problems were no greater than those demonstrated by nonconfabulating frontal control subjects, at least for the short time intervals studied here. These findings do *not* negate the contribution of these deficits to confabulation; however, they suggest that other factors are involved in this patient. Along with temporal duration and speaker identification deficits, G.S. demonstrated enhanced memory for imagined events and profound difficulty searching autobiographical memory in response to categorical cues. We hypothesize that it is this configuration or cognitive profile of deficits, rather than a single factor, that accounts for G.S.'s tendency to confabulate.

APPENDIX A

G.S.'s Description of the Events of 1/27/92: The Confabulation

G.S. reports that he was talking to his friend Ed who was seated in his truck with G.S.'s son when he (G.S.) fell backward, banging his head on the side of the road. He believes that Ed and his son were in the truck preparing to leave for an unknown destination. After the fall, they took him into the house to lie down on the couch. They stayed with him for a little while. All this occurred around 7 PM on the previous Sunday night after G.S. had eaten supper. G.S. stated that he has no doubts about the veracity of this event and that he can see the event in his mind's eye. G.S. believes that he was then taken to CM Hospital and then to B Hospital in RI. He described BH as an older hospital which may have been built in the early 1900s.

Anniversary Party (1/26/92)

G.S. recalled attending his father-in-law's 25th wedding anniversary at the S Lodge on a Friday night (it was on a Saturday) a couple of months ago. He stated that approximately 50 people were at the party. He did not recall the dinner but did recall drinking diet soda and eating cake with white frosting. He remembered that his brother-in-law gave a speech. He believes that he sat near the rear of the room but did not know who sat at his table. G.S. did not recall leaving the party to drive his daughter to a friend's house and insisted that he stayed at the party the whole time. He did remember a fight in the parking lot between his brother-in-law and his wife. He did not recall his wife's dress for the occasion, a dress that he had purchased that day. He also insisted that his brother-in-law attempted ''to get a band going'' during the party, something that his wife denied. G.S. did not remember having a headache that night even though his wife said that he complained of one all evening and that his behavior was atypically withdrawn.

REFERENCES

Baddeley, A. 1982. Amnesia: A minimal model and an interpretation. In L. S. Cermak (Ed.), *Human memory and amnesia.* Hillsdale, NJ: Erlbaum. Pp. 305–336.

Baddeley, A. D., & Wilson, B. 1986. Amnesia, autobiographical memory, and confabulation. In D. C. Rubin (Ed.), *Autobiographical memory.* New York: Cambridge Univ. Press. Pp. 225–252.

Barbizet, J. 1963. Defect of memorizing of hippocampal–mammillary origin: A review. *Journal of Neurology, Neurosurgery, and Psychiatry,* **26,** 127–135.

Batchelder, W. H., & Riefer, D. M. 1990. Multinomial processing models of source monitoring. *Psychological Review,* **97,** 548–564.

Berlyne, N. 1972. Confabulation. *British Journal of Psychiatry,* **120,** 31–39.

Bonhoffer, K. 1904. Der Korsakowsche Symptomen Komplex in seinen Beziehungen su den verschiedenen Krankheitsformen. *Allgemeine Zeitung Psychiatrie,* **61,** 744–752.

Dalla Barba, G. 1993a. Confabulation: Knowledge and recollective experience. *Cognitive Neuropsychology,* **10,** 1–20.

Dalla Barba, G. 1993b. Different patterns of confabulation. *Cortex,* **29,** 567–581.

Damasio, A. R., Graff-Radford, N. R., Eslinger, P. J., Damasio, H., & Kassell, N. 1985. Amnesia following basal forebrain lesions. *Archives of Neurology,* **42,** 263–271.

DeLuca, J., & Cicerone, K. D. 1991. Confabulation following aneurysm of the anterior communicating artery. *Cortex,* **27,** 417–423.

Ferguson, S. A., Hashtroudi, S., & Johnson, M. K. 1992. Age differences in using source-relevant cues. *Psychology of Aging,* **7,** 443–452.

Fischer, R. S., Alexander, M. P., D'Esposito, M., & Otto, R. 1995. Neuropsychological and neuroanatomical correlates of confabulation. *Journal of Clinical and Experimental Neuropsychology,* **17,** 20–28.

Green, D. M., & Swets, J. A. 1966. *Signal detection theory and psychophysics.* New York: Wiley.

Hashtroudi, S., Johnson, M. K., & Chrosniak, L. D. 1990. Aging and qualitative characteristics of memories for perceived and imagined complex events. *Psychology and Aging,* **5,** 119–126.

Hashtroudi, S., Johnson, M. K., Vnek, N., & Ferguson, S. A. 1994. Aging and the effects of affective and factual focus on source monitoring and recall. *Psychology and Aging,* **9,** 160–170.

Hu, X. 1990. *Source monitoring program.* Version 1.0. Irvine: Institute for Mathematical Behavioral Sciences; School of Social Sciences, University of California.

Johnson, M. K. 1983. A multiple-entry, modular memory system. In G. H. Bower (Ed.), *The psychology of learning and motivation.* San Diego, CA: Academic Press. Vol. 17, pp. 81–123.

Johnson, M. K. 1988. Discriminating the origin of information. In T. F. Oltmanns & B. A. Maher (Eds.), *Delusional beliefs.* New York: Wiley. Pp. 34–65.

