

Relations Between Source Amnesia and Frontal Lobe Functioning in Older Adults

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A study is reported in which the relations among normal aging, source amnesia, and frontal lobe functioning were explored. Twenty-four older adults (aged 60-84 years) were tested on their ability to remember where they had acquired new factual information; they were also given the Wisconsin Card Sorting Test (WCST), a test of verbal fluency, and other psychometric tests. The degree of source amnesia in this normal sample correlated with age, verbal fluency, and some measures from the WCST. Source amnesia was not related to Performance IQ, however, or to a measure of fact recall. The implications for the relations among aging, memory, and frontal lobe functions are discussed.

There is general agreement that age-related differences in memory are much greater in some tasks than in others (Craik, 1983; Salthouse, 1982). As one example, decrements in memory for specific events (episodic memory) are typically large, whereas the decline in memory for general information (semantic memory) is comparatively slight as people age (Salthouse, 1982). The hallmark of episodic memory is that the person can recollect the time and place of occurrence of the event in question. That is, recollection of a specific episode necessarily involves some retrieval of the temporal and spatial context associated with the event's initial occurrence. If there is a correlation between age and episodic memory, older people might be expected to have greater difficulty in integrating an experienced event with its temporal and spatial context during encoding and also perhaps in recollecting contextual information in the course of retrieval.

The phenomenon of recalling a fact or recognizing a person in the absence of being able to remember where or when the information was originally acquired or experienced has been termed *source amnesia* by Schacter, Harbluk, and McLachlan (1984). They have reported some experimental studies in which amnesic patients were read fictitious statements about well-known and unknown people; some minutes later, the patients were able to answer questions concerning the newly learned facts, but they could not recollect where they had acquired the information. On the basis of further observations, the authors commented that "the overall pattern of results suggests that

some memory-disordered patients—those with signs of frontal lobe dysfunction—have special difficulties remembering the episodes in which information has been acquired" (Schacter et al., 1984, p. 609). Whereas frontal lobe lesions are not usually associated with amnesia (Milner, 1967; Squire, 1987), there is growing evidence for subtler impairments in memory-related processes. For example, Milner (1971) showed that patients with unilateral frontal lesions were impaired in their ability to judge which of two stimuli had been presented more recently. Similarly, Petrides and Milner (1982) found that patients with such lesions exhibited impairments in a task requiring subjects to remember which of a set of 12 repeated stimuli they had pointed to in previous trials. These deficits may be described as a failure to discriminate among prior episodes. The evidence linking frontal lesions to a deficit in episodic processing has been discussed by Schacter (1987) and by Squire (1987). Squire (1987) concluded that "frontal cortex allows information to be remembered in its appropriate context, that is, in the correct temporal order and with accurate reference to other spatially and temporally coincident events" (p. 239). In a recent study by Shimamura and Squire (1987), source amnesia was examined in amnesic patients, and the researchers found a positive (although nonsignificant) relation between the degree of source amnesia and measures of frontal lobe dysfunction. Finally, a study by Tulving, Risberg, and Ingvar (reported by Tulving, 1989) has shown greater frontal lobe activity, as measured by increased cerebral blood flow to that region, during episodic remembering by normal adults.

If normal older people have difficulty in integrating experienced events with their contexts and in retrieving contextual information, they should also show some degree of source amnesia. McIntyre and Craik (1987), using the paradigm developed by Schacter et al. (1984), carried out a study on normal younger and older adults, and they found that older people exhibit considerable source amnesia when tested for new facts acquired in the previous week. There is some evidence, then, that the normal aging process may resemble frontal lobe pathology in that both conditions are associated with a difficulty in inte-

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grating experienced events with their temporal and spatial contexts. Further evidence linking the normal aging process to inefficient frontal lobe functioning can be found in studies of brain anatomy (Squire, 1987), electrophysiology (Woodruff, 1985), and neuropsychology (Albert & Kaplan, 1980; Whelihan & Leshner, 1985).

To summarize, there is strong evidence that normal aging is associated with losses in memory for specific episodic events, suggesting an age-related impairment in the integration of events with their temporal and spatial contexts of occurrence. This impairment results in a degree of source amnesia in older people; in turn, there is evidence linking source amnesia to dysfunctions of the prefrontal cortex. Because there is also evidence that the prefrontal cortex may be particularly vulnerable to the effects of aging, the implication is that "normal" aging is associated with cognitive impairments that are essentially the same as, although milder than, those seen in patients with frontal lobe lesions. The purpose of our study is to present further evidence in support of this conclusion. In particular, the question we asked is whether there is a relation between the degree of source amnesia exhibited by normal elderly people and scores on neuropsychological tests of frontal lobe function.

