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Dissociation between verbal and autonomic measures of memory following frontal lobe damage

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Article abstract—*Objective:* The objective of this study was to contrast overt verbal versus covert autonomic responses to facial stimuli in a patient with false recognition following frontal lobe damage. *Background:* False recognition has been linked to frontal lobe dysfunction. However, previous studies have relied exclusively on overt measures of memory and have not examined whether or not patients with false recognition continue to demonstrate preserved covert discrimination of familiar and unfamiliar items. *Methods:* We recorded skin conductance responses (SCRs) in a patient with frontal lobe damage and in normal control subjects while they performed a familiarity decision task using famous and unfamiliar faces as stimuli. *Results:* Patient J.S. produced significantly more overt false recognition errors and misidentifications in response to unfamiliar faces than control subjects. However, similar to the control subjects, he showed accurate covert autonomic discrimination of truly familiar faces from unfamiliar ones. Furthermore, SCRs to falsely recognized unfamiliar faces were not significantly different from SCRs generated to unfamiliar faces that J.S. correctly rejected. *Conclusions:* Our findings provide further neuropsychological evidence that overt and covert forms of face recognition memory are dissociable. In addition, the failure to detect an autonomic correlate for the false recognition errors and misidentifications in J.S. suggests that these memory distortions were not related to the spurious activation of stored memory representations for specific familiar faces. Instead, these incorrect responses may have been driven by the sense of familiarity evoked by novel faces that had a general resemblance to faces encountered previously. We propose that false recognition in J.S. resulted from the breakdown of strategic frontal memory retrieval, monitoring, and decision functions critical for attributing the experience of familiarity to its appropriate source.

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Frontal lobe dysfunction is considered to play an important role in the pathogenesis of memory distortions such as false recognition[1-5] and confabulation.[6-9] False recognition refers to incorrect statements by patients that novel stimuli had been encountered previously, either during the study phase of a recognition memory experiment[1-3] or within a larger autobiographic context.[4,5] Such misattributions of familiarity are occasionally followed by the retrieval of additional false memories about the target, resulting in frank confabulation.[4,5] For example, a patient may not only claim incorrectly that an unfamiliar face is familiar, but may also provide false identity-specific semantic and name information about the person.

To date, studies of false recognition in frontal lobe patients have relied exclusively on explicit tests of memory, requiring that subjects consciously recollect previously experienced events. However, neuropsychological evidence indicates that explicit and implicit measures of memory are potentially dissociable. Specifically, it has been demonstrated that verbal and autonomic measures of recognition memory are poorly correlated in patients with various forms of agnosia and amnesia.[10] For instance, patients with prosopagnosia fail to recognize the faces of familiar individuals and insist that all faces look unfamiliar. Despite the virtually complete absence of recognition on explicit tests of face memory, some prosopagnosics have been found to generate discrim-

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inatory skin conductance responses (SCRs) to familiar faces, consistent with preserved covert autonomic recognition.[11,12] These observations suggest that at least in certain forms of prosopagnosia stored memory representations for familiar faces are still being activated in a relatively normal fashion, but the output of the face recognition system is unavailable to conscious awareness. Similarly, patients with amnesia may show accurate covert autonomic recognition of items that had been presented in the study phase of a memory experiment, even though their verbal responses indicate severely defective explicit memory for the same stimuli.[13,14] Thus, some amnesics apparently remain capable of acquiring new episodic memories without conscious awareness that such learning is taking place. In short, covert autonomic recognition may be preserved in patients with agnosia or amnesia whose overt verbal behavior suggests impaired conscious access to the relevant memory representations.

The present study was undertaken to determine whether a dissociation between verbal and autonomic measures of recognition memory can also be demonstrated in neuropsychological conditions where the overt behavior of the patient is characterized by a spurious sense of familiarity and the abundant production of illusory memories. In particular, we wanted to learn whether a patient with striking false recognition and confabulation following frontal lobe damage would nevertheless continue to show preserved covert autonomic discrimination of truly familiar items from unfamiliar ones.

Patient report. J.S. is a 63-year-old right-handed man who was referred to us for evaluation of memory impairment following surgical repair of a ruptured anterior communicating artery (ACoA) aneurysm. J.S. had 16 years of formal education and worked as a salesman for a medical equipment company prior to his illness. CT revealed bilateral infarction of the basal forebrain/septal area and the ventromedial frontal region, including orbitofrontal cortex, anterior cingulate gyrus, and the genu of the corpus callosum. Frontal lobe involvement was more extensive on the right side, where the lesion extended into anterior (frontopolar) and inferior dorsolateral prefrontal areas (figure 1). A single photon emission computed tomographic (SPECT) study was consistent with the CT findings and demonstrated severe reduction of blood flow in anterior cingulate gyrus and prefrontal cortex, especially pronounced on the right side.

