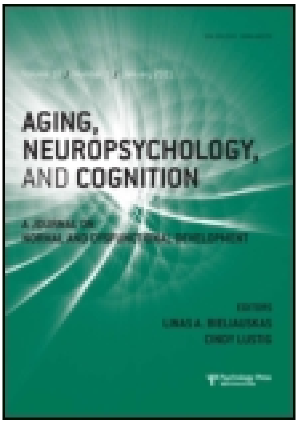

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Semantic encoding enhances the pictorial superiority effect in the oldest-old*

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ABSTRACT

We examined the effect of a semantic orienting task during encoding on free recall and recognition of simple line drawings and matching words in middle-aged (44–59 years), older (60–89 years), and oldest-old (90+ years) adults. Participants studied line drawings and matching words presented in blocked order. Half of the participants were given a semantic orienting task and the other half received standard intentional learning instructions. Results confirmed that the pictorial superiority effect was greater in magnitude following semantic encoding compared to the control condition. Analyses of clustering in free recall revealed that oldest-old adults' encoding and retrieval strategies were generally similar to the two younger groups. Self-reported strategy use was less frequent among the oldest-old adults. These data strongly suggest that semantic elaboration is an effective compensatory mechanism underlying preserved episodic memory performance that persists well into the ninth decade of life.

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The pictorial superiority effect (PSE) refers to the finding that concrete items are better remembered when presented in a pictorial format than in a verbal format. Prior research confirms the reliability and generality of the PSE across a variety of populations, including children and adolescents (Whitehouse, Maybery, & Durkin, 2006), college students (Toglia, Hinman, Dayton, & Catalano, 1997; Snodgrass & Asiaghi, 1977), healthy older adults (Park, Puglisi, & Sovacool, 1983; Rissenberg & Glazner, 1986), and oldest-old adults (Cherry et al., 2008). Other evidence has shown that persons with mental retardation show a PSE, as do their normal intelligence counterparts (Cherry, Applegate, & Reese, 2002). PSE's are also observed when pictures and words are used as stimuli in studies of implicit and explicit retrieval processes (Weldon & Roediger, 1987); false recognition (Dodson & Schacter, 2002); and brain activity during episodic remembering (Springer, McIntosh, Winocur, & Grady, 2005).

Paivio's (1971) dual-coding theory is prominent among the early theoretical accounts of the memorial advantage of pictures relative to their verbal referents. Based on this view, pictures can be dually represented in memory by visual and verbal codes, whereas words are represented primarily by verbal codes. Pictures are better remembered than words, on the assumption that two codes are better than one. An alternative explanation for the memorial efficacy of pictures is that the sensory codes for pictures are richer than

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those of words, leading to a more differentiated representation that is less susceptible to interference (Nelson, Reed, & Walling, 1976). More recently, it has been suggested that pictures benefit from greater conceptual processing than do words (Stenberg, 2006). Whether code redundancy, a richer sensory representation of items in picture format, or enhanced conceptual processing of pictures accounts for the PSE is a matter of theoretical interest and debate (Mintzer & Snodgrass, 1999; Paivio, 1991). The finding that pictures are better remembered than words is also a matter of practical importance, as pictures may be useful in educational contexts to aid in retention of written material (Cherry, Park, Frieske, & Smith, 1996).

The primary objective of the present research was to examine the contribution of semantic encoding processes to memory for pictures and words in middle-aged, older, and oldest-old adults. Cherry et al. (2008) has demonstrated that oldest-old adults (age 90+ years) show a pictorial superiority advantage in free recall and recognition. These data were interpreted to suggest that nonagenarians utilize nonverbal memory codes to support long-term retention as effectively as do younger reference groups. In this study, we focus on semantic encoding as a compensatory mechanism for age deficits in episodic memory based on the assumption that the PSE reflects enhanced conceptual processing of pictorial stimuli. If the memorial advantage of pictures is primarily driven by enhanced conceptual processing at encoding as Stenberg (2006) suggests, then one would expect to observe a larger PSE with an orienting task that prompts semantic elaboration of the to-be-remembered stimuli relative to a control condition without explicit reference to the semantic properties of the memory stimuli. This hypothesis was tested in the present research using a semantic orienting task where participants identified the taxonomic category membership of the to-be-remembered stimuli during acquisition. Of greater interest is whether very old adults will show a memorial benefit of semantic encoding compared to younger reference groups. Prior research confirms that oldest-old adults benefit from task-relevant memory support in the form of prior knowledge (Wahlin et al., 1993) and retrieval cues (Bäckman & Larsson, 1992; Bäckman & Wahlin, 1995), suggesting that even very old adults may use semantic information in support of episodic remembering. Given the well-documented age sensitivity in episodic remembering in late life, oldest-old adults may benefit as much as or possibly more than their younger counterparts from enriched semantic encoding of the to-be-remembered material.

