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Age-Related Differences in Memory for Lateral Orientation of Pictures[1]

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Abstract

Two experiments examined memory for the lateral orientation of scenic pictures by young and elderly adults. In Experiment 1, an input list of pictures was followed by a test demanding discrimination between (a) targets versus reversed copies of input items, or (b) targets versus new pictures which verbally resembled input items. The age-related difference was reliably larger in the former task than in the latter. Experiment 2 compared incidental versus intentional acquisition of orientation under conditions of short (1 second) and long (5 second) presentation of pictures at input. With short presentation, though not with long presentation, intentional instructions reliably *impaired* orientation memory. With both presentation times, robust age-related differences were obtained. The results suggest an age-related deficit in truly non-intentional encoding of orientation, and pose a challenge for capacity theories of memory across the lifespan.

Keywords

Human memory; Left-right relations; Spatial memory; Nonverbal memory; Intentional learning; Incidental learning; Pictorial memory; Visual memory; Attention and memory; Capacity and memory

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A Currently popular notion is that age-related differences in memory reflect age-related declines in cognitive capacity or resources needed for effortful memory tasks (Craik & Simon, 1980; Hasher & Zacks, 1979). Support for this notion comes from tasks such as verbal free recall, known to be effortful and known to produce robust age-related deficits. Support also comes from tasks such as memory for frequency, apparently unaffected by effortful strategies and also insensitive to age-related effects (e.g., Attig & Hasher, 1980; McCormack, 1981, 1982). Unfortunately, capacity accounts of age-related differences have been tested primarily with verbal materials. An important issue is the generalizability of such accounts to memory for nonverbal materials.

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A recent study by Park et al. (1982) suggests that, indeed, capacity accounts might generalize to memory for nonverbal stimuli. Using line drawings of objects as stimuli, Park et al. examined memory for the attribute of spatial location. They compared young and elderly adults and found an age-related deficit in performance. This deficit, however, was larger when spatial location was learned intentionally than when it was learned incidentally (i.e., without forewarning that memory for spatial location would be tested). Thus, the study demonstrated an age-related deficit in intentional memorization of spatial location. On the assumption that intentional strategies are effortful (cf. Hasher & Zacks, 1979), the study suggests an age-related deficit effortful processing of pictorial information.

Although the Park et al. (1982) study suggests age differences in effortful processing, it does not eliminate the possibility of age differences in automatic processing. Our concern in the present research was with this latter possibility, and so we examined memory for a pictorial attribute that *appears* to be encoded automatically. This is the attribute of lateral orientation (e.g., Intraub, 1980; Standing et al., 1970).

In a prior study Kraft and Jenkins (1977, Experiment 2) compared memory for orientation of scenic pictures under incidental and intentional conditions. They failed to find a reliable difference, which suggests that orientation encoding might be automatic (i.e., independent of limits on capacity/resources). The question addressed here was whether such orientation encoding is susceptible to age-related deficits.

Experiment 1 of this research examined age differences in orientation memory under incidental learning conditions only (Experiment 2 included intentional conditions as well). We decided to employ scenic photographs as stimuli, due to their high-interest value to persons of all ages. Using a free-choice recognition test and a measure based on signal detection theory (A′, see Grier, 1971), we assessed adult age differences in discrimination between (a) exact copies of previously presented pictures (targets), and (b) left-right reversals of these pictures (reversals). It obviously is important to assess age differences in orientation memory *not* simply in absolute terms but also relative to age differences in other types of pictorial memory. For this reason we also assessed adult age differences in discrimination between (a) exact copies of previously presented pictures (targets) and (b) new pictures chosen to resemble verbally previously presented pictures (verbal-match items). For purely exploratory purposes we also examined recognition memory for verbal descriptions presented along with pictures at input.

Experiment 1

Method

Young and elderly participants received an input list of pictures, each accompanied by an appropriate verbal description. There was a recognition test for one half of the input descriptions, and then another recognition test for all of the input pictures. There were two experimental conditions, which differed with respect to the picture recognition test. In this test approximately one half of the participants (within each age group) attempted to distinguish among targets (each identical to an input item), reversals (each a lateral reversal of an input item), and control lures. The remaining participants attempted to distinguish among targets, verbal-match items (each a new picture chosen to verbally resemble an input item), and control lures.