General neuropsychological observations. J.S. was alert and cooperative, and had a cheerful disposition. Language production and comprehension were well preserved. J.S. had no recollection whatsoever of having had brain surgery and denied having any problems with his memory. In fact, he boasted that he had been told by "professionals" that he had a "photographic" memory. He was not oriented to time or place and thought that he was only 50 years old. Specific questions about his current status or his personal history provoked frequent confabulations, many of which were fantastic and highly improbable. For instance, while still in the hospital he insisted that he took daily business trips, sometimes traveling as far as South America and back within the span of 4 to 6 hours. J.S. also claimed to have "recognized" unfamiliar individuals whom he had met for the first time. He seemed unaware of these recognition errors and made no attempt to verify the correctness of his initial impression regarding the person's identity.

On the Wechsler Adult Intelligence Scale-Revised, J.S. achieved a verbal IQ of 94 (average range), a performance IQ of 79 (borderline range), and a full-scale IQ of 87 (low average range). These values are lower than expected for a person with his educational and occupational background. Formal assessment of memory functions revealed evidence of severely defective recall and recognition for both verbal and visual materials. Performance on the Wechsler Memory Scale-Revised was profoundly impaired (all Index scores, except for attention/concentration, were at or below the first percentile). Similarly, on the California Verbal Learning Test (CVLT) J.S.'s scores fell more than 2 SDs below the mean on trials of immediate and delayed free recall, cued recall, and recognition memory. Of particular note was the high false-positive rate on the CVLT recognition memory trials, where he endorsed all items (16 targets and 28 foils) as having been on the original study list. On both the words and faces subtests of the Warrington Recognition Memory Test J.S.'s scores fell below the fifth percentile. J.S. also performed extremely poorly on tests sensitive to frontal lobe dysfunction, such as the Controlled Oral Word Association Test (FAS total = 12), Wisconsin Card Sorting Test (zero categories achieved), Stroop Test (below the second percentile), and the Trail Making Test (unable to complete part B). In contrast, he obtained normal scores on the Benton Facial Recognition Test (Corrected Long Form Score = 42), and on a test of famous face recognition used in our laboratory (31 of 36; control mean, 32.32; SD = 2.12). In summary, J.S.'s neuropsychological profile was remarkable for severe global amnesia and frontal lobe dysfunction.

False recognition. False recognition and confabulation could be readily elicited from J.S. in response to a variety of stimuli. For example, when shown different sets of unfamiliar faces and asked to judge whether the faces were familiar (i.e., "seen before") or unfamiliar (i.e., "never seen before"), his false recognition rates ranged from 45% to as high as 90%. When asked to provide additional information about the unfamiliar faces he incorrectly judged familiar, J.S. sometimes indicated that he did not have more specific knowledge or responded with general statements (e.g., "a guy I used to see on TV" or "movie actor"). However, he also frequently misidentified unfamiliar faces as specific famous individuals, personal acquaintances (e.g., school teacher, childhood friend, colleague from work), or family members. The particular false memories produced in response to unfamiliar faces were strongly influenced by the context of the testing session, and J.S. showed a tendency to incorporate into his answers irrelevant events that preceded the recognition experiment. For instance, following a casual conversation about horse racing in England, he misidentified unfamiliar faces as BBC sports announcers, famous English jockeys, and horse trainers. On another occasion he correctly identified a picture of the Eiffel Tower and subsequently misidentified unfamiliar faces as people he met in France while visiting Paris after World War II. In addition to influencing the specific con-