Our second objective in the present research was to provide direct new evidence concerning the processing strategies participants may use to help them remember the pictures and words. In Cherry et al.'s (2008) study, follow-up analyses of clustering in free recall revealed that a greater number of taxonomic categories were accessed (*assumed to reflect participants' retrieval plan*) and more items were recalled per category (*assumed to reflect* *participants' encoding strategy*) when pictures served as stimuli compared to words (see also Bäckman & Wahlin, 1995). These clustering indices were proportional for the nonagenarians compared to the other age groups, although the absolute level of performance was somewhat lower for the oldest-old, as expected. Based on these findings, Cherry et al. suggested that nonagenarians engage in qualitatively similar organizational strategies in support of recall as do the younger age groups. However, self-reports of strategy use during the free recall task were not solicited in their study, which would have provided valuable information on potential age group differences in strategic encoding and retrieval processes. In the present research, we solicited post-experimental verbal reports to provide new evidence on the ways participants went about remembering the pictures and words. Analyses of clustering in free recall were also conducted to demonstrate the reliability and generality of our prior findings.

To summarize, we expected to observe PSEs in free recall and recognition of a similar magnitude across age groups. Of greater interest is whether the nonagenarians benefit from the semantic orienting task during encoding in a manner similar to their younger counterparts. Based on prior research (Bäckman & Larsson, 1992; Bäckman & Wahlin, 1995; Wahlin et al., 1993), we expected that the semantic encoding manipulation would enhance recall and recognition of pictures and words for all age groups. Such a pattern of outcomes would confirm Cherry et al.'s (2008) earlier findings and extend them to show the mnemonic benefit semantic elaboration in episodic remembering well into the ninth decade of life. Analyses of clustering in free recall, together with post-experimental verbal reports, were expected to provide new evidence on the strategic processes participants use in support of episodic memory.

METHOD

Participants

In all, 160 individuals participated in the study. There were 48 middle-aged adults ($M = 51.3$ years, $SD = 4.1$, age range 44–59 years), 64 older adults (($M = 71.8$ years, $SD = 8.1$, age range 60–89 years) and 48 oldest-old adults ($M = 91.2$ years, $SD = 1.6$, age range 90–96 years). All were enrolled in the Louisiana Healthy Aging Study (LHAS), a multidisciplinary study of the determinants of longevity conducted in collaboration with LSU Health Sciences Center in New Orleans, Tulane University School of Medicine, the University of Alabama at Birmingham, and the Pennington Biomedical Research Center in Baton Rouge, LA. LHAS participants were sampled randomly from the Voters Registration 2000 files for those age 20–64 years old and from the Medicare Beneficiary Enrollment Data file of the Center for

Medicare and Medicaid Services (CMS) for those age 65 years and older for the eight parishes (counties) constituting the Greater Baton Rouge community. Informed consent was obtained for all participants according to protocols approved by the respective institutional review boards. All participants in this study were visually capable and free of neurological impairment due to stroke or adult dementia. All scored at least a 25 or higher on the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975). Table 1 presents a summary of the individual difference and self-reported health characteristics of the sample.

We conducted one-way ANOVAs and χ^2-tests of independence (when indicated) on the individual difference data with age group as a between group factor. An ANOVA on the MMSE scores yielded a significant age group effect, $F(2, 155) = 22.05$, $MSE = 1.85$, $p < .0001$. Pairwise comparisons (Tukey) confirmed that the oldest-old adults' mean MMSE score was lower than the three comparison groups' scores ($p < .0001$ for each comparison, see Table 1). A short-form of the Wechsler Adult Intelligence Scale (WAIS) Vocabulary subtest (Jastak & Jastak, 1965) was given as a measure of verbal intelligence. Analyses of the vocabulary scores yielded a significant age group effect, $F(2, 154) = 4.77$, $MSE = 56.24$, $p = .01$. Analyses of the Geriatric Depression Scale (GDS; Sheikh & Yesavage, 1986) yielded a nonsignificant age group effect. The majority of the sample (92.5%) was within the normal range at the time of testing, with GDS scores well below the score of 6 representing mild depression.

The Forward Digit Span (FDS) and Backward Digit Span (BDS) tests from the WAIS (Wechsler, 1981) and the Size Judgment Span (SJS) test (Cherry, Elliott, & Reese, 2007) were administered to assess participants' ability to simultaneously hold and process auditorily presented information.[1] The SJS test involves the manipulation of visuospatial information. Participants hear progressively longer sequences of individual words whose referents can be easily visualized (e.g., frog-piano-hairpin). They repeat the sequence of words in order of the referents' relative physical size, from the smallest to the largest item (e.g., hairpin-frog-piano). Means appear in Table 1. An ANOVA on the FDS scores yielded a significant effect of age group, $F(2, 157) = 4.49$, $MSE = 0.95$, $p = .01$. Pairwise comparisons confirmed that the span estimate for the middle-age adults was significantly higher than that of the oldest-old adults ($p < .01$) who did not differ from the older group. An ANOVA on the BDS scores yielded a nonsignificant age group effect ($p = .06$). An ANOVA on the SJS scores yielded

[1]Digit span tests were scored by giving full (set size) credit for sequences where both of the two trials were correct and half credit if only one trial per set size was correct. The SJS test was scored by giving full credit to sequence levels where at least two out of three trials were correct and half credit if only one of three trials was correct.