Participants—The 52 young participants (*M* age = 19 years, 71 % female) were undergraduates at Southern Methodist University, and the 42 elderly participants (*M* age = 67 years, 55% female) were alumni of the same university. The latter were paid ($5.00) whereas the former received extra credit in a psychology course. Average performance on a vocabulary test (second half of the WAIS) was 19.9 (*SD* = 6.6) in the young group and 31.5 (*SD* = 6.7) in the elderly group. All participants had visual acuity of 20/30 or better in their best eye (corrected).

Materials—The picture stimuli were pairs of 35 mm color transparencies of scenes taken from a magazine. Each pair comprised two different pictures chosen to match the same verbal description. Each pair was classified as a landscape pair (no buildings or man-made objects) or a cityscape pair (one or more buildings or man-made objects).

The input list consisted of 48 to-be-remembered pictures (one member from each of 48 different pairs), along with 10 fillers, five at the beginning of the list and five at the end. The order was random with the constraint that landscapes and cityscapes alternated. Each input picture was preceded by a short (five to seven word) verbal description read aloud by the experimenter. Each description was contrived to be congruent not only with the picture it accompanied but also with the verbally-matching mate of this picture.

The input list was followed by a verbal description test that contained 24 target descriptions (presented at input) and 24 lures. Each lure was constructed by interchanging the initial noun phrase of two target descriptions. For counterbalancing purposes there were two versions of the verbal test, each presented to approximately half of the participants (within age group). One of these versions contained only the landscape descriptions, and the other contained only the cityscape descriptions.

The verbal description test was followed by one of two types of picture recognition test (depending upon experimental condition). The verbal-match test contained 24 verbal-match items (mates of input pictures), as well as 24 targets and 24 control lures. The reversal test contained 24 reversals of input items, as well as 24 targets and 24 control lures. For counterbalancing purposes there were two versions of each test type, each version presented to approximately half of the participants (within age group and experimental condition). The two versions differed with respect to which items were tested as targets and which were tested as verbal-match items or reversals.

Design and procedure—The two major be-tween-subjects variables were experimental condition (verbal-match vs. reversal test) and age. The four resulting cells each included from 19 to 28 participants. Sex also was included as a between-subjects factor in the major analysis of variance. The two within-subjects variables both pertained only to the picture recognition test. The first was cue (targets, related items, and control lures), and the second was description testing. With respect to the latter, recognition performance was scored separately for items whose descriptions were present on the verbal description test and for items whose descriptions were not.

Experimental sessions included two to four participants. Participants were told that picture-description pairs would be presented, and that they should rate the appropriateness of each description to its respective picture using a 6-point scale. They were not forewarned of a memory test. Verbal descriptions were printed on sheets distributed to participants, but they also were read aloud by the experimenter 3 seconds prior to their respective pictures. Each picture was presented for 1 second (controlled by a Lafayette 41010 projection tachis-toscope) and was followed by a 5 second response interval during which the projection screen was illuminated from another projector.

After the input list the verbal description tests were distributed. Participants were told to proceed through these tests at their own pace, responding to each description using a 6-point scale (1 = sure new, 6 = sure old). This test always was completed within 5 minutes.

After participants completed the verbal test, the picture-recognition forms were distributed. Participants were told that another series of slides would be presented. Their task was to view each slide and indicate whether it was a "same" (target) item, a verbal-match or reversal item, or a "new" (lure) item. The test pictures were presented for 10 seconds each, with a minimal inter-stimulus interval (the change time of the projector). Verbal descriptions were not presented on this test.

Results

Verbal recognition test—Correct recognitions of target descriptions were .80 and .81 for young and elderly participants, respectively. False recognitions of lure descriptions were .11 and .21 for the two age groups. The average A′ score (Grier, 1971) for target-lure discrimination was .904 (n = 52, SD = .066) for young participants and .868 (n = 42, SD = .092) for elderly participants (A′ scores generally vary between .50 and 1.00). Though small, the age effect was reliable, $t(92) = 2.21$, $p < .05$, $\omega^2 = .039$.