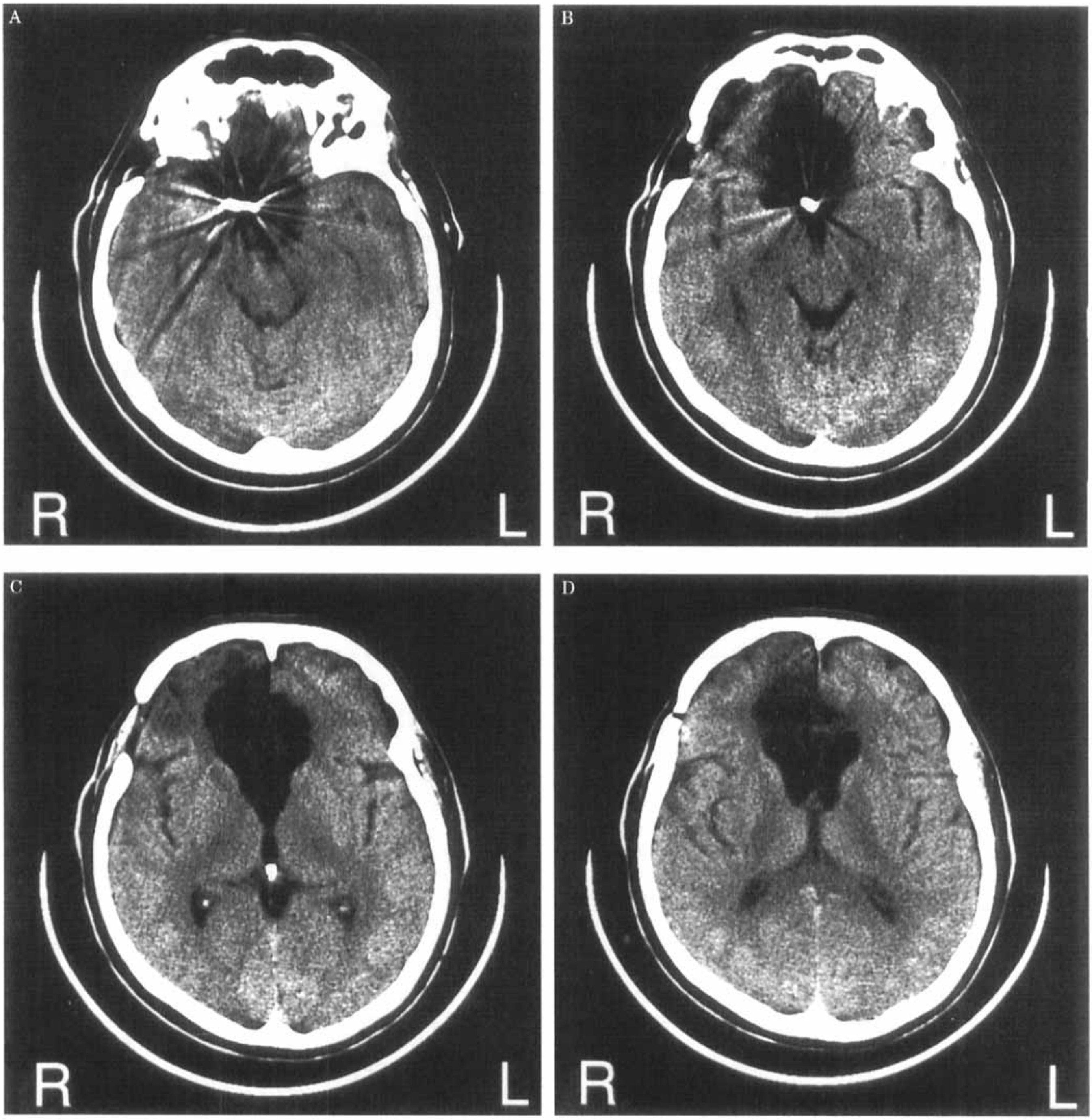

Figure 1. Axial CT demonstrates bilateral damage to the basal forebrain/septal region, anterior cingulate gyrus, and prefrontal cortex. Prefrontal involvement is more extensive on the right side.

tent of confabulatory responses, the frequency of false recognition errors could also be manipulated by the context set by the examiner for the recognition task. For example, J.S. was once shown a page from a yearbook containing 40 photographs and was told that this was a graduation picture of his old high school class. When asked if any of the faces looked familiar, he falsely recognized 18 of 40 unfamiliar faces (45%) as classmates, although he could not identify any by name. A week later he was shown the exact same set of pictures, but this time he was told that these were students from a high school in Montana of which he had never heard. Following this introduction, he reported that only 1 of 40 faces (2.5%) looked familiar.

As noted earlier, false recognition in J.S. was not limited to faces. He also produced an abnormally high rate of false recognition errors and confabulations in response to unfamiliar names (15 of 30 or 50%), voices (9 of 15 or 60%), and pictures depicting unfamiliar landscapes or urban scenes (15 of 30 or 50%).

