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Stimulus modality and verbal learning performance in normal aging[☆]

Fofi Constantinidou[a,*] and Susan Baker[b]

[a] *Department of Speech Pathology and Audiology, 2 Bachelor Hall, Miami University, Oxford, OH 45056, USA*

[b] *Department of Communication Sciences and Disorders, University of Florida, Gainseville, FL, USA*

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Abstract

The present study investigated the effects of modality presentation on the verbal learning performance of 26 older adults and 26 younger cohorts. A multitrial free-recall paradigm was implemented incorporating three modalities: Auditory, Visual, and simultaneous Auditory plus Visual. Older subjects learned fewer words than younger subjects but their rate of learning was similar to that of the younger group. The visual presentation of objects (with or without the simultaneous auditory presentation of names) resulted in better learning, recall, and retrieval of information than the auditory presentation alone. © 2002 Elsevier Science (USA). All rights reserved.

Keywords: Stimulus modality; Working memory; Delay; Interference; Recall; Retrieval; Recognition; Learning styles

1. Introduction

Current research suggests that a decline in working memory performance is a consequence of normal aging even without neurological involvement (Baddeley, Cocchini, Della Sella, Logie, & Spinnler, 1999; Craik & Salthouse, 1992; Jones & Rabbit, 1994). Age differences are generally noted in tasks that target working memory mechanisms by manipulating information (e.g., recall of digits backward) or by requiring delayed recall, as compared to simple automatic tasks such as forward digit span tasks (Craik, 1991; Kasniak, Poon, & Riege, 1986). Furthermore, when the amount of information to be remembered exceeds the typical auditory span (of five to nine items), then the older adults may perform worse than their younger counterparts (Swanson, 1999).

Research paradigms incorporating multitrial tasks such as list learning, consisting of word lists that exceed nine items, have been found to be sensitive in assessing

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[*] Corresponding author. Fax: +1-513-529-2502.

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memory and learning abilities in clinical populations such as patients with brain injury, learning disabilities, and depression (Constantinidou & Neils, 1995; Constantinidou, Neils, Bouman, Lee, & Shuren, 1996; King, Cox, Lyness, Yeates, & Caine, 1998; O'Donnell, Radtke, Leicht, & Caesar, 1988). Constantinidou and Neils (1995) designed an experimental task derived from the Auditory Verbal Learning Test (AVLT) in which subjects were asked to recall words and pictures in a supraspan (i.e., word lists exceeding nine items) list-learning format under three conditions (auditory only, visual only, and auditory plus visual).

The studies by Constantinidou and Neils (1995) and Constantinidou et al. (1996) reported that young normal subjects and young subjects with moderate-severe brain injury performed significantly better during the visual presentation of information. Specifically, the recall and recognition performance improved during the visual only and auditory plus visual presentations compared to the auditory presentation alone. Furthermore, the visual presentation was the most resistant to the effects of interference (Constantinidou, 1999). It would be beneficial to determine whether this pictorial superiority observed with younger adults during multitrial free-recall paradigms extends into older adulthood. Furthermore, the effects of stimulus modality on retention abilities following delay should also be explored with older adults.

In addition to the effects of stimulus modality on memory performance, the relationship between individual learning styles (verbal or imagery) and performance on visual and auditory tasks could be investigated with older adults. It is assumed that the brain contains distinctive systems for processing verbal and nonverbal information. If these two systems have unequal speed and processing capacity, then the individual will prefer to use the more accommodating system whenever possible. The preference for one system will eventually result in an established learning style (Riding & Read, 1996). While some individuals are deeply set into one learning style preference, most individuals switch their styles in accordance with various tasks and their demands (Riding & Cheema, 1991). Older adults may switch their style based on preserved brainpower that predominates in one hemisphere.

Literature examining the interaction of learning style preferences and stimulus modality is limited in aging research. The Visualizer–Verbalizer Questionnaire (VVQ; Richardson, 1977) has been used to make comparisons between learning preferences and visual and verbal ability levels. A significant relationship was found between the visual preference and achievement on the Street Figure-Comprehension Test (Alesandrini, 1981). A weak relationship was found between the verbal preference and the performance on the WAIS Similarities subtest. Using a revised version of the VVQ (Kirby, Moore, & Schofield, 1988), Schofield and Kirby (1994) found a significant relationship between the visual preference and the high ability level in locating information on a topographical map. Previous investigations with the VVQ and revised VVQ have been performed with young adults. To our knowledge, there are no investigations of learning style in the verbal–visual continuum in older adults and its relationship with verbal learning.

The purpose of the present study was to identify effective ways of presenting information to older adults in order to maximize memory performance. A multitrial, free-recall research paradigm was implemented to assess the effects of presentation modalities on memory performance with older adults. In addition, the relationship between individual learning styles and stimulus modality presentation was explored. The primary research hypotheses were:

1. Word recall performance of participants will be affected by the presentation modality.
2. Younger subjects will recall more items than older subjects under each learning trial.