Picture recognition performance—Analyses of recognition accuracy were based on probabilities of same (exact identity) judgments. For young participants in the verbal-match condition, these probabilities were .86, .03, and .01 for targets, verbal-match items, and control lures, respectively. For elderly participants in the verbal-match condition, the corresponding probabilities were .78, .08, and .04. For young participants in the reversal condition, the probabilities of same judgments were .91, .34, and .05 for targets, reversals, and control lures, respectively. For elderly participants in the reversal condition, the corresponding probabilities were .79, .47 and .11.

Statistical analyses were based on A′ scores representing discrimination between targets and reversals (reversal group) and between targets and verbal-match items (verbal-match group). An analysis of variance supported a reliable main effect of age group, $F(1, 86) = 25.8$, $p < .0001$, $\omega^2 = .091$, and for experimental group, $F(1,86) = 56.0$, $p < .0001$, $\omega^2 = .201$, and also a marginal main effect for sex, $F(1,86) = 3.89$, $p = .05$, $\omega^2 = .011$. These three effects reflected superior discrimination performance on the part of young participants, reversal group participants, and men (the sex effect was only .03 in magnitude on the A′ scale).

The analysis also included the within-subjects factor of description-testing (one half of a participant's targets and resembling items were represented in the verbal test that preceded picture recognition; the other half were not). It produced no main effect ($F < 1$) and participated in no reliable interactions ($ps > .05$).

The most important result of the analysis of variance was the age group × experimental group interaction, $F(1,86) = 8.60$, $p < .005$, $\omega^2 = .028$. Average A′ scores were .95 ($n = 28$, $SD = .03$) and .91 ($n = 23$, $SD = .07$), respectively, for young and elderly participants in the verbal-match group, and they were .86 ($n = 24$, $SD = .07$) and .73 ($n = 19$, $SD = .14$), respectively, for young and elderly participants in the reversal group. The reliable interaction reflects the fact that the age difference in the reversal condition was larger than the age difference in the verbal-match condition.

Figure 1 displays the age × experimental group interaction for easy and difficult items separately (the distinction between easy and difficult items was based on an item analysis of the data from each experimental group). The data support the age × experimental group interaction and suggest that this interaction does not vary with overall performance level (which obviously was greater with easy items than with difficult items). Indeed, a second analysis of variance, which included item difficulty as a within-subjects factor, supported again the age × experimental group interaction, $F(1,90) = 5.56$, $p = .02$, $\omega^2 = .015$ (the age × item-difficulty interaction was not significant, though of course the main effect for item difficulty was robust, $p < .0001$).

Discussion

The results of Experiment 1 supported a substantial age-related deficit in memory for orientation, as assessed by discrimination between targets and reversals in a picture recognition test (reversal group). Not only was this deficit large in absolute terms, it was reliably larger than a deficit observed in another type of pictorial discrimination, that between targets and verbally similar lures (verbal-match group). It also appeared larger than a small deficit observed in recognition of picture-descriptions.

Impressively, the age-related deficit in orientation recognition was observed under incidental learning conditions. Hence, the data suggest age-related differences in nonintentional encoding of orientation. Age-related differences in nonintentional encoding raise the possibility of age-related differences in automatic encoding. Experiment 2 examined this possibility.

Experiment 2

An important type of evidence for automaticity of attribute encoding comes from comparisons of attribute memory after incidental versus intentional learning instructions. Three results of such comparisons are possible: Attribute memory might be better after intentional instructions, better after incidental instructions, or no different after incidental and intentional instructions. The no-difference result clearly is supportive of automatic processing, though the finding that incidental instructions are superior also has been interpreted in this way (Hasher & Zacks, 1979; Schulman, 1973; but see Park et al., 1982). A finding that intentional instructions are superior supports effortful (i.e., attention-demanding) encoding of the attribute. The strongest evidence for effortful processing, however, is a trade-off pattern, in which intentional learning instructions are shown to improve memory for the attribute while impairing simple recognition memory for the to-be-remembered stimuli themselves (Light et al., 1975). In view of the possibility of a trade-off pattern, Experiment 2 assessed effects of intentional learning instructions for orientation upon (a) memory for orientation, and (b) discrimination between old and entirely new pictures in recognition.