Overt versus covert recognition. Procedure. The experimental task we selected to contrast verbal versus autonomic measures of recognition memory in J.S. and 15 neurologically intact control subjects (age range, 62 to 80 years) was a modified version of the SCR covert face recognition paradigm described by Tranel et al.[12,15] The stimulus set consisted of photographs of eight famous and 30 unfa-

Table *Face recognition scores and confidence ratings for J.S. and control subjects**

	J.S.	Controls
Famous faces	8	7.73 (0.59)
Unfam/FR	20†	4.40 (3.92)
Unfam/CR	10†	25.53 (3.91)
Conf/F	1.0 (0.00)	1.06 (0.07)
Conf/FR	1.9 (0.55)	2.16 (0.56)
Conf/CR	1.7 (0.82)	1.31 (0.57)

* SDs are in parentheses.

† Recognition scores >3 SDs from the control mean.

Unfam/FR = false recognition responses to unfamiliar faces; Unfam/CR = correctly rejected unfamiliar faces; Conf/F = mean confidence ratings for famous faces; Conf/FR = mean confidence ratings for false recognition responses; Conf/CR = mean confidence ratings for correct rejections.

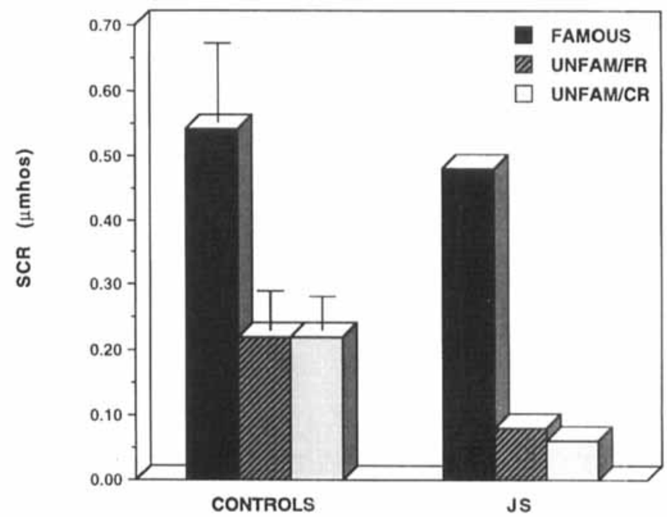

Figure 2. Mean skin conductance response (SCR) amplitudes to famous and unfamiliar faces in the patient (J.S.) and normal control subjects. Unfam/FR = false recognition responses to unfamiliar faces; Unfam/CR = correctly rejected unfamiliar faces. Bars show standard error of the mean.

miliar faces that were digitized and presented on a computer screen in random order. Presentation of the stimulus set was preceded by two practice items that were not included in the analysis. Following presentation of each face, subjects were asked to indicate verbally whether it was familiar or unfamiliar, and to rate their level of confidence in their decision on a three-point scale (1 = very sure, 2 = somewhat sure, 3 = uncertain). Prior to testing, participants were told explicitly to call faces familiar only if they thought that they had seen that particular individual before, either in person or through the media. If a face was judged familiar, subjects were asked to provide any additional information they might have concerning the person's identity (e.g., occupation or name). Faces remained on the screen until subjects produced a verbal response or until 6 seconds had elapsed. The next trial was initiated when at least 20 seconds had elapsed since the offset of the previous stimulus and when subjects were not generating an SCR. SCRs to facial stimuli were recorded with Ag-AgCl electrodes from the index and middle finger tips of the left hand (12-mm electrode gel contact area), using a 0.050-molar NaCl electrolyte in a Unibase cream medium (as recommended by Fowles et al.[16]). A BioPac GSR 100A amplifier (BioPac Systems; Santa Barbara, CA), employing a constant voltage technique, sampled absolute (DC) skin conductance at a rate of 120 samples per second and recorded SCRs through BioPac AcqKnowledge software running on a Macintosh II SI computer (Apple Computer; Cupertino, CA). For each trial a latency window of 1 to 6 seconds after stimulus onset was used, and the amplitude of the largest SCR with onset falling within this window was recorded.