Method

Participants

Twenty-four older adults participated in the study. They ranged in age from 60 to 84 years ($M \pm SD = 71.3 \pm 6.2$ years). They were home-dwelling community residents who had volunteered to participate in experiments on aging. They had received an average of 12.5 years of education ($SD = 3.7$ years), and their average score on the Mill Hill Vocabulary test was 15.6 ($SD = 2.5$). Twelve of the participants had already been tested in the long-delay condition of Experiment 2 in the study by McIntyre and Craik (1987); they were recalled approximately 6 months after their initial visit and were given the neuropsychological tests described later in this article. Twelve additional participants from the same population were given the neuropsychological tests and the test of source amnesia.

Materials and Procedure

Source amnesia. The paradigm used to assess source amnesia was developed by Schacter et al. (1984) and used by McIntyre and Craik (1987), who have described the method and materials in detail. In summary, the participants were presented with made-up "facts" about 36 public personalities, who were well known, somewhat known, or fictional. In addition, true facts about 24 well-known people were presented. Examples of the statements presented are "Jane Fonda always eats oatmeal for breakfast"; "Ronald Reagan's favorite candies are jelly beans." The 36 made-up facts and 24 true statements were mixed randomly to give a presentation list of 60 items. Half of the statements were presented auditorily, and half were read by the participant, but this feature of the design is not relevant to our investigation and is not discussed further. The statements were presented at a rate of one statement every 10 s.

Retention of the newly acquired facts was tested 1 week later for all 24 participants. The test list consisted of 84 questions; 36 pertained to the original made-up facts, 12 to the original true facts, and 36 to new facts about famous, not-so-famous, or fictional people. Examples are "What does Jane Fonda always eat for breakfast?" "What are Ronald Reagan's favorite candies?" "What is Rosemary Walker's favorite soft

drink?" The various types of question were randomly intermixed. Participants were given the questions on a typed sheet, with each question followed by a space for the answer and a space for the source; that is, participants had to state where they had first learned the fact in question (e.g., television, radio, newspaper, book, or in the experiment). The participants were asked to specify a source for every previously learned item, even if the answer to the question could not be recalled. The test was self-paced.

Wisconsin Card Sorting Test (WCST). This test is used widely in clinical settings to detect cognitive impairments associated with frontal lesions (Stuss & Benson, 1986). In our study, the full, 128-card version with six categories was administered. The measures used were the number of categories attained, the total number of errors, and the number of errors broken down into perseverative and nonperseverative errors. Perseverative errors were scored in accordance with Heaton's (1981) criteria: (a) a response in Categories 2 through 6 that would have been correct in the immediately preceding category; (b) repetitions of the first incorrect unambiguous response in Stage 1 (before the first category is completed); and (c) repetitions of any response after three successive, incorrect, unambiguous matches involving that response.

Verbal fluency test. An impairment in the ability to generate words from a given category is another clinical sign of frontal dysfunction (Stuss & Benson, 1986). In our study, verbal fluency was assessed by asking participants to generate words beginning with the letters *F*, *A*, and *S*. The participant was given three 1-min trials, one trial for each letter. The task was to say as many different words as possible that begin with the given letter.

Wechsler Adult Intelligence Scale-Revised (WAIS-R). To provide a rough measure of general intellectual functioning, the Performance Intelligence Quotient (PIQ) was obtained for each participant with a short form of the WAIS-R. The short form comprised the Block Design and Object Assembly subtests.

Results and Discussion

Two measures of source amnesia were calculated for each participant. The first measure was based on the answers to correctly recalled "facts" (from the 36 newly acquired facts) that were wrongly attributed to some extraexperimental source; the actual measure was the number of such misattributions expressed as a proportion of facts correctly recalled. For example, if a participant correctly recalled 12 of the newly acquired facts, correctly attributed 8 of the answers to the experiment, but erroneously stated that the remaining 4 facts had been acquired elsewhere, the participant's index of source amnesia would be $4/12 = 0.33$. A second measure was calculated to take account of the observation that participants often knew that a question pertained to a statement that had been presented in the experiment, although the participant could not remember the answer to the question. This second measure, referred to as source recognition, was simply the number of the 36 critical questions correctly attributed to the experiment, less the number of new questions (presented for the first time on the test list) wrongly attributed to the experiment. The source recognition measure is thus analogous to the "hits minus false alarms" measure commonly used in studies of recognition memory.