3. Older subjects will be affected by retroactive interference to a greater degree than younger subjects.
4. Older subjects will demonstrate a greater decline in performance compared to younger subjects during the 30-min delay condition.
5. Participants who demonstrate a verbal learning preference on the VVQ will recall a greater number of items during the auditory presentation as compared to the other stimulus modalities.
6. Participants who demonstrate a visual learning preference will recall a greater number of items during the visual presentation as compared to the other stimulus modalities.

2. Method

2.1. Participants

Twenty-five males between the ages of 50 and 77 ($M = 62.9$, $SD = 7.5$) and 25 males between ages 19 and 38 ($M = 25.32$, $SD = 4.22$) participated in this study. The educational levels ranged from 12 to 21 years ($M = 17.0$, $SD = 3.2$) for the older participants and from 12.50 to 21 years ($M = 16.9$, $SD = 2.22$) for the younger participants. There was no significant difference in the educational levels of the two groups, $t(49) = .166$, $p = .869$. All participants were volunteers from southwest Ohio.

In order to screen for cognitive decline and presence of depression, all participants were required to score 26 or higher (out of 30) on the Mini Mental State Examination (Folstein, Folstein, & Hughes, 1975) and 13 or lower on the Beck Depression Inventory-II (Beck, 1996). Participants were excluded from this study if they had a positive history of the following: (a) neurological insult or disorder, (b) reported episodes of loss of consciousness, (c) reported use of antipsychotic medication at the time of testing, (d) a cognitive or learning disability, (e) a language or speech disorder, and (f) substance abuse.

Participants were required to pass a vision and a hearing screening. Each participant's hearing was screened at an intensity level of 40 dB HL for 1000 Hz. The participants were required to pass the screening for at least one ear. Each participant's vision was screened by having them read aloud five words printed in 10-point type. The participants were required to correctly read all five words aloud in order to pass the screening.

2.2. Neuropsychological tests

The neuropsychological battery administered to each participant included tests of attention, memory, and visuo-spatial processing. The entire test battery (the neuropsychological tests and experimental tasks) lasted approximately 180 min and was administered over two sessions. Participants were provided with scheduled breaks in the testing sessions in order to avoid mental fatigue. The following tests were administered as part of this study:

- Wechsler Memory Scale—Revised Subtests: Logical Memory I, Logical Memory II, Digit Span, Visual Memory Span (Wechsler, 1987)
- Rey Osterreith Complex Figure Test (Rey, 1941, as cited in Lezak, 1995)
- The Trail Making Test (Army Individual Test Battery, 1944, as cited in Lezak, 1995)
- Letter Cancellation Task (Diller, Ben-yishay, & Gertsman, 1974)

- Rey Auditory Verbal Learning Test (Rey, 1964; Taylor, 1959, as cited in Lezak, 1995)

Verbalizer–Visualizer Questionnaire. The revised version of the VVQ was used as a means of evaluating an individual's learning preference style. The questionnaire consists of 15 true–false questions obtained from Paivio's (1971) original 86-item Individual Differences Questionnaire. The revised VVQ version produces three scores: verbal, imagery, and dream. Only the verbal and imagery scores were used for this investigation. Participants were asked to respond "true" or "false" to each item. The items were phrased either positively or negatively. Examples of positive items include: "I can easily think of synonyms for words." (verbal scale) and "I like newspaper articles that have graphs." (imagery scale). Examples of negative items include: "I dislike looking up words in dictionaries." (verbal scale) and "I don't believe that anyone can think in terms of mental pictures." (imagery scale). One point was awarded to each "true" response to a positively phrased item and to each "false" response to a negatively phrased item. The maximum score for each of the verbal and imagery scales was 10. Appendix A is the VVQ.

3. Experimental tasks

Experimental items. The 144 items selected for the experimental task were chosen based on characteristics that have been documented to affect memory and word retrieval. The following criteria were used for selection, as described by Constantinidou and Neils (1995): (a) familiarity (all of the List A items were highly familiar, occurring in the English language 100 times or more per million words as rated by Thorndike & Lorge, 1944; the List B items were less frequently occurring words), (b) concreteness (each word was a noun representing objects, animals, or body parts that were easily depicted as line drawings), (c) length (each word consisted of two or four sounds), (d) syllabification (only one-syllable words were selected). Appendix B contains the items for List A.

Each item was represented as a line drawing on 3×4 inch cards. The drawings were obtained from the Contrast Picture File (Elbert, Rockman, & Saltzman, 1980). All line drawings were static, not representing any movement.

Experimental procedure. This study followed the experimental procedures as described in Constantinidou et al. (1996). The experimental task required the participants to recall words and pictures under three conditions. These conditions included: (a) auditory (participants listened to the words), (b) visual (participants were presented with line drawings), and (c) auditory plus visual (participants were presented with a line drawing and simultaneous naming of the object). Participants were given one practice trial for each of the three conditions. After the practice trial, a target list (List A) was presented five times. A different list of 15 items was presented for each condition. Each time List A was presented the participant was asked to recall as many items as possible from the list.

