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Source Memory and Encoding Strategy in Normal Aging*

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ABSTRACT

Of the memory deficits associated with aging, elders are most impaired at attributing the source to remembered information. Additionally, aging is marked by a decrease in the use of encoding strategies that are thought to enhance the acquisition and retention of information. We examined how manipulating the encoding strategy during acquisition affected item and source memory in 32 young and 68 elderly participants. Elderly participants were dichotomized into young-old and old-old based upon the median age (74 years). Memory was assessed using Word List A from the California Verbal Learning Test (CVLT) and its alternate form. Encoding strategy was manipulated by semantic clustering. For the Blocked List, words were presented grouped into their semantic categories, whereas for the Unblocked List categories were intermixed within the list. Item and source memory judgments were made 20 minutes after the final CVLT recall trial and again one week later. Results revealed a disproportionate decline in source, compared to item memory in the two older groups. Semantic blocking enhanced item memory for the elders, but not for the young. The amount of semantic clustering performed by the elders showed a decline with age and was positively related to source performance. Results also suggest that subtle age-related changes in semantic knowledge may be related to declines in semantic clustering and memory performance.

Though memory loss is common among the elderly, aging does not impact all domains of memory equally. For example, researchers have distinguished between remembering the content of information and remembering the context in which it was presented (e.g., Craik & Jennings, 1992). Although the recollection of context is not required for the recollection of content, contextual information has been shown to improve recognition (Graf & Mandler, 1984). Older adults are less adept at monitoring the context of information they have received and are less able to recover the context or "source" of previously experienced events, e.g., temporal context (Fabiani & Friedman, 1997; McCormack, 1982; Trott, Friedman, Ritter, & Fabiani, 1997), spa-

tial context (Parkin, Hunkin, & Walter, 1995), or perceptual context (McIntyre & Craik, 1987) while they are less impaired or are not impaired at all on simple item recognition memory, i.e., in identifying whether an item is old or new (Craik & McDowd, 1987; Fabiani & Friedman, 1997; Trott et al., 1997). A recent meta-analysis demonstrated that the effect size for item recognition memory deficits in aging ($d = 0.57$) was smaller than that for remembering either the stimulus-related context ($d = 0.80$) or spatiotemporal context ($d = 1.17$) of the to-be-remembered material (Spencer & Raz, 1995).

Patients with frontal lobe damage are also impaired in making source judgments (Butters, Kaszniak, Glisky, Eslinger, & Schacter, 1994;

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Milner, Corsi, & Leonard, 1991). Hence, source memory appears to depend upon a frontally-based system (Janowsky, Carper, & Kaye, 1996), whereas item memory appears to depend more upon the medial temporal lobe system (Squire & Zola-Morgan, 1991). Given elders' disproportionate difficulty with source compared to item memory, it appears that age-related memory decline may be due, in part, to frontal lobe dysfunction. This hypothesis is consistent with research reviewed by Salthouse (1990), the results of which suggest that at least some of the effects of cognitive aging can be accounted for by reduced efficiency of working memory, the ability to maintain information "in mind" to use for comparison or for other cognitive operations required by the task. Working memory has been linked to frontal lobe function in both animal and human studies (e.g., Goldman-Rakic, 1992; Moscovitch, 1994).

In addition to deficits in source memory, elders also show a decline in the use of meta-cognitive strategies to assist in memory performance (Sanders, Murphy, Schmitt, & Walsh, 1980; Witte, Freund, & Brown-Whistler, 1993). In fact, memory training programs aimed at elder populations focus primarily on increasing the use of mnemonic techniques and encoding strategies to enhance the acquisition and retention of new information (for a meta-analysis, see Verhaeghen, Marcoen, & Goossens, 1992). Deficits in working memory may partly account for this decline, as some meta-cognitive strategies rely on working memory. For example, semantic clustering is a commonly used strategy to aid in the encoding and recall of a list of semantically related words. Semantic clustering requires the individual to actively re-order items into their semantic grouping, while simultaneously holding the list items in mind. This, by definition, involves working memory. In addition to working memory, semantic clustering involves semantic knowledge to be able to identify the relationship between items within a category, and the ability to use abstract reasoning to identify the superordinate category in which items should be categorized. Thus, failure to use semantic clustering may reflect impairment in working memory and/or in semantic knowledge.