The mean values the participants obtained on the various measures are listed in Table 1. The short form of the WAIS-R yielded a mean PIQ of 110.9. Therefore, we concluded that the sample showed no general intellectual impairment. The participants correctly recalled an average of just more than 7 of the 36 newly acquired facts. The proportion recalled (0.20) is substan-

Table 1
Experimental and Psychometric Measures

Measure	<i>M</i> ± <i>SD</i>
Memory	
Fact recall	7.33 ± 3.13
Source amnesia	0.30 ± 0.36
Source recognition	9.58 ± 5.58
Psychometric test	
Prorated Performance IQ	110.9 ± 12.0
Verbal fluency	39.1 ± 9.4
Wisconsin Card Sorting Test	
Categories	3.4 ± 2.2
Nonperseverative errors	12.0 ± 7.8
Perseverative errors	24.4 ± 14.2
Total errors	36.4 ± 18.5

tially lower than the corresponding value for young adult subjects (0.46) reported by McIntyre and Craik (1987). The amount of source amnesia ranged widely in our sample (0.00–1.00), and the mean value of 0.30 is considerably greater than the value for young subjects (0.07) from the previous study. Scores on the WCST are broadly comparable with the mean scores reported by Heaton (1981) for a group of 15 normal control subjects older than 59 years. Heaton reported the following scores: categories = 4.2, nonperseverative errors = 19.9, perseverative errors = 24.2, and total errors = 44.1. Corresponding scores for 100 normal subjects under 40 years of age were 5.6, 11.2, 10.4, and 21.6 (Heaton, 1981). The most striking difference between the younger and older samples is thus the increase in perseverative errors in the older groups.

The main point of the study was to explore possible relations between liability to source amnesia and measures of frontal lobe functioning. The correlations between the three measures of memory—fact recall, source amnesia, and source recognition—and the various individual difference measures are shown in Table 2. Note that whereas higher scores on source amnesia indicate poorer performance, higher scores on source recognition indicate better performance; the two measures are therefore negatively correlated. Note also that whereas source amnesia and source recognition correlated significantly ($r = -.67$, $p < .001$), neither measure correlated reliably with fact recall ($r = -.29$ for source amnesia, and $r = .19$ for source recognition). Thus, although the two measures of source memory were derived from somewhat different subjective judgments—source amnesia from judgments of where and when the facts had been acquired, and source recognition from whether the questions pertained to statements presented during the experiment—they appear to tap some common ability that is separate from the ability to recollect factual information.

The major question addressed by our investigation, that is, whether the degree of source amnesia shown by normal elderly people is related to scores on tests of frontal function, is answered in the affirmative by the findings that both measures of source memory correlated reliably with verbal fluency, number of categories achieved, total errors, and perseverative errors on the WCST. Furthermore, there is evidence that the source amnesia and frontal dysfunction complex increases with age

within the age range tested (60–84 years) because age correlated reliably with both of the source measures and with perseverative errors ($r = .53$).

The incidence of source amnesia probably reflects more than some general cognitive impairment, because the mean PIQ score was 110 and this measure did not correlate reliably with either source amnesia ($r = -.20$) or source recognition ($r = .27$). Nonetheless, the three measures most clearly related to cognitive performance—vocabulary, years of education, and PIQ—correlate with the source amnesia measures in the direction indicating that source amnesia is associated with lower levels of cognitive training or achievement. Because perseverative errors are those most clearly related to frontal dysfunction (Heaton, 1981, Table 5), the critical correlations from Table 2 are those relating perseverative errors to source amnesia ($r = .42$) and to source recognition ($r = -.43$). Partial correlations between perseverative errors and source amnesia after partialing out the effects of vocabulary, years of education, and PIQ were .46, .38, and .39, respectively; all values remained statistically significant at $p < .05$ with one-tailed tests. Corresponding partial correlations for perseverative errors and source recognition were $-.42$, $-.40$, and $-.40$ for vocabulary, years of education, and PIQ, respectively; again, these values were considered reliable at $p < .05$. Therefore, the relation between mild degrees of frontal dysfunction and source amnesia in an elderly sample does not seem to be secondary to general cognitive inefficiency.