An interference list of 15 items (List B) was presented as Trial 6. The items in List B were presented using the same stimulus modality (auditory, visual, or auditory plus visual) as List A. For example, after five visual presentations of List A, List B would be presented visually. Immediately following the presentation of List B, the participant was asked to recall as many items as possible from List A (Trial 7). Thirty minutes after Trial 7, the participants were again asked to recall as many items as possible from List A (Trial 8). During these 30 min, the participants completed other assessments that were a part of this neuropsychological test battery.

If the participant was not able to recall all 15 items for List A during Trial 8, they were presented with a recognition task. The list of items for the recognition task contained all 15 items for List A and all 15 items from List B as well as 20 foils semantically or phonetically linked to List A and B. Participants were asked to indicate a yes–no response as to whether the item presented belonged in List A. Items in the recognition list were presented in the same stimulus modality as List A and B.

Different lists of 15 items (from the original 45) were used under each condition. Each list was equivalent in regards to the selection criteria for the items. To avoid a possible condition effect due to the order of presentation, the order of the presentations was counterbalanced.

Order of conditions		
$A^{(\text{Auditory})}$	$B^{(\text{Visual})}$	$C^{(\text{Auditory plus Visual})}$
B	C	A
C	A	B

Data scoring and analysis. Each trial of the experimental task contained a total of 15 items. One point was given for each item recalled in the trial (maximum score was 15 for each trial). The primary statistical design was a mixed-model analysis of variance with one between and two within factors, comparing the two groups under the three modality conditions across the five repeated trials.

4. Results

The primary purpose of the present study was to determine if one of the three conditions tested resulted in improved learning and recall performance in normal elderly subjects. The multivariate analysis resulted in a significant (alpha level set at .05) overall main effect for group, $F(1,49) = 14.11$, $p = .0001$, $= .957$, modalities, $F(2,48) = 27.268$, $p = .0001$, $= 1.00$, and repeated trials, $F(4,46) = 202.721$, $p = .0001$, $= 1.00$. Furthermore, trials by modality, $F(8,42) = 2.443$, $p = .029$, power = .839, interaction was significant. The group by modality, $F(2,48) = 2.008$, $p = .145$, the trials by group, $F(4,46) = .596$, $p = .667$, and group by trials by modality interactions were not significant, $F(8,42) = 5.75$, $p = .793$.

In order to identify which modalities contributed to the significant modality effect, preplanned orthogonal univariate comparisons were used (Helmert contrasts, alpha level set at .025). The first Helmert contrast compared the auditory modality to the visual and simultaneous auditory plus visual modalities. The comparison resulted in a significant univariate effect, $F(1,49) = 55.607$, $p = .0001$. The second Helmert contrast compared the visual modality to the simultaneous auditory plus visual modality. The comparison did not reach statistical significance, $F(1,49) = 1.974$, $p = .166$. The above results indicate that the auditory presentation resulted in less effective learning compared to the visual and auditory plus visual presentation for both groups. Table 1 displays the trial means for each group under each modality. Table 2 displays the means for each trial across modalities. Fig. 1 is the graphic display of the trials by modality interaction. Fig. 2 is the profile plots for each group on each trial.

4.1. Interference effects

Retroactive. Retroactive interference was assessed in order to determine the magnitude of decline in word recall performance of List A after the presentation and

Table 1
Recall scores on individual trials for each modality condition

	T1	T2	T3	T4	T5	T6 (List B)	T7	T8 (30 min)	Total (T1–T5)	Recognition
Auditory										
Older										
M	5.88	8.15	9.31	10.31	11.12	10.83	8.38	6.79	44.77	12.92
SD	1.80	2.15	2.35	2.17	2.01	1.81	2.81	3.51	8.91	2.08
Younger										
M	7.00	9.56	11.44	12.28	12.88	12.92	11.71	11.21	53.16	13.96
SD	2.53	2.42	1.89	2.05	1.62	1.64	2.87	2.90	8.58	0.93
Visual										
Older										
M	7.31	10.31	12.00	12.62	12.38	12.25	11.75	11.58	54.62	14.72
SD	1.76	1.97	2.37	1.30	1.72	1.70	2.09	1.82	6.87	0.61
Younger										
M	8.40	11.24	12.84	13.52	13.28	13.25	13.33	13.33	59.28	14.64
SD	2.22	2.22	1.86	1.73	2.25	2.29	1.74	2.10	8.59	0.76
Auditory and visual										
Older										
M	6.35	9.73	10.69	11.92	12.42	12.21	11.13	9.63	51.12	13.42
SD	1.35	2.11	2.31	1.72	1.96	1.89	1.99	3.97	7.61	4.01
Younger										
M	8.12	11.12	12.92	13.60	14.08	14.13	13.33	12.54	59.84	14.84
SD	2.64	2.91	1.98	1.53	1.19	1.19	2.04	2.08	8.42	0.47

Table 2
Estimated marginal means across the modalities

Trials	Mean	Standard deviation
Older		
1	6.51	.33
2	9.40	.33
3	10.67	.33
4	11.62	.28
5	11.97	.28
Younger		
1	7.84	.33
2	10.64	.34
3	12.40	.34
4	13.13	.29
5	13.41	.28