TABLE 1. Summary of individual difference characteristics

	Middle-age			Older			Oldest-old		
	%	*M*	*SD*	%	*M*	*SD*	%	*M*	*SD*
Age		51.29	4.06		71.8	8.13		91.21	1.58
MMSE[a]*		28.83	1.35		28.64	1.25		27.17	1.49
Vocabulary[b]*		25.54	7.71		25.63	7.1		21.58	7.8
GDS[c]		2.27	3.09		1.64	2.08		2.29	2.45
FDS[d]*		6.05	0.89		5.72	0.97		5.46	1.06
BDS[d]		4.45	1.15		4.22	0.95		3.93	1.09
SJS[e]*		4.54	0.77		4.09	0.68		3.58	0.65
Years of Education									
High school	2.08			4.69			14.58		
<High school	18.75			18.75			25.00		
Partial college or training	31.25			37.5			31.25		
College degree	25.00			25.0			14.58		
Graduate degree	22.92			14.06			14.58		
Health at the present time									
Excellent	18.75			25			18.75		
Good	60.42			51.56			66.67		
Fair	16.67			23.44			14.58		
Poor	4.17			0			0		
Health prevents activities									
Not at all	52.08			42.19			33.33		
A little/some	39.58			43.75			47.92		
A great deal	8.33			14.06			18.75		
*Health compared to others**									
Better than	41.67			73.02			83.33		
The same as	43.75			22.22			16.67		
Worse	14.58			4.76			0		
Clubs and social organizations									
None	18.75			4.69			8.33		
Between 1 and 3	72.92			76.56			72.92		
Between 4 and 6	2.08			14.06			14.58		
More than 6	6.25			4.69			4.17		
*Hours per week spent outside**									
None	0			0			6.25		
Between 1 and 5	2.13			17.19			20.83		
Between 6 and 9	10.64			18.75			39.58		
Between 10 and 19	17.02			17.19			12.50		
More than 19	70.21			46.87			20.83		
*Social support**									
Very satisfied	40.43			73.44			81.25		
Fairly satisfied	34.04			26.56			18.75		
A little satisfied	14.89			0			0		
Not satisfied	10.64			0			0		
Confidant*	91.67			93.75			72.92		

Notes: [a]Mini-Mental State Exam (Folstein et al., 1975). [b]Vocabulary (Jastak & Jastak, 1965). [c]Geriatric Depression Scale (Sheikh & Yesavage, 1986). [d]From the Wechsler Adult Intelligence Scale (Wechsler, 1981). [e]From Cherry, Elliott, and Reese (2007).
$^{*}p < .01$ from χ^2-test.

a significant effect of age group, $F(2, 157) = 22.65$, $MSE = 0.49$, $p < .0001$. Pairwise comparisons confirmed that the middle-aged adults' mean span estimate was significantly greater than the older and oldest-old adults' span estimate ($p \leq .001$ for both). Similarly, the older adults' mean span exceeded that of the oldest-old adults ($p < .001$). Together, the results of these analyses confirm that only the SJS test empirically discriminated the three age groups, replicating Cherry et al. (2008).

The association between educational attainment and age group was non-significant by χ^2-test ($p = .24$). Participants' responses to three self-perceived health questions from the Older American Resources and Services Multidimensional Functional Assessment Questionnaire (Duke University Center for the Study of Aging and Human Development, 1975) indicated that most were generally in good health. Analyses of the health ratings yielded non-significant associations for age group and health at the present time ($p = .25$) and health prevents activities ($p = .37$). For health compared to others, the oldest-old rated their health as better than their age mates more often than did the younger groups ($p = .0001$). Analyses of the social activity ratings yielded a non-significant association for age group and the number of clubs and social organizations ($p = .10$). For the number of hours per week spent outside of the home, the middle-age group reported more hours per week spent outside of their home compared to the other groups ($p < .0001$). For satisfaction with social support they receive for dealing with day to day problems, the middle-age adults' social support ratings were lower than the other groups' ratings ($p < .0001$). Participants indicated whether they had a confidant, described as someone they can talk to about issues that concern them. For the confidant ratings, the oldest-old adults reported having a confidant less often compared to the other two age groups ($p = .003$).