In the current study, we examined how semantic clustering related to source memory in aging. Processing demands of a word list learning task were manipulated by presenting one list of words already blocked into semantic categories and a second list of words intermixed, i.e., not blocked into semantic categories. Subsequently, participants performed free recall, as well as item and source recognition judgments, of words from the studied lists. Since elders are less apt than younger participants to implement encoding strategies like semantic clustering, we predicted that they would benefit more from the semantic blocking than the younger participants.

Source memory tests are typically performed in the context of item recognition judgments. That is, participants are first asked to recognize items as old or new and then asked to identify the source from which the old items originated. The rationale for this is that one must first recognize that an item has been encountered before determining the context of that encounter. However, in this manner, source judgments are dependent upon (1) intact item memory; (2) intact source memory; and (3) intact processes that bind together item and source (Chalfonte & Johnson, 1996). Since this method confounds age-related changes in source memory with age-related changes in item-memory, it seems judicious to explore means of assessing source memory independently of item memory. To this end, the current study used separate tests of item and source memory.

Further, memory for item is often tested with a yes/no recognition test, whereas memory for source is tested with a cued recall test. Studies have shown that cued recall is generally more difficult than recognition (Craik & McDowd, 1987; Light & LaVoie, 1993). Thus, the disproportionate decline in source memory may be due, in part, to the different methods used to assess item and source memory. In the current study, in order to evaluate age-related changes in item and source memory more equitably, item and source recognition were assessed using the same type of recognition test.

In addition to the item and source memory tests, we administered tests of working memory and semantic knowledge to explore how they

relate to semantic clustering and source memory. We hypothesized that the reported decline in meta-cognitive strategies, like semantic clustering, is related to changes in working memory function. Thus we predicted that scores on the working memory tests would correlate positively with both the amount of effortful semantic clustering performed by the older participants and their overall source memory performance.

METHOD

Participants

Thirty-two young and 68 elderly individuals participated in the study. To further examine the effects of aging, elderly participants were dichotomized into two groups (young-old and old-old) based upon the median age of 74 years. Elder participants were recruited from our ongoing, studies of aging and dementia in the Washington Heights and Inwood communities of New York City. As part of that study, we developed a registry of individuals unaffected by dementia. Sources of the participants included regional medical facilities, nursing homes serving local residents, a state agency list of home care recipients, and senior centers. As part of the larger study, elderly participants were evaluated by a neurologist and completed neuropsychological testing prior to their enrollment in the current study. Those who demonstrated significant cognitive impairment on the neuropsychological battery from the registry were excluded from participation in the current study, as were individuals with known or suspected neurologic or psychiatric condition that might affect cognition. Young participants were volunteers re-

sponding to flyers posted around the campus of Columbia-Presbyterian Medical Center and Columbia University. The majority of young participants were undergraduate students at Columbia University. The institutional review board approved this project, and all participants provided written informed consent.

Demographic characteristics of the participant groups are provided in Table 1. Participants' IQ scores were estimated from abbreviated versions of selected subtests (Information, Vocabulary, and Similarities) of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Satz and Mogel, 1953). In order to eliminate group differences in total years of education and estimated IQ between the young and old participants, only elders with at least 12 years of education were included in the current analyses.

Procedures

All participants were administered two 16-item word lists (Monday List and Tuesday List) in a single test session, each list consisted of sixteen words (four words from each of four semantic categories). One list was presented with words blocked into their semantic categories, the other with categories intermixed. The order of presentation of the word list and list condition was counter-balanced across participants. For each list, memory testing consisted of five immediate recall trials and a 20-minute delay recall (recall data have been presented elsewhere – see Jacobs et al., submitted). Non-memory cognitive tests were administered during the 20-minute delay. The administration of the 20-minute delayed recall of the Monday List was followed by a 15-minute break. Then, the five immediate recall trials of the Tuesday List were administered, in addition to the 20-minute delayed recall. Following the delayed recall of the Tuesday

Table 1. Demographic Profiles of the Three Groups.

	Young (<i>n</i> = 24) <i>M</i>	Young-Old (<i>n</i> = 23) <i>M</i>	Old-Old (<i>n</i> = 24) <i>M</i>
Age	22 (17-30)	71 (63-73)	79 (74-87)
Education	15 (12-20)	14 (12-20)	14 (12-18)
Estimated IQ*	124 (88-150)	117 (86-150)	119 (88-150)
% Caucasian	50%	61%	75%

*IQ scores were estimated from selected subtests (Information, Vocabulary and Similarities) of the Wechsler Adult Intelligence Scale-Revised.

list, an Item Recognition Test and a Source Recognition Test were administered (see below). One week later incidental recall, item recognition, and source recognition tests were repeated; participants were not informed that they would be required to remember the lists for their follow-up visit.