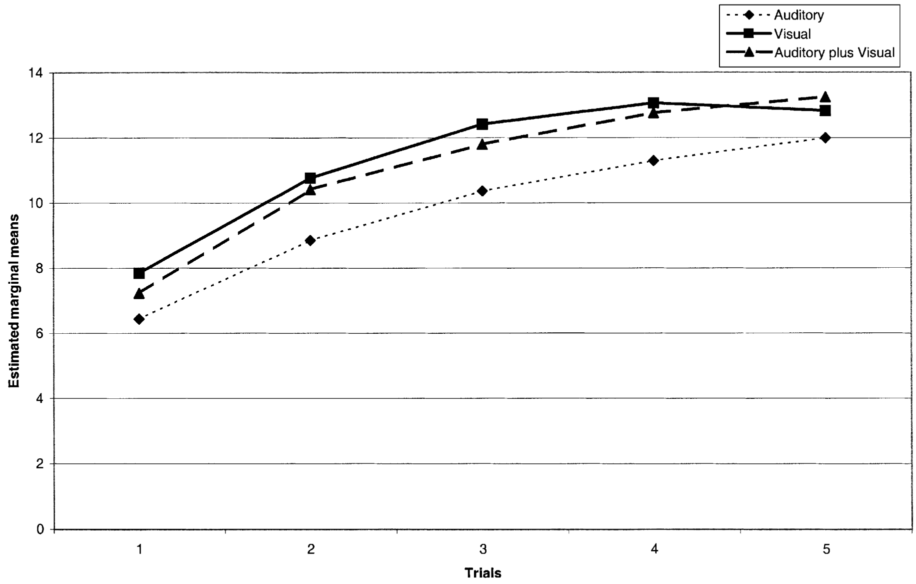

Fig. 1. Trials by modality interaction.

recall of competing stimuli (List B). The difference scores between the last learning trial (Trial 5) and Trial 7 (recall after interference) were calculated as recommended by Lezak (1983) and Delis, Kramer, Kaplan, and Ober (1987). Table 3 displays the declines in performance for each of the experimental conditions. A mixed-model analysis of variance (ANOVA) compared the two groups across the three modalities ($\alpha = .05$). The dependent variable was the difference scores. The ANOVA resulted in a significant modality effect, indicating that the decline in performance for both older and younger participants was affected by the presentation modality $F(2, 48) = 10.492$, $p = .0001$. The group effect was not significant $F(l, 49) = 2.481$, $p = .122$, indicating that the amount of decline in performance of older adults was not greater compared to younger participants. The group by modality interaction was not significant, $F(2, 48) = .254$, $p = .777$; thus similar patterns of decline were observed by the two groups across the three modalities.

Preplanned univariate orthogonal contrasts (Helmert contrasts at $\alpha = .025$) were performed to identify which modality conditions contributed to the significant

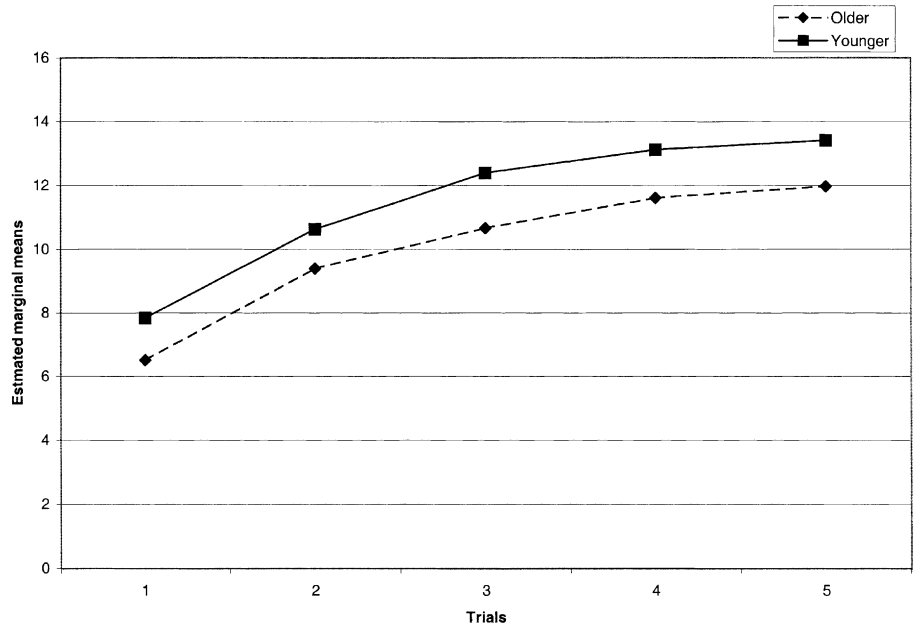

Fig. 2. Profile plots of group performance per trial across the three modalities.

modality effect. The first contrast compared the auditory modality with the visual and the simultaneous auditory plus visual modalities. The contrast resulted in a significant univariate effect, $F(1,49) = 18.848$, $p = .0001$. The second contrast comparing the visual modality to the auditory plus visual presentation was not significant, $F(1,48) = 5.039$, $p = .029$. The above comparisons indicated that the amount of decline was greater during the auditory presentation compared to the other two modalities.