Materials

Stimulus items were black and white line drawings from the Snodgrass and Vanderwart (1980) corpus and matching words, after Cherry et al. (2008). Acquisition stimuli consisted of 64 pictures and matching words, representing 8 taxonomic categories with 8 exemplars per category. Four acquisition lists of 16 items were created. Two lists contained target items presented for study (one picture list, one word list). For each participant, 16 study items were presented in picture format and the other 16 in word format. The non-presented lists served as distracter items in the picture and word recognition tests. Acquisition lists were counterbalanced so that each item appeared as a study item and a non-presented item equally often across participants and stimulus formats. To increase the difficulty of the recognition test, 16 additional distractor items (matched for category membership) were included in the recognition task to create a 2:1 distractor to target item ratio. All study and test stimuli were presented individually on 6 × 9 inch index cards.

Design and Procedure

The design was a 3 × 2 × 2 mixed factorial with age group (middle-age, older, oldest-old) and acquisition task (control, semantic orienting task) as between group variables and stimulus format (words, pictures) as a repeated measures factor. To control for presentation order effects, the study/test materials were pictures in block 1 and words in block 2 for half of the participants. This order was reversed for the other half. Participants were tested individually. An example item was shown to familiarize participants with the stimuli. Participants in the control task condition were given standard intentional learning instructions where they were told to study the items carefully as they would be asked to remember these items later on, after Cherry et al. (2008). Those in the semantic orienting task condition were told that the study items were members of certain taxonomic categories and that they were to indicate the category to which each item belonged from among the category alternatives. They were told that studying the items in relation to their categories would help them remember the items. They were also told to study the items carefully as they would be asked to remember them later. A 3-item practice task followed. After practice, 16 items were presented for study (5 s rate). Participants named each item aloud as it was shown to ensure that all stimuli were encoded and that we had a record of possible unique verbal labels assigned to pictures (e.g., naming the 'sofa', 'a couch', or 'davenport'). Those in the semantic orienting task condition named the item and then stated the category to which it belonged, given 4 categories to choose from which were printed on a prepared card. After the last study item was presented, the category card was removed from sight. For all participants, a 2-minute distractor task followed, where they described their favorite foods (block 1) and favorite holidays (block 2). Next, participants orally recalled as many of the studied items as possible. For recognition, participants make yes/no judgments for each item in a mixed list of 16 studied items and 32 foils (8 s rate). On block 2, the stimulus format was changed relative to block 1 (i.e., from pictures to words or vice-versa) and the same study/test sequence was administered. Next, participants answered 3 open-ended questions which were designed to solicit a verbal report of the strategies used during the acquisition and test phases of the experiment. The questions were as follows: (1) *Do you have any observations or comments about the memory tasks that you just completed?*; (2) *When I presented the words and pictures for study, how did you go about remembering them?*; and (3) *Did you use a strategy to help you recall the words and pictures? If yes, please tell me what you did to help you recall the items*. The experimenter recorded their responses on a prepared sheet. The working memory measures were administered and debriefing followed.

RESULTS

Mixed Model Analyses of Variance

Free Recall

Free recall was scored as the proportion of items correctly recalled (out of 16). Mean proportion correct by age group, acquisition task and stimulus format appears in Table 2 (upper panel). Analyses of the free recall scores yielded a significant main effect of age group, $F(2, 154) = 31.26$, $p < .001$. Mean recall performance was highest for the middle-age (0.60), followed by the older (0.52) and the oldest-old adults (0.35), as expected. The acquisition task main effect was significant, $F(1, 154) = 7.56$, $p = .007$. The semantic orienting task lead to greater mean recall (0.53) compared to the control condition (0.46). The stimulus format main effect was also significant, $F(1, 154) = 69.77$, $p < .001$. Recall of pictures exceeded that of words, with means of 0.55 and 0.43, respectively, replicating our previous findings showing a PSE in free recall (Cherry et al., 2008). Interpretation of these effects was qualified by a significant acquisition task by stimulus format interaction effect, $F(1, 154) = 9.42$, $p = .003$. As can be seen in Figure 1, the magnitude of the PSE was larger for those with a semantic orienting task during encoding compared to the control condition. This is an important finding which is consistent with the view that the PSE reflects enhanced conceptual processing

FIGURE 1. Acquisition task by stimulus format interaction effect in free recall. Error bars represent standard errors.