Neuropsychological Measures

Memory was assessed using List A of Form I from the standard California Verbal Learning Test (CVLT) and List A of Form II of the alternate form of the CVLT (Delis et al., 1991). These two lists are frequency matched, and have been shown to yield equivalent mean scores on all learning and memory variables (Delis et al., 1991). No interference lists were administered. Presentation of words in the Unblocked condition was in the same order as the standard administration of the CVLT. For the Blocked condition, words were grouped into their semantic categories and presented in the following order: Tools, fruits, spices then clothing for Form I of the CVLT; office supplies, vegetables, desserts, then sporting equipment for Form II. Standard procedures were used for the 5 learning trials. Briefly, participants were told that they would be read a list of items to buy while shopping. They were asked to listen carefully, and recall as many items from the list as possible. They were not told how many items were on the list, that the words could be organized into four categories, that they should try to categorize the words into semantic categories or that they would have to remember the source of the items (Monday or Tuesday) for a later test. This procedure was repeated for the five immediate recall trials. After completion of Trial 5, participants were told to try to remember the word list, because they would be asked to recall it again in a little while. Delayed recall of the word list, item recognition, and source recognition were assessed after 20 minutes.

The Item Recognition Test consisted of 64-words; half of the words appeared in one of the two lists, half were new foils. Half of the foils were semantically related to the target items; half were unrelated. A performance measure of item recognition was calculated as the total number of correctly identified words (as being either old or new) minus the total number of incorrectly identified foils.

Source recognition was assessed independently of item recognition. The Source Recognition Test consisted of the 32 words from the two lists. Participants made forced-choice judgments, indicating whether words came from the Monday or Tuesday list. Source recognition scores were calculated as

the total number of items correctly attributed to the list from which they originated.

In this particular source task, it is possible to determine the source of the individual items based on their semantic category. Since all the Monday items belonged to four semantic categories and all the Tuesday items belonged to four distinct semantic categories, one only need remember the four categories on the Monday list to correctly identify the 16 individual items on that list. To examine whether recognized source items tended to cluster within a semantic category, semantic cluster scores were calculated from the source recognition data using the following formula (note: this formula is generally applied to free recall data – see appendix C of CVLT manual; Delis, Kramer, Kaplan & Ober, 1987).

$$SEM = \sum (T_n(T_n - 1) / MX)$$

Where T_n is the number of words attributed to the correct list from category type n , and MX is the total number of words attributed to the correct list overall. Higher semantic cluster scores indicate more semantic clustering, with a maximum cluster score of 3.0. If individuals use the semantic categories to inform their source performance, then the source of items within one semantic category should be either correctly or incorrectly identified together. For example, if one remembers that Fruits were on the Monday list, then all the fruits should be correctly attributed to Monday. However, if one mistakenly remembers and places the Fruits on the Tuesday list, then all of the fruits should be incorrectly attributed to Tuesday. In this way, semantic clustering can be independent of source memory performance. One may keep items together within their semantic category and achieve a high semantic cluster score, and still misattribute the list from which the items originated, thus achieving a low source memory score.

Tests of working memory included digit span, number reordering and subtraction span. Digit span forward and backward were administered using the standard instructions of the Wechsler Adult Intelligence Scale – Revised (Wechsler, 1981). Number re-ordering required participants to repeat a series of numbers after rearranging them in numerical order from lowest to highest. For digit subtraction span, participants were read a series of digits and asked to subtract 2 from each during recall (Salthouse, 1990).

A 15-item short form of the Boston Naming Test and a category fluency test (animals, clothing, vegetables; 60 sec for each category) were admin-

istered as measures of naming ability and semantic knowledge.

Statistical Methods

Item and Source Recognition scores were submitted to a $3 \times 2 \times 2$ mixed factors ANOVA, with GROUP (young, young-old, and old-old) as the between-subjects factor and TIME (20-minute delay, 1-week delay) and BLOCKING (blocked, unblocked) as the within-subject factors. Post-hoc comparisons were conducted using a Bonferroni-corrected p value of 0.05.