Thirty-minute delayed recall. The aging process does not seem to produce a pronounced retroactive interference effect. However, another objective was to determine performance across time and to determine whether the visual superiority would continue at 30-min delayed recall. A mixed-model analyses of variance was performed in order to identify the patterns of word recall after a 30-min delay ($\alpha = .05$). The two within factors were the stimulus modalities and recall trials (Trials 5, 7, and 8). Consistent with previous results, the analyses resulted in a significant group effect, $F(1,46) = 23.614, p = .0001$, modality effect, $F(2,45) = 32.565, p = .0001$, and trials effect, $F(2,45) = 28.264$, $p = .0001$. The trials by group, $F(2,45) = 4.169$, $p = .022$, modality by trials, $F(2,43) = 10.029$, $p = .0001$, and modality by group, $F(2,45) = 5.085$, $p = .010$ interactions were also significant.

These findings indicate that overall, older subjects recalled a fewer amount of words than their younger counterparts across time. Performance in both groups declined across trials, following a linear trend, $F(1,46), = 55.279$, $p = .0001$. The group-by-trials interaction suggests that the rate of decline in performance was faster in the older subjects. Fig. 3 depicts the group-by trial-interactions.

The presentation modality continued to affect performance during the delay trials as it did during the five learning trials. Pairwise Helmert contrasts ($a = .025$) indicate that visual and combination auditory plus visual conditions resulted in better recall than the auditory presentation alone, $F(1,46) = 64.446$, $p = .0001$. There was no significant difference between the visual and simultaneous auditory plus visual conditions, $F(1,46) = 3.141$, $p = .083$. Interestingly, the two groups differed in their

Table 3
Decline in recall performance after interference for each modality condition

	Time 1 (After list B)	Time 2 (30 min delay)	Overall means
Auditory			
Older			
M	2.458	1.583	2.021
SD	1.793	2.586	2.190
Younger			
M	1.208	.500	.854
SD	1.841	1.503	1.672
Overall means			
M	1.833	1.042	
SD	1.817	2.044	
Visual			
Older			
M	.500	1.67	.334
SD	2.067	1.926	1.997
Younger			
M	−.050	.170	.060
SD	2.225	1.794	2.010
Overall means			
M	.225	.169	
SD	2.146	3.720	
Auditory and visual			
Older			
M	1.083	1.500	1.292
SD	1.558	3.331	2.445
Younger			
M	.792	.792	.792
SD	1.351	1.474	1.413
Overall means			
M	.938	1.146	
SD	1.456	2.403	

Note. Time 1 scores were obtained by subtracting the Trial 7 score from Trial 5 for each stimulus modality. Time 2 decline scores were obtained from subtracting Trial 8 scores from Trial 7.

patterns of performance under each modality. As depicted in Fig. 3, older subjects' performance improved significantly during the visual presentation alone; younger subjects' performance was not affected as much by the modality presentation. Fig. 4 shows the group by modality interaction.

4.2. Recognition performance

After the 30-min delayed recall, subjects were presented with a recognition task. Difference scores were calculated between the last free-recall trial (Trial 8, recall after 30 min. delay.) and the recognition trial in order to determine the amount of improvement. The older subjects demonstrated a greater amount of improvement than the younger subjects ($X = 4.36$, $SD = 2.62$ and $x = 2.09$, $SD = 2.153$, respectively). The inferential analyses ($\alpha = .05$) also confirmed the above descriptive results, $F(1, 45) = 15.984$, $p = .0001$. While both groups benefited from the recognition paradigm and their performance improved, the older subjects demonstrated significantly greater gains than the younger groups. Since younger subjects performed better throughout the previous trials, they did not have as much room for improvement as the older group.