Only one prior study (Kraft & Jenkins, 1977, Experiment 2) compared incidental and intentional learning of orientation of pictures. No differences were observed, but the study is limited in that a measure of old/new discrimination was not included. Moreover, only young adults were employed. This is important, as incidental-intentional differences are sometimes restricted to elderly participants (Kausler & Puckett, 1981).

In designing Experiment 2 we considered three complexities that might attend incidental-intentional learning comparisons. First, intentional learning effects on orientation memory might depend upon how orientation memory is measured. The A′ measure of target-reversal discrimination (Experiment 1) removes criterion effects but may be highly correlated with old-new discrimination. This correlation could conceal a trade-off between old-new discrimination and memory for orientation, per se.

In the present Experiment 2 we decided to assess orientation memory not only with the A′ measure but also by computing the conditional probability of correct orientation judgments given (a) recognition of pictures as old, and (b) highly confident recognition of pictures as old. We planned to evaluate all three measures by examining their correlations with old/new discrimination.

Regardless of how orientation memory is measured, a second complexity we faced was that effects of intentional learning strategies might depend upon presentation time for pictures at input. Intraub (1980) has shown that increased presentation time (holding study time constant) can improve memory for orientation. It appeared possible (and important) that relatively lengthy presentation times (5 seconds) might be required in order for intentional learning strategies to benefit orientation memory.

The third complexity we faced was that intentional learning effects obviously might depend upon the particular incidental-learning task to which intentional-learning is compared. Experiment 2 included three different versions of the incidental learning condition. The first was a verbal description condition, included to maximize the comparability of Experiment 2 and Experiment 1 (in which verbal descriptions were presented at input). Because of possible effects that descriptions might have on picture memory, we also included a standard-incidental condition, in which the verbal descriptions were dropped. In both of these first two conditions participants were forewarned of a memory test for the input pictures but were not told that this test would pertain to orientation. These conditions may not be truly incidental (Mandler et al., 1977), and so we added a true-incidental condition in which participants were not forewarned of *any* memory test.

Method

Young and elderly adults received an input list of pictures, half presented for 1 second each and the remainder presented for 5 seconds each. There were four different input conditions, including an intentional condition and three different incidental conditions, each experienced by a separate group of participants (within each age group). The input list was followed by a recognition test in which participants attempted to distinguish between old and new pictures, and to judge the orientation (same vs. different) of all pictures judged old.

Participants—The 60 young participants (*M* = 19 years, 50% female) were from the same population used in Experiment 1. The 67 elderly participants (*M* age = 72 years, 67% female) were recruited from two residential communities for the elderly (47 persons) and from church retirement groups (20 persons). All participants were high school graduates with 20/30 vision or better in their best eye. Vocabulary scores (second half of the WAIS) were 20.2 (*SD* = 7.6) in the young group and 19.3 (*SD* = 8.2) in the elderly group.

Materials—The color slides were of the same type as used previously except that all had an identifiable object clearly localized on the right- or left-hand side of the frame (this was to maximize orientation-memory performance). A five-to-nine word description was devised for each picture (but these were used only in the verbal-description condition).

The input list included 64 to-be-remembered pictures and 10 fillers (five at each end). The picture recognition test consisted of 32 targets, 32 reversals, and 32 control lures. The ordering was random with the constraint that each half of the test contained 16 targets, 16 reversals, and 16 lures.

Design—The major between-subjects variables were age and instructional condition (four levels). Each of the eight resulting cells included from 13 to 20 participants. Again, sex also was included in analyses of variance. The within-subjects variables were cue (targets, reversals, and lures) and presentation-time at input. One half of the input pictures were presented for 1 second each and the remaining for 5 seconds each with the sequence of short and long presentation times randomly determined.