Semantic Cluster scores were analyzed similarly; however, we excluded the young participants for the following reason. The young maintained source recognition scores at or near ceiling for both the 20-minute and 1-week delays. When all the items are attributed to the correct list, all the items within a semantic category are by default clustered together. As such, a ceiling source recognition performance results in a perfect semantic cluster score. However, in cases of ceiling performance, a perfect semantic cluster score does not necessarily imply the use of a semantic strategy. It is possible that all the items were judged correctly, but independently, without reference to their semantic categories. Since the young performed at or near ceiling on the source recognition test, analysis of their semantic cluster scores would not help to reveal whether they used a semantic strategy or not.

Step-wise regression analyses were used to assess which cognitive tasks were associated with semantic clustering scores and source recognition performance. Stepwise forward entry into the equation was based upon a probability for entry of $p < .05$ and a probability for removal of $p > .10$.

RESULTS

As shown in Table 2, item recognition performance was high for all three groups at the 20-minute delay (89%-99%). An interaction between Time and Group showed that performance at the 1-week delay decreased for the two older groups, but not the young participants [$F(2, 66) = 11.1, p < .001$]. At both delays, performance of the young participants was significantly better than the two older groups [$F(2, 66) = 20.7, p < .001$]. Between the two older groups, decline in item recognition over time was most conspicuous in the scores of the old-old. Post-hoc tests revealed differences between the two older groups such that the young-old outperformed the old-old at the 1-week follow-up ($p < .05$), but not at the 20-minute delay.

Since young individuals are more likely to spontaneously use clustering as an encoding strategy, we predicted that the blocking manipulation would disproportionately enhance the performance of the old participants. This prediction was confirmed in an Age $\times$ Blocking interaction [$F(2, 66) = 3.1, p = .05$]. Whereas young participants performed equally on item recognition across the two blocking conditions, old participants tended to do worse in the unblocked condition compared to the blocked condition. A main effect of Blocking, driven by the two older groups, was also significant [$F(1, 66) = 5.4, p < .05$].

Table 2. Performance on the Item and Source Recognition Tests.

	Delay	Young ($n = 24$)				Young-Old ($n = 23$)				Old-Old ($n = 24$)			
		Blocked		Unblocked		Blocked		Unblocked		Blocked		Unblocked	
		<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)
Item	20-minute	31.6	(0.6)	31.8	(0.5)	30.7	(1.7)	29.7	(2.1)	30.1	(2.2)	28.9	(3.6)
	1-week	30.2	(1.6)	30.3	(1.3)	26.8	(3.0)	27.0	(2.6)	24.7	(4.3)	23.9	(4.2)
Source	20-minute	15.8	(0.4)	15.9	(0.3)	13.5	(2.5)	13.2	(3.1)	11.1	(4.4)	11.6	(4.2)
	1-week	15.4	(1.1)	15.5	(1.1)	11.1	(3.6)	11.1	(2.8)	9.2	(4.1)	11.0	(3.3)

Note. Total possible for each condition is 32 for item memory and 16 for source memory.

As shown in Table 2, young participants scored nearly at ceiling on the source recognition task at both the 20-minute and 1-week delays, significantly outperforming both older groups [$F(2, 65) = 45.3, p < .001$]. Source recognition of the old-old was particularly impaired. In fact, at the 1-week delay, their performance in the blocked condition was not significantly better than chance [$t(23) = 1.43, p > 0.10$].

A Time $\times$ Age interaction [$F(2, 65) = 7.67, p = .001$] revealed that the young-old correctly identified the source of more items than the old-old at the 20-minute delay ($p < .01$), but not at the 1-week delay ($p > .10$). Unexpectedly, the effects of blocking were not significant for the source recognition task, suggesting that presenting the words in semantically blocked lists did not affect source recognition for any of the three groups.

We next examined the extent to which the two older groups used the semantic categories to organize their source judgments. Semantic cluster scores in the elders ranged widely (1.4–3.0), thus not reflecting a consistent use of the semantic categories. The mixed-factors ANOVA on semantic clustering revealed an Age $\times$ Time interaction [$F(1, 41) = 4.04, p = .05$] whereby the young-old had higher semantic cluster scores than the old-old at the 20-minute, but not the 1-week delay. The relationship between semantic

clustering and age was confirmed by a correlational analysis, which revealed a strong negative relationship between the amount of semantic clustering performed and the participant's age [$r(44) = -0.481, p < .01$]. Surprisingly, the effect of Blocking was not significant suggesting that presenting the lists in semantically blocked categories did not facilitate the use of a semantic strategy in completing the source recognition task.