Results. *Overt recognition.* Verbal recognition scores and mean confidence ratings for J.S. and the control subjects are summarized in the table. J.S. rated all famous faces as familiar, and he could also correctly identify these individuals by name. However, he produced significantly more false recognition errors in response to unfamiliar faces than control subjects, frequently providing additional false information about the person depicted. Inspection of confidence ratings revealed that J.S. and control subjects were equally confident in their correct responses to famous faces. With respect to unfamiliar faces, control subjects expressed greater confidence in correct rejections than in false recognition errors. In fact, the chi-square value for the difference between confidence ratings for correct rejections and false recognition errors was highly significant ($p < 0.01$) for every control subject who produced two or more false recognition responses. By contrast, confidence ratings for correct rejections and false recognition errors were not significantly different for J.S. ($\chi^2 = 4.38$, $p = 0.12$). These findings suggest that J.S. was less able to judge whether responses made to unfamiliar faces were correct. This conclusion was also supported by an analysis of the relationship between confidence ratings and response accuracy on unfamiliar face trials in which subjects reported high levels of confidence in their decisions (i.e., "very sure"). Response accuracy for control subjects on these trials was 97%, whereas the corresponding figure for J.S. was only 56%—a score not significantly different from chance. Thus, subjective confidence ratings in J.S. were poorly correlated with response accuracy.

Covert recognition. SCRs to famous and unfamiliar faces in J.S. were compared using the Mann-Whitney U test. J.S. generated significantly greater SCRs to famous faces (mean = 0.48 µmhos) than to unfamiliar faces (mean = 0.08 µmhos; ($U = 41$, $z = -2.83$; $p < 0.01$). By contrast, SCRs to falsely recognized unfamiliar faces (mean = 0.08 µmhos) were not significantly different from SCRs generated to those unfamiliar faces that he correctly rejected (mean = 0.06 µmhos; $U = 95$, $z = -0.22$; $p = 0.83$; figure 2). The overall pattern of SCRs produced by J.S. was very similar to that obtained in our control subjects (see figure 2) who, as a group, also generated greater responses to famous faces (mean = 0.54 µmhos) than to unfamiliar faces (mean = 0.22 µmhos; Wilcoxon's rank sum test, $z = -3.07$; $p < 0.01$), while showing no significant SCR differentiation between false recognition errors (mean = 0.22 µmhos) and correct rejections (mean = 0.22 µmhos; $z = -0.59$; $p = 0.55$). Thus, in both J.S. and the control subjects, veridical recognition of familiar faces was associated with discriminatory SCRs, whereas false recognition of unfamiliar faces did not have a clearly identifiable autonomic correlate.

Discussion. Following damage to the basal forebrain/septal region, anterior cingulate gyrus, and prefrontal cortex, J.S. presented with severe amnesia and executive dysfunction—a combination of neuropsychological deficits commonly observed in patients with ruptured ACoA aneurysms.[17-19] A striking feature of J.S.'s cognitive impairment was the abnormally high rate of false recognition errors to novel stimuli, frequently accompanied by the retrieval of additional false memories about the target. However, in an experimental paradigm that allows direct comparisons between verbal and autonomic responses to facial stimuli we obtained evidence for a clear dissociation between overt and covert measures of recognition memory. Specifically, we demonstrated that despite numerous overt false recognition errors and misidentifications, J.S. continued to show accurate covert autonomic discrimination of truly familiar faces from unfamiliar ones. In fact, the overall pattern and magnitude of covert SCRs to facial stimuli were quite similar in J.S. and normal control subjects. These results thus provide further empirical support for the hypothesis that overt and covert forms of face recognition memory are mediated by separate neural systems.[11,15] Our findings in J.S. also provide an interesting contrast with prosopagnosia. The pathognomonic clinical features of prosopagnosia include the absence of the feeling of familiarity and the complete inability to retrieve pertinent biographic information about known individuals from facial cues, whereas false recognition is characterized by the spurious sense of familiarity evoked by unfamiliar faces and the production of illusory memories resulting in confabulatory misidentification. Despite the dramatic differences in overt behavior, in both neuropsychological conditions covert discrimination of familiar and unfamiliar faces may be preserved. Taken together, the dissociations between verbal and autonomic measures of face recognition memory documented in prosopagnosia and false recognition are consistent with the view that the sense of familiarity and the subjective experience of remembering are attributions that may not always accurately reflect the presence or absence of a veridical underlying memory representation.[20]

Our failure to detect an autonomic correlate for the false recognition errors and misidentifications in J.S. (i.e., no significant SCR differences between false recognitions and correct rejections) suggests that these memory distortions were not related to the spurious activation of stored memory representations for *specific* familiar faces. Instead, these recognition errors may have been driven by the sense of familiarity created by novel faces that had a *general* similarity to faces encountered previously. The hypothesis that this type of general familiarity may contribute to incorrect recognition decisions is supported by the finding that "typical"-looking unfamiliar faces or faces that bear a categorical resemblance to certain stereotypes (e.g., "politician type") are more likely to elicit false recognition errors in normal subjects.[21-23] False facial recognition in J.S., therefore, may have resulted from a pathologic inability to distinguish between familiarity based on memory for specific faces and familiarity based on memory for faces in general.