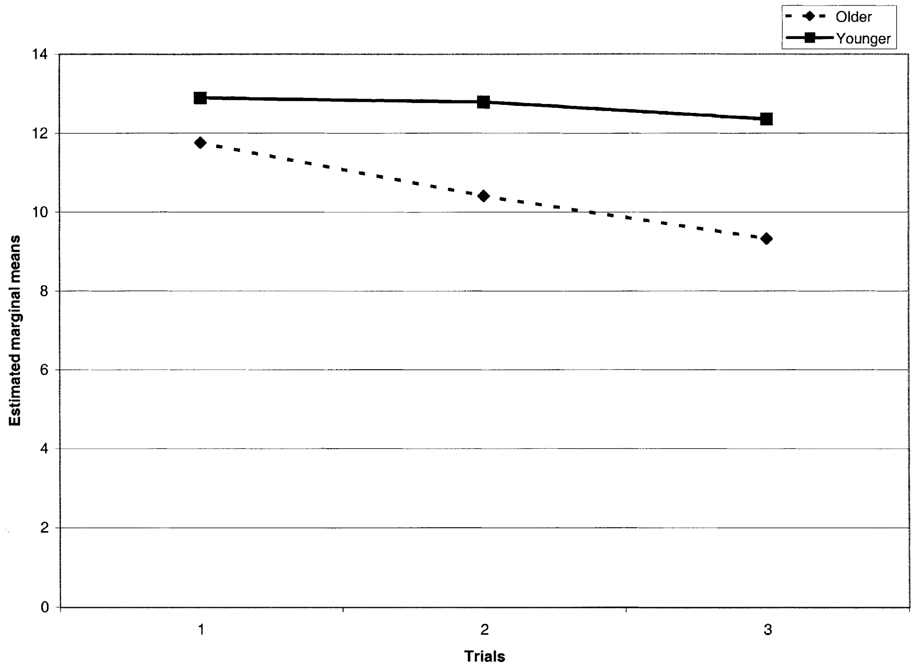

Fig. 3. Group by trials (Trials 5, 7, and 8) interaction.

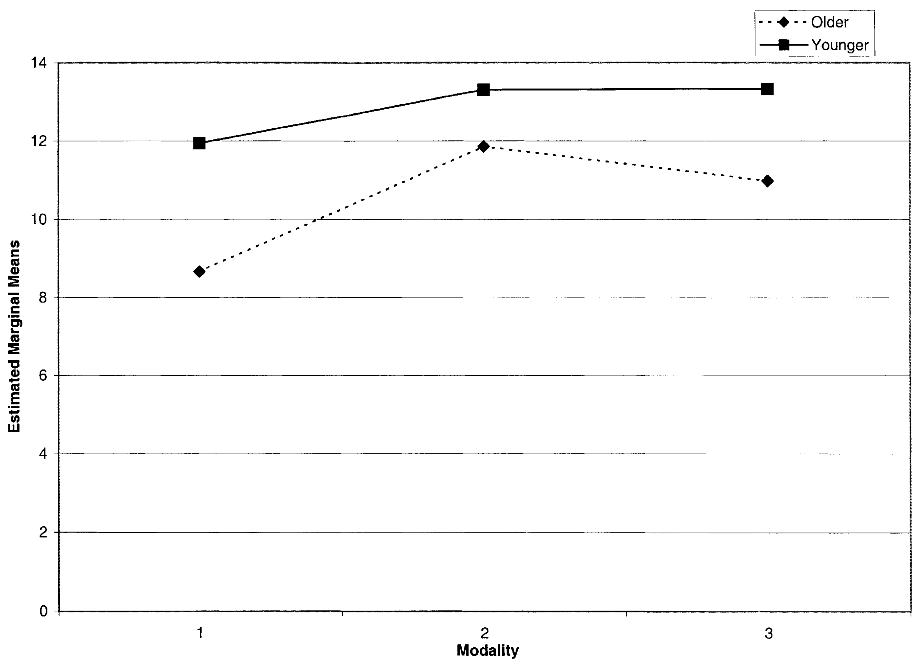

Fig. 4. Group by modality interaction.

4.3. Relationship between verbal learning and the VVQ performance

The Verbal and the Imagery scores were used for the purposes of this project. Each subject could obtain a maximum of 10 points on each VVQ scale. Median splits were performed in order to select subjects who scored high on each of the VVQ Verbal and the VVQ Imagery Scales. Twenty-nine subjects (from both groups) scored above the median for the Verbal Scale (7 or greater). There was a significant correlation between subjects' performance on the VVQ Verbal Scale and the total scores (Trials 1 through 5) of the visual condition, $r = 513$, $p < .001$. High performance on the VVQ Verbal Scale did not correlate significantly with the other two presentation conditions. These findings may suggest that subjects who have a verbal learning style may perform better on verbal learning tasks that provide a pictorial input.

Thirty-four subjects scored above the median (9 or greater) on the VVQ Imagery Scale. Strong performance on this scale did not correlate significantly with any of the experimental tasks; therefore, it appears that there is no relationship between a visual learning style and the actual learning of verbal items that are presented visually or auditorily.

4.4. Performance on neuropsychological tests

The experimental verbal learning tasks implemented in this study were modeled after the AVLT. There were significant correlations between the AVLT and the auditory, visual, and auditory plus visual modalities ($r = .738$, $p = .001$, $r = .518$, $p = .001$, and $r = .630$, $p = .001$, respectively). These relationships suggest that all tasks assess verbal learning tasks. As suspected, the strongest relationship was between the AVLT and the auditory modality condition.

In order to compare the performance of older and younger subjects on the AVLT, a mixed-model-multivariate analyses of variance was performed ($\alpha = .05$). Older subjects were able to learn more items over the five learning trials, $F(1, 49) = 21.027$, $p = .0001$. Both groups of subjects benefited from the repeated presentation of the target items and learned more words as the trials progressed, $F(4, 46) = 63.884$, $p = .0001$. The rate and pattern of learning was similar between the two groups, and the group-by-trials interaction was not significant, $F(4, 46) = .745$, $p = .566$.