We next examined the relationship between semantic clustering and source recognition performance in the elders. Figure 1 illustrates that semantic clustering was positively related to source recognition. This was true for the blocked condition in both the young-old [$r(22) = 0.589, p < .01$] and the old-old [$r(23) = .589, p < .01$] and for the unblocked condition in both the young-old [$r(22) = 0.747, p < .001$] and the old-old [$r(23) = .576, p < .001$]. The magnitude of the correlations between the blocked and unblocked conditions or between the young-old and the old-old did not differ.

Finally, we tested whether the amount of semantic clustering performed by the elders in the sample and/or their source recognition performance related to our other neuropsychological tests, which tested working memory, semantic knowledge and naming ability. Performance for the three groups on the non-memory tests is reported in Table 3. Regression analyses revealed

Fig. 1. Depiction of the positive linear relationship revealed between semantic cluster and source memory scores for the blocked and unblocked list conditions in both groups of elders.

that category fluency was the only measure to provide an independent contribution to the prediction of the semantic clustering scores both at the 20-minute delay ($\beta = .670, p < .001$) and the 1-week delay ($\beta = .430, p = .01$). A similar pattern evinced for source recognition scores at the 20-minute delay ($\beta = .525, p = .001$) and the 1-week delay ($\beta = .516, p = .01$). Since category fluency taps both executive and semantic function, interpreting which function was associated with source recognition on this task was not readily discernable. To further explore this differential, a second set of regression analyses was conducted excluding the category fluency factor. Of the remaining tests, the Boston Naming Test significantly predicted semantic clustering scores at the 20-minute delay ($\beta = .464, p < .01$), with Digit Subtraction Span making a further significant contribution in the model ($\beta = .329, p < .01$). No test scores were predictive of semantic clustering scores at the 1-week delay. For source recognition performance at the 20-minute delay, only the Boston Naming Test was significantly predictive ($\beta = .375, p < .03$). No test scores were predictive of source performance at the 1-week delay.

DISCUSSION

Our results confirm the deleterious effects of aging on source memory. As has been shown in previous studies in which source judgments were dependent on correct item recognition (e.g., Fabiani & Friedman, 1997; Trott et al., 1997), we found a significant reduction in source memory in the elderly using a source test that was independent of the participants' item performance. Further, our result confirms deficits in source memory with age even when source memory is assessed using a less demanding yes-no recognition format instead of the commonly-used cued recall format (Chalfonte & Johnson, 1996). Despite these methodological efforts to facilitate source memory performance, aging effects for source memory ($d = 2.86$) were still twice as large as the aging effects revealed for item memory ($d = 0.98$). This pattern of result is consistent with the aging literature (Craik & Jennings, 1992; Spencer & Raz, 1995), although the size of these effects appears larger than is typically reported. The inflated effect sizes reported here are primarily due to the reduced variance of the young participants, who generally performed near ceiling on both item and source recognition tasks.

Table 3. Test Scores on Non-Memory Tests for the Three Participant Groups.

	Young (<i>n</i> = 24)		Young-Old (<i>n</i> = 23)		Old-Old (<i>n</i> = 24)	
	<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)
Digit Span Forward (raw score)	7.8	(1.1)	6.4	(1.2)	6.0	(1.1)
Digit Span Backward (raw score)	6.1	(1.3)	4.6	(1.1)	4.5	(1.2)
Digit Span Reordering (raw score)	4.3	(0.9)	3.7	(0.9)	3.6	(0.7)
Digit Span Subtraction (raw score)	6.1	(1.4)	4.6	(1.1)	4.1	(1.0)
Category Fluency (sum over 3 trials)	59.2	(10.5)	49.5	(11.9)	44.8	(11.3)
Boston Naming Test (Total correct)	14.3	(0.5)	14.2	(1.3)	13.0	(2.3)

Results provided tentative confirmation of the effects of our blocking manipulation on item recognition memory. We predicted that presenting list items in a semantically blocked format would differentially benefit the old participants, who are less likely to implement mnemonic strategies, like semantic clustering, on their own. Whereas young participants' item recognition memory was equivalent across the two blocking conditions, elders, especially the old-old, performed better when the lists were presented in a semantically blocked format. One potential confound in interpreting the interaction between Age and Blocking Condition derives from the high performance of the young participants. For both conditions, they performed nearly perfectly (96.5% for the blocked list, 97.0% for the unblocked list). It is possible that scores for the young may have varied by blocking condition if a more difficult task, e.g., a longer list, had been administered. We return to this issue later in the discussion.