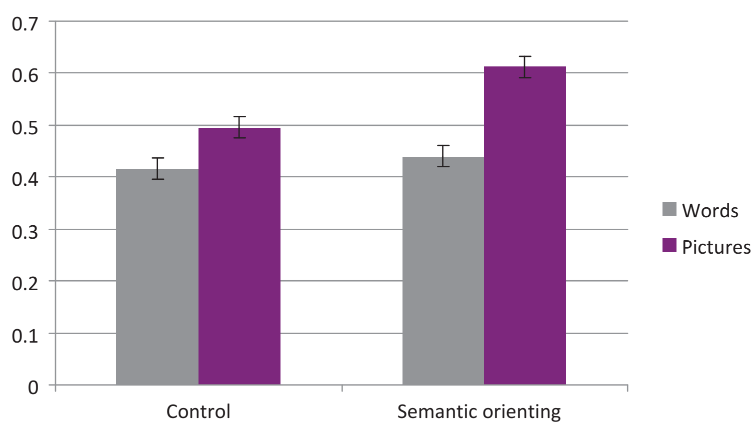

Table 2. Mean free recall and recognition as a function of age group, stimulus format, and acquisition task

	Stimulus format			
	Words		Pictures	
	M	*SD*	*M*	*SD*
Free recall				
Age group				
Middle-age adults				
Control task	0.51	0.18	0.63	0.14
Semantic orienting task	0.55	0.24	0.71	0.20
Older adults				
Control task	0.47	0.23	0.53	0.12
Semantic orienting task	0.47	0.20	0.63	0.13
Oldest-old adults				
Control task	0.26	0.15	0.34	0.11
Semantic orienting task	0.29	0.24	0.49	0.25
Recognition				
Age group				
Middle-age adults				
Control task	0.87	0.16	0.98	0.04
Semantic orienting task	0.81	0.18	0.97	0.08
Older adults				
Control task	0.82	0.18	0.98	0.06
Semantic orienting task	0.78	0.16	0.95	0.08
Oldest-old adults				
Control task	0.78	0.22	0.94	0.10
Semantic orienting task	0.74	0.19	0.94	0.06

Notes: Free recall scores reflect mean proportion correct. Recognition scores reflect corrected recognition (hits minus false alarms).

of pictures, relative to words. Note also that the semantic orienting task had no effect on free recall of words, as the means in Table 2 indicate.

To provide insight into participants' organizational strategies on the free recall task, we conducted clustering analyses using the Scoring Options for Recall Tests (SORT) program, version 2.0 (Elie & Payne, 1999). Two dependent measures were of particular interest, namely, the number of taxonomic categories accessed (assumed to reflect participants' retrieval plan), and the number of items recalled per category (thought to reflect participants' encoding strategy) (Bäckman & Wahlin, 1995). Means appear in Table 3. For the number of categories accessed, means for middle-age (3.52) and older (3.36) adults exceeded the mean for the oldest-old (2.48), $F(2, 154) = 34.51$, $MSE = 0.73$, $p < .001$. The mean for pictures (3.56) exceeded the mean for words (3.12), $F(1, 154) = 26.59$, $MSE = 0.58$, $p < .0001$ with no other significant effects. Interpretative caution is warranted, however, as the middle-age adults were at ceiling for the number of categories accessed.

TABLE 3. Analyses of clustering in free recall

	Number of categories accessed		Items per category	
	Words	Pictures	Words	Pictures
Age group				
Middle-age				
Control task	3.54	3.83	2.32	2.60
Semantic orienting task	3.50	3.92	2.40	2.91
Older				
Control task	3.28	3.62	2.18	2.33
Semantic orienting task	3.43	3.91	2.16	2.55
Oldest-old				
Control task	2.50	2.92	1.46	1.88
Semantic orienting task	2.46	3.17	1.65	2.39

Note: Stimulus lists were comprised of 4 taxonomic categories with 4 exemplars per category.

For the number of items recalled per category, means for the middle-age (2.36) and older (2.17) adults exceeded the mean for the oldest-old adults (1.56), $F(2, 154) = 20.09$, $p < .0001$. Acquisition task was also significant, $F(1, 154) = 5.72$, $p = .02$, with means of 2.13 and 2.34 for the control and semantic orienting task conditions, respectively. The mean for pictures (2.44) exceeded that of words (2.03) $F(1, 154) = 51.06$, $p < .0001$. Importantly, the Acquisition Task × Stimulus Format interaction was significant, $F(1, 154) = 5.26$, $p = .02$, owing to greater number of items recalled per category with pictures compared to words following semantic encoding relative to the control condition. Together, the results of these analyses are suggestive of deficits in both encoding and retrieval processes for the oldest-old, compared to their younger counterparts (see Bäckman & Larsson, 1992; Bäckman & Wahlin, 1995). These data also imply that the PSE observed for all age groups in this study may be mediated at least in part by participants' strategic processes at both encoding and retrieval. Importantly, the two-way interaction observed in the analysis of the number of items recalled per category provides further evidence that the semantic orienting task was most beneficial for recall of pictures for all age groups.

Recognition

Recognition was scored by calculating hit and false alarm rates that were used to derive a measure of corrected recognition (hits minus false alarms). The analysis of corrected recognition scores yielded a significant main effect of age group, $F(2, 154) = 6.7$, $p = .002$. Means for the middle-age (0.87) and older (0.85) exceeded the mean for the oldest-old adults (0.79). The main effect of stimulus format was also significant, $F(1, 154) = 114.79, p < .0001$ owing to the greater recognition of pictures compared to words. Means, in order, were 0.92 and 0.76 for pictures and words. Interpretative caution is in order, because the means for the two younger comparison groups are approaching ceiling in the picture condition.