Table 4 displays the means and standard deviations on the other neuropsychological tests. In general, the performance of the older participants was slightly lower than that of younger participants; however, the difference was less than one standard

Table 4
Performance of older and younger adults on a battery of cognitive tests

	Older adults ($n = 26$)		Younger adults ($n = 25$)		$F(1, 49)$
	M	*SD*	*M*	*SD*	
Logical memory 1	12.77	2.80	14.41	3.01	−2.01*
Logical memory 2	10.93	3.11	12.89	3.34	−2.16*
Rey figure copy	33.00	3.09	33.32	3.38	−.035
Rey figure recall	17.17	7.37	23.69	7.13	−3.21*
Trail making A[a]	36.58	10.48	22.60	10.61	4.73*
Trail making B[a]	84.12	39.99	54.72	22.70	3.21*
Digit span forward	8.92	2.08	9.20	1.78	−.051
Digit span backward	7.81	2.37	8.04	2.64	−0.33
Visual span backward	8.31	1.91	9.08	1.85	−1.60
Letter cancellation[a]	72.31	35.85	66.32	36.39	0.59
Mini mental exam	29.15	1.32	29.28	0.79	−0.41
Beck depression	4.92	4.08	5.32	3.28	−0.38

[a] Time required to complete task in seconds.
* Significant at $p < .05$.

Table 5
Performance profile for selected individual subjects

	Subject 1	Subject 2	Subject 3
Raw scores on neuropsychological tests			
Logical memory I	9	11.5	8
Logical memory II	9	11.5	7.5
Rey figure recall	6.5	11	4
Digit span forward	4	7	6
Digit span backward	4	5	5
Visual span forward	8	6	7
Visual span backward	6	8	8
Trail making B (in seconds)	240	141	63
Total scores on experimental tasks (Trials 1–5)			
Auditory	28	39	38
Visual	42	58	53
Auditory and visual	46	46	48

deviation. The exception is in the Trail Making Test, Parts A and B, where the older subjects' performance was much slower (greater than one standard deviation) than that of younger subjects. Statistical differences in performance were found on the Logical Memory 1 and 2 (from the Wechsler Memory Scale), the Complex Figure Test recall, and the Trails Parts A and B. There were no statistically significant differences in simple span tasks such as the Digit Span Forward and Backwards and the Visual Span Forward and Backwards (all from the Wechsler Memory Scale). It should also be mentioned that unlike clinical populations, the variability in performance was similar between the two groups as manifested by similar standard deviations.

As indicated above, the older group's performance was within one standard deviation of the younger group's mean scores. However, three older subjects scored at least one standard deviation below the mean score of the younger subjects on the majority of neuropsychological tests. This performance level indicates a significant decline in memory function for these older subjects suggestive of possible Age Associated Memory Impairment (AAMI). As defined by the National Institutes of Mental Health (NIMH) work group, those with AAMI perform one standard deviation below the mean of young adults on a series of memory tasks (Crook et al., 1986).

The first subject was a 63-year-old male with a Master's degree. The second subject was a 62-year-old male with three years of college-level course work. The third subject was a 58-year-old male with a high school education. These subjects represent the spectrum of education levels of the younger and older subjects in this study. All three of these subjects were able to recall more items under the visual and simultaneous auditory plus visual presentation than under the auditory presentation (Table 5). These individual cases provided further support for the use of presentation modes that include a visual component to aid with recall performance specifically with individuals who demonstrate decreased memory function.

5. Discussion

The present findings demonstrate that the visual presentation of information resulted in superior learning, recall, and recognition performance in older and younger participants. The visual presentation of items may have provided additional support for learning to older subjects (Sharps, 1991; Sharps & Gollin, 1988). The present findings of the picture superiority in verbal learning tasks are in agreement with previous research with younger subjects with brain injury and noninjured controls

(Constantinidou & Neils, 1995; Constantinidou et al., 1996; Lezak, 1983; Paivio, 1971, 1976).

In the present study, the auditory plus visual modality did not result in significantly better performance compared to the visual condition alone. It is possible that the presentation of pictures was adequate for dual coding or semantic processing and that the external auditory input was superfluous. In other words, the semantic processing elicited by the pictures enhanced the subject's learning to the extent that hearing the name of the picture added nothing more.

Similar learning patterns were observed on the AVLT and on the three experimental modalities. As expected, older subjects demonstrated learning over the five repeated presentations of the same list during the experimental tasks and the AVLT. Even though the rate of learning was similar between the two groups, the amount of words learned or the capacity for learning was significantly different. The older group consistently recalled fewer items than the younger group during the experimental conditions and the AVLT. Swanson (1999) reported that the working memory capacity peaks at approximately age 45 and begins to decline after age 50. The present findings confirm that the multitrial paradigm utilizing supraspan tasks is sensitive in identifying preferred stimulus modalities and in detecting verbal learning changes associated with normal aging.

5.1. Interference effects

In the present study, the presentation and recall of the interference list (List B) did not result in a significant decline in the recall of previously learned material for older subjects. The amount of decline between Trial 5 (last learning trial) and Trial 7 (recall after interference) was similar between the two groups. These results are different from those of clinical populations with memory problems such as patients with brain injury or learning disability, whose results demonstrate a significant retroactive interference effect (Constantinidou, 1999; O'Donnell et al., 1988).