For the elders, presenting the words in a semantically blocked format tended to improve their item recognition ability, especially at the 20-minute delay. These results are consistent with our expectations and are consistent with the recall data collected during this experiment (see Jacobs et al., submitted). On the free recall test, both young and old participants benefited from the semantic blocking. However, the benefit of blocking was equivalent across the age groups. Again, it is possible that the item recognition results would have replicated the recall results more closely had the young participants not attained ceiling effects in their recognition performance.

The relationship between strategy use and age was explored directly in the analyses of the semantic clustering data. Results showed a negative correlation between age and the amount of semantic clustering employed, indicating a significant drop in semantic clustering in the older participants. This is consistent with past research showing a decline in the use of mnemonic strategies amongst elders (Witte, Freund, & Brown-Whistler, 1993). Importantly, the amount of semantic clustering correlated positively with performance on the source memory

task (Fig. 1), suggesting that those who implemented a semantic clustering strategy were better able to remember the source of the words on the two lists. This result supports findings in the memory training literature, which show that memory performance can be enhanced in elders when meta-cognitive strategies, like semantic clustering, are employed (for meta-analysis, see Verhaeghen, Marcoen, & Goossens, 1992).

Despite the correlation between semantic clustering and source performance, the semantic blocking manipulation used in the task had no measurable effect on participants' performance on the source recognition task. Scores across the semantically blocked and unblocked lists were nearly identical in all three groups. This dissociation in the pattern of results for the item and source recognition memory tests supports evidence from clinical populations (e.g., Janowsky, Shimamura, & Squire, 1989; Taylor, Saint-Cyr, & Lang, 1990) and other gerontological studies (Spencer & Raz, 1995) showing that different memory mechanisms are involved in recalling "what" you encounter, compared to recalling "when" or "where" you encountered it.

Results of the regression analyses failed to support our hypothesis that the decline in use of mnemonic strategies seen in aging is due to a decline in working memory function. Only one of the working memory measures, Digit Span Subtraction, made a contribution to the prediction of semantic cluster scores at the 20-minute delay, and no working memory measures were related to source memory performance. Alternatively, category fluency and naming were consistently and strongly related to both semantic clustering and source memory performance. Performance on tests of verbal fluency and naming also show an age-related decline (Spreeen & Strauss, 1998), though the effect is more subtle than that seen in age-related source memory decline. Although no causal relationship can be inferred from these data, the regression analysis suggests that the decline in semantic clustering is more closely related to changes in semantic knowledge rather than processing limitations in working memory. Several studies have suggested that the structure of semantic knowledge breaks down in patients with Alzheimer's dis-

ease (Chan et al., 1993; Hodges, Salmon, & Butters, 1992; Smith, Murdoch, & Chenery, 1989). Less is known about the changes in the organization of semantic knowledge with normal aging. It is possible that subtle changes in semantic knowledge occur with aging and are related, as in this study, to memory abilities. This possibility should be tempered by noting that the memory task used in the current study included a significant semantic component. As such, results may not generalize to other non-semantic memory tasks. In other words, working memory, in addition to or instead of semantic knowledge, may predict the use of mnemonic strategies in tasks that do not rely as heavily on semantic processes.

One important aspect of the results limits somewhat the conclusions that can be made from these data. As mentioned earlier, extremely high and low performance levels were noted on the source memory recognition task. While the young participants scored nearly perfectly at both the 20-minute and 1-week delay, the old-old participants were near chance levels at both delays, and not different than chance at the 1-week delay for the blocked words. A prevailing obstacle in the aging literature involves developing tasks that elders are capable of completing, but which also challenge younger participants. Ceiling effects reported here in the young attenuate the range of performance they are likely capable of and thereby diminish the size of the group differences that exist. As such, these effects impede proper group comparisons and highlight the importance of careful task selection in studies that include both young and old participants.

In summary, our results confirm that elders' ability to identify the source of remembered information shows a disproportionate decline in aging compared to their ability to remember information content. In this study, source memory ability was significantly related to use of semantic clustering, a meta-cognitive strategy that also showed an age-related decline. Both the use of semantic clustering and source memory performance were related to tests of semantic knowledge, and not tests of working memory, suggesting that age-related declines reported on certain

verbal memory tasks may be related to changes in the structure of semantic knowledge, in addition to or instead of a reduction in information processing resources.

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