Normally, recognition judgments reflect the outcome of two separate but closely interrelated psychological processes.[24] The first component is largely automatic and involves the detection and assessment of stimulus familiarity, whereas the second component requires more effort and involves a strategic memory search for possible contexts (i.e., the attempt to attribute familiarity to a specific source). Conscious efforts to recollect a specific source or context can be used by normal individuals to oppose and inhibit judgments based on undifferentiated familiarity alone.[25,26] For instance, the intentional retrieval of appropriate supporting memories increases our confidence that a person who appears familiar is somebody we know, whereas the unavailability of more specific contextual information might ultimately lead us to reach the opposite conclusion. We suggest that the abnormally high rate of false recognition errors in J.S. resulted from an overreliance on general or undifferentiated familiarity, without an organized attempt to search for plausible contexts and use this information as the basis for recognition judgments. We propose further that this decision bias in J.S. was caused by the breakdown of strategic frontal cognitive operations that are normally recruited to retrieve possible contexts when there is uncertainty about the origin of familiarity.[26,27] J.S. could easily identify the famous faces in our recognition experiment, because for these well-known individuals the face cue alone was sufficient to elicit unique memories about the person and thus provide a specific context. By contrast, he experienced significant difficulty in dealing with the sense of familiarity evoked by novel faces, since in these situations the source of familiarity was not immediately obvious. On those occasions when J.S. did make a perfunctory attempt to attribute this type of general familiarity to a specific source, he produced inappropriate contexts resulting in confabulations. In fact, the retrieval of incorrect contexts may have paradoxically reinforced and sustained J.S.'s false belief that he was remembering rather than inventing.

In addition to organized memory search, strategic frontal lobe functions also include the monitoring and critical evaluation of the information retrieved.[9,26-28] That this monitoring and verification process was defective in J.S. is demonstrated by his apparent failure to appreciate that the memories and associations triggered by unfamiliar faces were patently false. J.S.'s difficulty in evaluating responses made to unfamiliar faces was also reflected in his confidence ratings, which deviated substantially from the pattern observed in normal control subjects. Dysfunction of the evaluation and judgment process, however, was not limited to information internally retrieved from memory. Impaired monitoring was also manifested by J.S.'s readiness to incorporate irrelevant environmental cues into his responses and by his unconditional willingness to accept false contexts suggested by the examiner. Due to the inappropriate influence of current events and contexts on face recognition judgments, J.S.'s performance often seemed more a reflection of his present cognitive state and environment than a function of his past experiences with faces. Increased susceptibility to suggestion, combined with an inability to suppress task-irrelevant external information, is frequently noted in patients with false recognition and confabulation[6,29-31] and is reminiscent of the "environmental dependency syndrome" described by Lhermitte[32] in patients with prefrontal damage.

In conclusion, we propose that false recognition in J.S. resulted from the breakdown of strategic frontal memory retrieval, monitoring, and decision functions critical for opposing the tendency to respond primarily on the basis of general or undifferentiated stimulus familiarity in recognition memory tasks. Whether a dysfunction of systems responsible for the initial assessment of familiarity[24] also contributed to the recognition impairment remains an open question, especially since it has been proposed that such preliminary cognitive judgments of stimulus familiarity/novelty may also be frontally mediated.[33] Support for our interpretation of J.S.'s neuropsychological deficit is provided by recent PET studies that have suggested an important role for right prefrontal cortex in intentional memory retrieval and monitoring functions necessary for item-specific recognition.[34-39] Of particular relevance is the study by Schacter et al.[39] in which false recognition in normal subjects was associated with bilateral orbitofrontal and right anterior prefrontal cortical activations. The authors hypothesized that blood flow increases in prefrontal cortex may have reflected the effort to inhibit, monitor, and make decisions about the sense of familiarity associated with false recognition. Damage to orbitofrontal and right anterior prefrontal cortical regions, therefore, may have been primarily responsible for the striking false recognition errors observed in J.S. across a variety of testing conditions. Further studies are needed to confirm this anatomic relationship and to determine whether the dissociation between overt and covert measures of recognition memory documented in J.S. extends to other frontal patients, stimulus domains, and memory tasks.

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