Post-Test Strategy Assessment

We developed a scoring key to categorize participants' responses to the 3 open-ended strategy assessment questions. In the first phase, all responses were reviewed and an initial list of prominent themes was created. Next, we developed a shorter set of 4 to 5 category codes for each question based on the initial themes list (see Appendix). In the second phase, three graduate students independently coded participants' responses to each question.[2] At least 2 of the 3 raters agreed in 97.5% of cases for Questions 1 and 2, and 99.4% of cases for Question 3.

Table 4 presents frequency counts of the number of responses by acquisition condition and age group for each of the three questions. For Question 1 (*Do you have any observations or comments about the memory tasks that you just completed*?), the older and oldest-old adults made general comments about the experiment and their own memory abilities, whereas middle-aged adults' remarks more often focused specifically on their own free recall and recognition performance in particular, suggestive of insight into memory task difficulty and strategy use. There were no off-topic comments in the semantic orienting task condition and only 2 in the control condition. For Question 2 (*When I presented the words and pictures for study, how did you go about remembering them?*), most of the middle-aged and older adults specifically mentioned strategy use, including both the taxonomic categories and other subjective associative strategies. Interestingly, use of categories and association was as frequent for the middle-aged and older adults in the control group as their counterparts with the semantic orienting task, suggesting that control participants were aware of the category structure of the stimuli although they had not been explicitly told about the categories. In contrast, very few of the oldest-old adults' responses in the control (4.0%) and semantic orienting task (28.0%) conditions mentioned using the categories and association as a strategy to improve retention. Oldest-old adults more often

[2]The total number of responses per question is not equal to the sample size because some participants' gave compound answers that contained multiple responses. For example, a compound answer to Question 1 might be: *'This was a hard task, but I thought the pictures were easier to remember than words'*. In this example, the participant's response fits two categories (e.g., *general comments about the task* and *insight and strategy*). Multiple responses occurred too infrequently to warrant analysis. Nonetheless, we used more than one category code when compound answers were made to capture the richness of these verbal reports.

Table 4. Post-test strategy assessment

	Acquisition condition					
	Control task			Semantic orienting task		
	Middle-age ($n = 24$)	Older ($n = 29$)	Oldest-old ($n = 24$)	Middle-age ($n = 24$)	Older ($n = 35$)	Oldest-old ($n = 24$)
Question 1						
General comments about task	3 (0.14)	9 (0.33)	10 (0.43)	8 (0.35)	12 (0.50)	15 (0.68)
General comments about memory	6 (0.27)	14 (0.52)	10 (0.43)	7 (0.30)	9 (0.38)	5 (0.23)
Insight and strategy	12 (0.54)	4 (0.15)	2 (0.09)	8 (0.35)	3 (0.13)	2 (0.09)
Off-topic comments	1 (0.05)	0 (0.00)	1 (0.04)	0 (0.00)	0 (0.00)	0 (0.00)
Total number of responses	22	27	23	23	24	22
Question 2						
Insight and strategy – categories/association	14 (0.50)	16 (0.53)	1 (0.04)	14 (0.52)	17 (0.50)	7 (0.28)
Insight and strategy – other	11 (0.39)	7 (0.23)	11 (0.44)	7 (0.26)	11 (0.32)	9 (0.36)
Don't know/no strategy	3 (0.11)	7 (0.23)	11 (0.44)	4 (0.15)	4 (0.12)	9 (0.36)
Miscellaneous	0 (0.00)	0 (0.00)	2 (0.08)	2 (0.07)	2 (0.06)	0 (0.00)
Total number of responses	28	30	25	27	34	25
Question 3						
Yes/categories strategy	10 (0.38)	17 (0.50)	3 (0.13)	12 (0.46)	10 (0.30)	7 (0.26)
Yes/used other strategy	8 (0.31)	6 (0.18)	1 (0.04)	5 (0.19)	3 (0.09)	5 (0.19)
No/described category strategy	2 (0.08)	1 (0.03)	0 (0.00)	3 (0.12)	2 (0.06)	1 (0.04)
No/described other strategy	1 (0.04)	3 (0.09)	3 (0.13)	1 (0.04)	1 (0.03)	2 (0.07)
No reported strategy	5 (0.19)	7 (0.21)	17 (0.71)	5 (0.19)	17 (0.52)	12 (0.44)
Total number of responses	26	34	24	26	33	27