While the aging process does not seem to produce a pronounced retroactive interference effect, older subjects demonstrated a faster rate of decline across time (up to 30 min delay) compared to younger subjects. Conditions containing a visual component were the most resistant to decline for both groups, particularly to the older subject group.

5.2. Recognition performance

The 30-min delay recall challenges the working memory mechanism, and to some degree loss of information is to be expected (Lezak, 1995). The decline in performance of the older subject group could be attributed to storage–retention or retrieval problems. The significantly improved recognition performance of the older subjects indicates that they are able to retain information previously learned. Furthermore, it suggests that some of the changes in working memory of older subjects may be due to retrieval difficulties. If the decline in performance on these tasks was primarily due to storage or retention difficulties, then the recognition performance would not have improved as dramatically. The visual presentation (with or without words) resulted in the most improved recognition performance.

5.3. Relationship between the VVQ and the experimental tasks

A high verbal score on the VVQ indicates that subjects favor verbal strategies when processing different kinds of information. Subjects in this study who scored high on the verbal scale of the VVQ tend to score high on the visual experimental condition. The pictorial presentation of objects in the present study may facilitate processing of verbal material by allowing verbalizers to apply more effective verbal learning strategies. High performance on the imagery score of the VVQ did not correlate with any of the experimental tasks, as these tasks were verbal in nature. These findings may imply that most people can switch strategies according to the nature of the tasks in order to meet task demands regardless of their learning styles (Richardson, 1977).

5.4. Conclusions

The present study aids in the understanding of the complex aging process. Older patients were able to learn and maintain new verbal information. A slow learning curve is not a characteristic of this population. The aforementioned pictorial superiority during verbal learning tasks provides additional support to the notion that situations which provide external support and reduce initiation would be of benefit to older adults (Craik, 1986).

Clinical implications. The present findings support the use of visual therapy materials with older adults. Simple pictures may enhance the learning and carryover of orthopedic exercises and oral motor exercises. Pictures may not only be of assistance with direct therapy techniques, but may enhance education sessions with patients and their significant others regarding anatomical dysfunctions or injuries.

The present study examined older adults ranging in age from 50 to 77. The needs of these individuals in this age range vary greatly. Beyond a therapy perspective, pictures may be used to aid recall and provide additional support for older adults and their caregivers for specific aspects of personal care (e.g., medication administration, insulin therapy, respiratory therapies, alternate feeding procedures). In a work setting or continuing education settings, pictures may be used to assist older adults in obtaining new job skills or hobbies as opposed to strictly oral or written instructions (e.g., an instruction manual containing pictures and words).

Furthermore, tasks that implement recognition of visual information compared to free recall would yield improved performance. This information could be of particular relevance during vocational and educational retraining to maximize opportunities for success. For example, menu-driven computer programs using icons related to specific job-related tasks may enhance information retrieval.

The present study did not assess presentation modes for patients with AAMI. The three subjects with significant memory decline on standard memory tests in the present study benefited from the visual presentation of verbal material. Future research should assess the generalizability of these results with patients with AAMI. Furthermore, the inclusion of older women and the effects of hormone replacement therapy and estrogen changes on the memory mechanism would be a fruitful line of investigation.

Appendix A. Visualizer–Verbalizer Questionnaire (VVQ): Verbal & Imagery Items

(Adapted from Kirby et al., 1988)

1. I enjoy doing work that requires the use of words.
2. I don't believe that anyone can think in terms of mental pictures.
3. I find illustrations or diagrams help me when I'm reading.
4. I enjoy learning new words.

5. I can easily think of synonyms for words.
6. I have a hard time making a "mental picture" of a place that I've only been to a few times.
7. I read rather slowly.
8. I seldom use diagrams to explain things.
9. I like newspaper articles that have graphs.
10. I prefer to read instructions about how to do something rather than have someone show me.
11. I have better than average fluency in using words.
12. I don't like maps or diagrams in books.
13. I spend little time attempting to increase my vocabulary.
14. When I read books with maps in them, I refer to the maps a lot.
15. The old saying "A picture is worth a thousand words" is certainly true for me.
16. I dislike word games like crossword puzzles.
17. I dislike looking words up in dictionaries.
18. I have always disliked jigsaw puzzles.
19. I have a hard time remembering the words to songs.
20. I find maps helpful in finding my way around a new city.

Appendix B. Experimental task stimuli: List A

1. book	16. house	31. saw
2. door	17. coat	32. hat
3. boat	18. feet	33. face
4. wall	19. ice	34. heart
5. ear	20. watch	35. fly
6. bed	21. man	36. roof
7. back	22. egg	37. cup
8. car	23. bear	38. fish
9. gate	24. ball	39. bird
10. rock	25. hand	40. shoe
11. sun	26. tree	41. chair
12. neck	27. girl	42. ship
13. head	28. safe	43. cloud
14. ring	29. mouth	44. hair
15. dog	30. glass	45. tie

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