When age is partialled out of the crucial correlations, however, the association weakens. The simple correlation between age and perseverative errors is .53. The partial correlation between perseverative errors and source amnesia, with age eliminated, is .21; the corresponding partial correlation for source recognition is $-.31$. Therefore, within this sample (aged 60–84 years), the older subjects seemed to make more perseverative errors than did the younger subjects, and the older subjects seemed to show the greatest incidence of source amnesia. This result suggests that the normal aging process is associated with a reduction in the efficiency of frontal lobe functioning and that

Table 2
Product-Moment Correlations Between Psychometric Tests and Memory Measures

Variable	Memory measure		
	Fact recall	Source amnesia	Source recognition
Age	-.38*	.49**	-.36*
Mill Hill Vocabulary	.10	-.17	.15
Years of education	.29	-.52**	.46*
WAIS-R	-.32	-.20	.27
Verbal fluency	-.00	-.38*	.48**
Categories	.20	-.55**	.51**
Nonperseverative errors	-.34*	.24	-.11
Perseverative errors	-.40*	.42*	-.43*
Total errors	-.45*	.43*	-.39*

Note. WAIS-R = Wechsler Adult Intelligence Scale-Revised.
* $p < .05$, ** $p < .01$, for one-tailed tests.

this impaired functioning is manifested (in part) as an increased liability to make source amnesia errors.

In this study, there were some clear similarities between the measures of source amnesia and memory for the facts themselves; in particular, both types of memory performance were related to age, and both were related to the incidence of perseverative errors (Table 2). However, direct comparisons showed that fact recall did not correlate reliably with either source amnesia ($r = -.29$) or source recognition ($r = .19$); therefore, we conclude that the incidence of source amnesia does not simply reflect a general memory impairment. The independence of fact memory and source memory confirms the previous reports of Shimamura and Squire (1987).

No young group was included in this study, largely because the incidence of source amnesia errors was very low in a previous experiment (McIntyre & Craik, 1987). Does frontal lobe functioning relate to source amnesia in normal young subjects, or is the age-related impairment in functioning necessary before the relation appears? The finding of no reliable correlation between perseverative errors and source amnesia after age was eliminated favors the latter possibility, but further work is necessary before a definitive answer can be given. Larger individual differences in frontal lobe functioning than those found within a group of undergraduates may be related to differences in memory for source.

In summary, this experiment enabled us to demonstrate substantial source amnesia in a group of normal elderly people and to show that the incidence of source amnesia is associated with measures of frontal lobe dysfunction within this group. The findings are in line with previous reports linking the frontal lobes to spatial and temporal processing and thus to episodic memory; the findings also contribute to the literature linking the normal aging process to impairments in the functioning of the frontal lobes.

References

- Albert, M. S., & Kaplan, E. (1980). Organic implications of neuropsychological deficits in the elderly. In L. W. Poon, J. Fozard, L. Cermak, D. Arenberg, & L. Thompson (Eds.), *New directions in memory and aging* (pp. 403-432). Hillsdale, NJ: Erlbaum.
- Craik, F. I. M. (1983). On the transfer of information from temporary to permanent memory. *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences*, 302, 341-359.
- Heaton, R. K. (1981). *A manual for the Wisconsin Card Sorting Test*. Odessa, FL: Psychological Assessment Resources.
- McIntyre, J. S., & Craik, F. I. M. (1987). Age differences in memory for item and source information. *Canadian Journal of Psychology*, 41, 175-192.
- Milner, B. (1967). Brain mechanisms suggested by studies of temporal lobes. In C. H. Millikan & F. L. Darley (Eds.), *Brain mechanisms underlying speech and language* (pp. 122-145). New York: Grune & Stratton.
- Milner, B. (1971). Interhemispheric differences in the localization of psychological processes in man. *British Medical Bulletin*, 27, 272-277.
- Petrides, M., & Milner, B. (1982). Deficits on subject-ordered tasks after frontal- and temporal-lobe lesions in man. *Neuropsychologia*, 20, 249-262.
- Salthouse, T. A. (1982). *Adult cognition*. New York: Springer-Verlag.
- Schacter, D. L. (1987). Memory, amnesia, and frontal lobe dysfunction. *Psychobiology*, 15, 21-36.
- Schacter, D. L., Harbluk, J. L., & McLachlan, D. R. (1984). Retrieval without recollection: An experimental analysis of source amnesia. *Journal of Verbal Learning and Verbal Behavior*, 23, 593-611.
- Shimamura, A. P., & Squire, L. R. (1987). A neuropsychological study of fact memory and source amnesia. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 13, 464-473.
- Squire, L. R. (1987). *Memory and brain*. New York: Oxford University Press.
- Stuss, D. T., & Benson, D. F. (1986). *The frontal lobes*. New York: Raven Press.
- Tulving, E. (1989). Memory: Performance, knowledge, and experience. *European Journal of Cognitive Psychology*, 1, 3-26.
- Whelihan, W. M., & Leshner, E. L. (1985). Neuropsychological changes in frontal functions with aging. *Developmental Neuropsychology*, 1, 371-380.
- Woodruff, D. S. (1985). Arousal, sleep, and aging. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 261-295). New York: Van Nostrand Reinhold.

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