Notes: Entries are frequency counts with proportion scores in parentheses. Total number of participants is 160. Question 1 = *Do you have any observations or comments about the memory tasks that you just completed*? Question 2 = *When I presented the words and pictures for study, how did you go about remembering them?* Question 3 = *Did you use a strategy to help you recall the words and pictures? If yes, please tell me what you did to help you recall the items.*

described subjective strategies other than the categories and association in the control (44.0%) and semantic orienting task (36.0%) conditions. Compared to their younger counterparts, the oldest-old were more likely to report that they did not know or did not use a strategy. For Question 3 (*Did you use a strategy to help you recall the words and pictures? If yes, please tell me what you did to help you recall the items*), most of the middle-aged and older adults across acquisition conditions indicated that they used the categories as a strategy or some other strategy. By comparison, the majority of the oldest-old adults' responses in the control condition (70.8%) and somewhat less than half of them in the semantic orienting task condition (44.4%) indicated no strategy use at retrieval.

DISCUSSION

The primary objective of this study was to examine the contribution of semantic encoding processes to memory for pictures and words in a sample of adults who ranged in age from 44 to over 90 years. Our results confirm a PSE in free recall and recognition for nonagenarians, replicating our first findings (Cherry et al., 2008). We also found that the semantic orienting task enhanced free recall for all age groups. This finding joins others in the cognitive aging literature where the mnemonic benefit of encoding activities that invite semantic elaboration or a deeper level of processing of the to-be-remembered items have been demonstrated (e.g., Springer et al., 2005; Troyer, Häfliger, Cadieux, & Craik, 2006; see also Bäckman, Mantyla, & Herlitz, 1992 and Craik & Jennings, 1992, for reviews).

The more interesting finding we wish to emphasize in this study was the significant Acquisition Task × Stimulus Format interaction. As can be seen in Figure 1, the PSE in free recall was greater in magnitude for those with a semantic orienting task at encoding compared to a control condition. Importantly, the mnemonic benefit of semantic orienting was confined to pictures as memory stimuli. This aspect of the data is consistent with the view that the PSE is driven by enhanced conceptual processing of pictures, relative to words (Stenberg, 2006). Alternatively, the semantic orienting task may have prompted a deeper analysis of the perceptual features of the stimuli resulting in a more distinctive encoding of pictures relative to words. Another possibility is that the semantic orienting task may have evoked an imagery-based, relational-organizational strategy where associations among the to-be-remembered items were stronger in pictorial compared to verbal format (Bower, 1970), as discussed later. Future research would be desirable to distinguish among these alternative accounts of the mnemonic benefit of semantic encoding on memory for pictures. The finding that the oldest-old demonstrated a comparable advantage of semantic encoding relative to the younger reference groups is exciting and implies that very old adults utilize semantic knowledge in support of episodic remembering as effectively as do their younger counterparts. Accordingly, one mechanism of preserved episodic memory in late life appears to be the ability to utilize semantic information to support episodic remembering. Other evidence has shown that young-old adults rely on semantic associations to facilitate free and serial recall (Golomb, Peelle, Addis, Kahana, & Wingfield, 2008). Our findings, among others, imply that the dynamic relationship between semantic and episodic memory processes in late life warrants further study.

The second objective in this study was to provide further evidence concerning the strategic processes that participants may bring to bear during encoding and retrieval to improve memory performance. We examined participants' strategic encoding and retrieval processes in two ways: (1) with analyses of clustering in free recall and (2) with self-reported strategy use.

Follow-up analyses of clustering demonstrated that a greater number of taxonomic categories were accessed (*assumed to reflect participants' retrieval plan*) and more items were recalled per category (*assumed to reflect participants' encoding strategy*) when pictures served as stimuli compared to words, replicating Cherry et al.'s (2000) findings (see also Bäckman & Wahlin, 1995). Importantly, a significant acquisition task by stimulus format interaction effect occurred in the analyses of items recalled per category, which followed the same form as the two-way interaction in the overall analyses of free recall. That is, the PSE obtained for the number of items recalled per category was larger in magnitude for those with the semantic orienting task relative to the control task. This is an interesting finding which implies that semantic encoding may lead to better organization due to stronger associations among stimuli in pictorial relative to verbal format, consistent with Bower's (1970) relational-organizational account of imagery effects in associative learning. That is, Bower has suggested that imagery increases relational associations among stimuli in paired associate learning that result in a memorial benefit relative to rote rehearsal. From this perspective, the semantic orienting task coupled with pictorial stimuli may have prompted both semantic elaboration and visual imagery that increased associations during encoding, resulting in better recall and stronger organization of the to-be-remembered items compared to standard learning instructions. The age group variable did not enter into any significant interactions in these analyses, suggesting that nonagenarians engage in qualitatively similar organizational strategies at encoding and retrieval, although their absolute level of performance was somewhat lower than the two younger reference groups.