The design also included two counterbalancing variables: (a) picture-to-presentation-time assignment (input pictures presented for 1 second to half of the participants were presented for 5 seconds to the remainder, and vice versa), and (b) picture-to-test-cue assignment (pictures tested as targets with half of the participants were tested as reversals with the remainder, and vice-versa).

Procedure—There were four different input conditions. In the true-incidental condition participants were not forewarned of any memory test. Their task was to rate each input picture with respect to pleasantness, using a 6-point scale. In the standard and verbal-description conditions participants were told to expect a recognition test for the pictures, but they were not forewarned that this test would demand memory for orientation. The task in both cases was to rate the memorability of each input picture using a 6-point scale. The two conditions were identical except for the presence versus absence of verbal descriptions for pictures in the input list. In the intentional condition participants were forewarned that memory for orientation of pictures would be tested. Their input task was to rate the memorability of the orientation of each picture.

In the standard, true-incidental, and intentional conditions each input picture was preceded by its serial position number (read aloud) and was followed by a 7-second response interval during which participants made their ratings. In the verbal-description condition the serial-position number for a picture was followed by its description (also read aloud) prior to presentation of the picture itself. Hence, the interval between pictures was approximately 2 seconds longer in the verbal-description condition than in the other three conditions.

During the recognition test pictures were presented for 7 seconds each, with a 9 second inter-stimulus interval. Participants made old-new judgments using a 6-point scale (1 = sure new, 6 = sure old). If a picture was judged old (4, 5, or 6 on the scale), participants also judged whether it was the same versus different with respect to orientation.

Results

Preliminary analyses of variance failed to produce any reliable differences among the three incidental-learning conditions on any memory measure used in the experiment. These analyses of variance included age and presentation-time as factors, in addition to incidental-learning group. In all subsequent analyses, we collapsed over the three incidental groups and compared them as a single condition to the intentional learning condition.

Discrimination between old and new pictures—The top two rows of Table 1 display A′ scores representing discrimination between targets and lures (first row) and between reversals and lures (second row) by age and input condition. Both measures were based on probabilities of old judgments to old items (hits) and to lures (false alarms). The A′ scores were subjected to an analysis of variance including measure (target-lure vs. reversal-lure discrimination) and presentation time as within-subjects variables and age, input condition, and sex as between-subjects variables.

Age produced a main effect, $F(1, 119) = 65.4$, $p < .0001$, $\omega^2 = .256$, as did input condition, $F(1,119) = 4.22$, $p < .05$, $\omega^2 = .013$, and measure, $F(1, 119) = 17.8$, $p < .0001$, $\omega^2 = .008$. As shown in Table 1, young participants outperformed the elderly, incidental learning gave higher performance than intentional learning, and target-lure discrimination was greater than reversal-lure discrimination. In addition, there was an unsurprising main effect for presentation time, $F(1, 119) = 13.1$, $p < .001$, $\omega^2 = .006$, as long presentation ($M = .82$) produced slightly higher performance than short presentation ($M = .80$). There was a puzzling interaction among age, measure, and presentation time, $F(1, 119) = 5.26$, $p < .05$, $\omega^2 = .002$, that we attempted to clarify through separate analyses of the short- and long-presentation data. Neither of these analyses supported an age × measure interaction (*ps* > .10). The original analysis of variance produced no main effect for sex, $F < 1$.

Memory for orientation—Our three measures of orientation memory were (a) target-reversal discrimination (A′), based on same judgments to targets (hits) versus reversals (false alarms), (b) probabilities of correct orientation judgments given I recognition of targets and reversals as old, and (c) probabilities of correct orientation judgments, given highly confident recognition of targets and I reversals as old. Rows 3, 4, and 5 of Table 1 display the age and input condition effects with each of these three measures. Note that 1.00 represents perfect performance and .50 represents chance performance with all three measures.