Johnson, M. K. 1991. Reality monitoring: Evidence from confabulation in organic brain disease patients. In G. P. Prigatano & D. L. Schacter (Eds.), *Awareness of deficit after brain injury: Clinical and theoretical issues.* New York: Oxford Univ. Press. Pp. 176–197.

Johnson, M. K. 1997. Identifying the origin of mental experience. In M. S. Myslobodsky (Ed.), *The Mythomanias: The native of deception and self-deception.* Mahwah, NJ: Erlbaum. Pp. 133–180.

Johnson, M. K., & Chalfonte, B. L. 1994. Binding of complex memories: The role of reactivation and the hippocampus. In D. L. Schacter & E. Tulving (Eds.), *Memory systems 1994.* Cambridge, MA: MIT Press. Pp. 311–350.

Johnson, M. K., Foley, M. A., Suengas, A. G., & Raye, C. L. 1988. Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General,* **117,** 371–376.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. 1993. Source monitoring. *Psychological Bulletin,* **114,** 3–28.

Johnson, M. K., Kahan, T. L., & Raye, C. L. 1984. Dreams and reality monitoring. *Journal of Experimental Psychology: General,* **113,** 329–344.

Johnson, M. K., Kounios, J., & Reeder, J. A. 1994. Time-course studies of reality monitoring and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* **20,** 1409–1419.

Joseph, R. 1986. Confabulation and delusional denial: Frontal lobe and lateralized influence. *Journal of Clinical Psychology,* **42,** 507–520.

Kapur, N., & Coughlan, A. K. 1980. Confabulation and frontal lobe dysfunction. *Journal of Neurology, Neurosurgery, and Psychiatry,* **43,** 461–463.

Kerns, L. L. 1986. Falsifications in the psychiatric history: A differential diagnosis. *Psychiatry,* **49,** 13–17.

Kixmiller, J., O'Connor, M., & Cermak, L. November 1994. *A WMS-R index for the diagnosis of amnesia.* Presented at National Academy of Neuropsychology, Orlando, FL.

Kopelman, M. D. 1987. Two types of confabulation. *Journal of Neurology, Neurosurgery, and Psychiatry,* **50,** 1482–1487.

Milner, B., Petrides, M., & Smith, M. L. 1985. Frontal lobes and the temporal organization of memory. *Human Neurobiology,* **4,** 137–142.

Moscovitch, M. 1989. Confabulation and the frontal systems: Strategic versus associative retrieval in neuropsychological theories of memory. In H. L. Roediger III & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving.* Hillsdale, NJ: Erlbaum. Pp. 133–160.

Multhaup, K. M. 1992. *Processing qualitative aspects of complex material: A comparison of older and younger adults.* Unpublished doctoral dissertation, Princeton University.

Reiser, B. J. 1986. The encoding and retrieval of memories of real-world experiences. In J. A. Galambos, R. P. Abelson, & J. B. Black (Eds.), *Knowledge structures.* Hillsdale, NJ: Erlbaum. Pp. 71–99.

Schacter, D. L. 1987. Memory, amnesia, and frontal lobe dysfunction. *Psychobiology,* **15,** 21–36.

Shapiro, B. E., Alexander, M. P., Gardner, H., & Mercer, B. 1981. Mechanisms of confabulation. *Neurology,* **31,** 1070–1076.

Shimamura, A. P., Janowsky, J. S., & Squire, L. R. 1990. Memory for the temporal order of events in patients with frontal lobe lesions and amnesic patients. *Neuropsychologia,* **28,** 803–813.

Stuss, D. T., Alexander, M. P., Lieberman, A., & Levine, H. 1978. An extraordinary form of confabulation. *Neurology,* **28,** 1166–1172.

Stuss, D. T., & Benson, D. F. 1986. *The frontal lobes.* New York: Raven Press.

Suengas, A. G., & Johnson, M. K. 1988. Qualitative effects of rehearsal on memories for perceived and imagined complex events. *Journal of Experimental Psychology: General,* **117,** 377–389.

Talland, G. A. 1961. Confabulation in the Wernicke–Korsakoff syndrome. *Journal of Nervous Mental Disorders,* **132,** 361–381.

Talland, G. A. 1965. *Deranged memory: A psychonomic study of the amnesic syndrome.* New York: Academic Press.

Warrington, E. K. 1984. *Recognition memory test.* Berks: Nofer-Nelson.

Whitlock, F. A. 1981. Some observations on the meaning of confabulation. *British Journal of Medical Psychology,* **54,** 213–218.

Whitty, C. W. M., & Lewin, W. 1960. A Korsakoff syndrome in the post-cingulectomy confusional state. *Brain,* **83,** 648–653.

Williams, J. M., Medwedeff, C. H., & Haban, G. 1989. Memory disorder and subjective time estimation. *Journal of Clinical and Experimental Neuropsychology,* **11,** 713–723.

Winograd, E. 1968. List differentiation, recall, and category similarity. *Journal of Experimental Psychology,* **78,** 510–515.

Wyke, M., & Warrington, E. 1960. An experimental analysis of confabulation in a case of Korsakoff's syndrome using a tachistoscopic method. *Journal of Neurology, Neurosurgery, and Psychiatry,* **23,** 327–333.