We solicited post-experimental, self-reports of strategy use to provide further evidence concerning age-related differences in strategic encoding and retrieval processes. The post-test strategy assessment yielded three main findings. First, the two older adult groups made general comments about the experiment and their own memory abilities, whereas middle-aged adults more often remarked about their free recall and recognition performance (first question), suggestive of insight into task difficulty and strategy use. Second, most of the middle-aged and older adults specifically mentioned strategy use when directly queried (second question), including both the taxonomic categories and other subjective associative strategies (see Table 4). Interestingly, reference to the taxonomic categories and association was as frequently mentioned for middle-aged and older adults in the control group as their counterparts with the semantic orienting task, suggesting that control participants were aware of the category structure of the stimuli although they had not been explicitly told about the categories or directed to use them as a memory aid. Oldest-old adults seldom mentioned using the categories and association during study, although they were somewhat more likely to describe subjective strategies other than the categories and association to improve retention. Compared to their younger counterparts, the oldest-old more often answered that they did not know or did not use a strategy, suggestive of deficits in metacognitive awareness. Third, most of the middle-aged and older adults across acquisition conditions reported that they used the categories as a strategy or some other strategy to help them recall the pictures and words (third question). By comparison, oldest-old adults' responses in the control (70.8%) and semantic orienting task (44.4%) conditions suggest little to no strategy use at retrieval. Together, the findings that emerged from the post-test strategy assessment imply that very old adults may have limited insight into strategic processes that bolster retention. It is also possible that strategic encoding and retrieval operations may be too cognitively taxing for nonagenarians. Springer et al. (2005) found that brain activity during study and recognition of pictorial and verbal stimuli differed for older adults relative to young controls in a study using functional MRI, implying the use of alternate brain networks in late life. Conceivably, brain regions mediating the strategic encoding and retrieval processes may differ in nonagenarians compared to younger reference groups. Future research that includes functional MRI to measure brain activity would be desirable to permit a more definitive analysis of the neurocognitive mechanisms that underlie episodic remembering in very old adults.

Several methodological limitations of the study warrant brief mention. First, LHAS participants are physically and psychologically capable, which raises concerns about the representativeness of the sample and possible selection bias in the direction of vitality. Second, ceiling effects were evident in picture recognition, a typical problem in studies with healthy older adults in the cognitive aging literature. Finally, we did not include neuropsychological measures of executive function which would permit more precise inferences on the neurocognitive mechanisms underlying the strategic use of semantic knowledge at encoding to support episodic remembering, an exciting direction for future research.

In closing, this study confirms the memorial advantage of pictures relative to words for nonagenarians. Our results imply that pictorial illustrations may be useful as a memory aid for very old adults in everyday life, but further research is necessary. Our results also imply that nonagenarians benefit from semantic elaboration during encoding to support episodic remembering as do middle-aged and young-old adults. Given that cognitive support at encoding and retrieval may be necessary to optimize episodic remembering in oldest-old adults (Bäckman et al., 1990; Bäckman & Wahlin, 1995), future studies where semantic information is reinstated at test, such as representing the taxonomic categories of the acquisition items, would be desirable.

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APPENDIX. Coding key for post-test strategy assessment

Question 1	Question 2	Question 3
1. General comments about task Comments on details of task (e.g., distractor, variety of items, speed of presentation, similarity of stimuli) General comments about task (e.g., activates your memory, might improve memory) Stated prior experience with this task or similar tasks Stated no prior experience with task Task was difficult Positive comments about task Negative comments about task Curious about purpose of task Difficulty with categories **2. General comments about memory** Associated stimuli with life/self/objects in room/pictured in use/interacting with each other Characterized own memory as bad/thinks task performance was poor Characterized own memory as good/thinks task performance was good General comments on memory **3. Insight & strategy** Categories Recognition easier than recall Recall easier than recognition Rehearsal/repetition Pictures easier than words Didn't concentrate hard enough/distracted/didn't try Miscellaneous strategies (e.g., recalled all exemplars of a category, started at end and worked backwards, visualization by category, turned words into pictures, created story, visualized colors) **4. Off-topic comments** Miscellaneous observations	**1. Insight and strategy – categories/association** Association Categories **2. Insight and strategy – other** Alphabetical order Associated stimuli with life/self/objects in room/pictured in use/interacting with each other Concentrating/telling self to remember/committing to memory Difficulty with categories Distracted/didn't concentrate/no strategy/guessing Miscellaneous strategies (e.g., recalled all exemplars of a category, started at end and worked backwards, visualization by category, turned words into pictures, created story, visualized colors) Pictures easier to remember than words Recognition easier than recall Rehearsal/Repetition Serial order Did not use categories/strategies Surface characteristics (e.g., starts with a G, spelling, details of pictures) Visualization/photographic memory/mental images **3. Don't know/No strategy** **4. Miscellaneous**	**1. Yes – used strategy – categories** **2. Yes – used strategy – other** **3. No but described strategy – category** **4. No but described strategy – other** **5. No reported strategy**