In the elderly group, measures *a*, *b*, and *c* were only minimally correlated (r = .21 or less) with the old-new discrimination measures. In the young group, however, the correlation of measure *a* with target-lure discrimination was .67, and that of measure *b* with target-lure discrimination was .59. Both correlations were disturbingly high, but, fortunately, the correlation of measure *c* with target-lure discrimination was only .37 (that of measure *c* with reversal-lure discrimation was similar, .41). For this reason, we chose measure *c* for our major statistical analyses. Note, however, that the three measures behaved similarly across age group and input condition (see Table 1).

An analysis of variance performed on measure *c* supported a main effect for age, $F(1, 119) = 135.2$, $p < .0001$, $\omega^2 = .118$, and for presentation time, $F(1, 119) = 11.3$, $p <.001$, $\omega^2 = .008$. There also was a main effect for sex, $F(1, 119) = 8.03$, $p < .005$, $\omega^2 = .006$, that supported a trend for men to perform slightly better than women (.71 vs .66) as in Experiment 1. Of greater interest, there was an input-condition × presentation-time interaction, $F(l,119) = 7.05$, $p<.01$, $\omega^2 = .005$. (The main effect for input condition was not significant.) Because of the interaction, we again analyzed the short-presenation data and the long-presentation data separately. The former supported a reliable main effect for input condition, $F(1, 119) = 9.08$, $p<.005$, $\omega^2 = .016$. The latter didnot ($F < 1$) but did suggest a marginal input condition × age interaction, $F(1, 119) = 3.13$, p < .08, $\omega^2 = .005$.

Table 2 shows the effects of input condition for each age group at each presentation time. With short presentation time both age groups showed the trend for a negative effect of intentionality (supported by the main effect of input condition). With long presentation time this negative effect appeared to be reduced (young) or even reversed (elderly). The positive intentionality effect shown by the elderly participants, however, did not reach conventional significance levels, $t(65) = 1.68$, $p > .05$.

Discussion

Experiment 2 replicated the principle finding of Experiment 1: There was a large age-related difference in memory for the orientation of complex pictures. The purpose of Experiment 2 was to determine whether effortful, intentional strategies could facilitate orientation memory. We suspected that effects of such strategies might vary with presentation time at input. Indeed, the short (1 second) and long (5 second) presentation conditions differed with respect to intentional learning effects.

In the long presentation condition there was a trend suggesting a beneficial effect of intentional learning instructions on orientation memory (Table 2). The trend, however, was shown only by elderly participants, and, even there, it did not reach conventional significance levels. In the short presentation condition there was clear evidence that intentional learning instructions reliably *impaired* orientation memory, and there was no indication that this effect varied with age.

Although the long-presentation data are somewhat ambiguous, the short-presentation data show clearly that intentional instructions can interfere with orientation memory (as well as old-new discrimination, see Table 1). Such a negative intentionality effect is by itself neither new nor surprising. Similar negative effects have been observed previously with both young (Schulman, 1973) and elderly (Park et al., 1982) participants. Such effects suggest that intentional instructions can sometimes evoke nonoptimal strategies for encoding attribute information. Such strategies apparently can interfere with nonintentional encoding of attribute information, producing a net loss in attribute recall.

What is new and surprising in the present data is the finding that negative effects of intentional instructions can co-exist with strong age-related differences in attribute recall. This pattern, obtained under short-presentation conditions, supports age-related differences in nonintentional encoding of orientation. On the assumption (cf. Hasher & Zacks, 1979) that nonintentional encoding implies automatic encoding, the results suggest age-related differences in automatic encoding of orientation. Such differences could not be explained in terms of limits on processing capacity in old age. Hence, they would threaten the generality of capacity accounts of age-related differences in memory.

Although the present results are compatible with age differences in automatic processing, they also bear an alternative interpretation. This second inter-pretation acepts the concept of “veiled control processes” (Shiffrin & Schneider, 1977), which draw on limited capacity but which are too rapid for voluntary control. If such veiled control processes contribute to orientation encoding, it makes sense that such encoding is unimproved or even impaired by intentionality and, yet, is susceptible to age-related differences. This possibility also is consistent with Intraub's (1980) work on orientation memory, which suggests very rapid attentional mechanisms for encoding orientation of pictures. Such mechanisms could be the source of the age-related deficits observed here.

A final issue to discuss is the relationship between the present results on memory for the left-right orientation of pictures and those of Park et al. (1982) on memory for the left-right spatial location of pictures. The results of these studies were in some respects similar, but only the latter showed positive effects of intentional instructions with young participants. Further, only the latter suggested that intentional instructions increased age-related differences in spatial memory. The apparent discrepancies between the two studies might reflect differences in the to-be-remembered stimuli (complex scenic photographs vs. simple line drawings) or in the particular visuospatial attribute examined (orientation vs. spatial location). It also is possible, however, that the inclusion of an irrelevant-drawing condition in the Park et al. study was critical. Park et al. found that the condition *without* irrelevant drawings produced (a) no tendency for intentionality to improve spatial location recall (collapsing over age groups), and (b) a large age-related difference in spatial location recall (collapsing over incidental vs. intentional instructions). Thus, the no-irrelevant-drawing condition of Park et al. appeared not unlike the present Experiment 2 (see Table 1).

Given the very small literature on age differences in memory for nonverbal stimuli (Arenberg, 1978, 1982; Ferris et al., 1980; Perlmutter et al., 1981; Riege & Inman, 1981; Smith & Winograd, 1978), it hardly is surprising that empirical ambiguities exist. Such ambiguities aside, the presentresults show that orientation memory with pictures is susceptible to strong age-related effects, even under incidental learning conditions and even when intentional learning instructions fail to improve performance. These findings pose a challenge to capacity theories of age differences in memory. Indeed, they must be accommodated by any adequate theory of memory across the lifespan.

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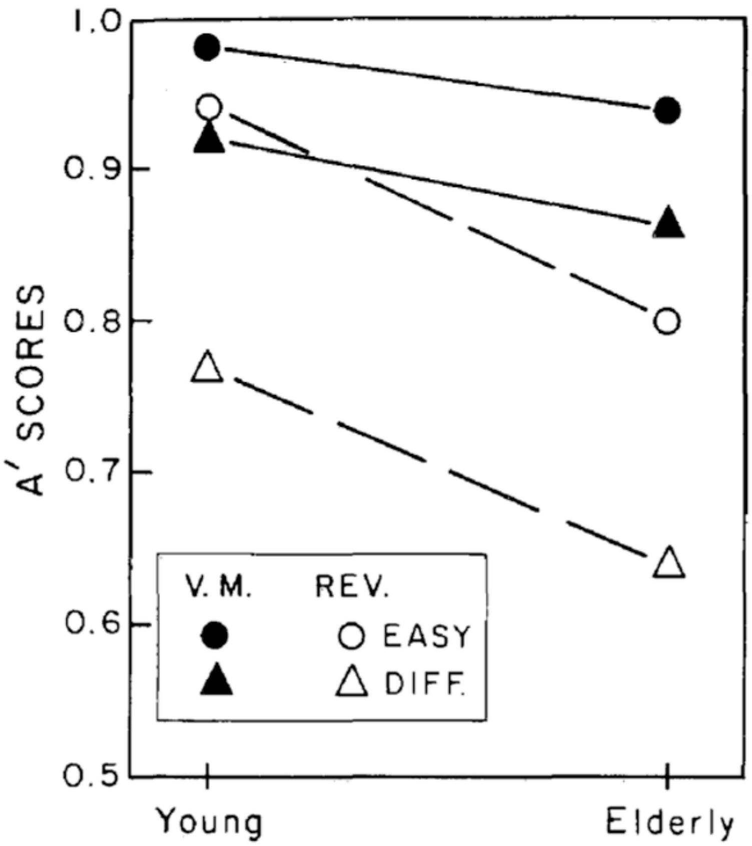

Figure 1.
Discrimination (A′) between targets and reversals (reversal condition) and between targets and verbal-match items (verbal-match condition) as a function of age and discrimination-difficulty.

Table 1

Discrimination (A′) between Targets and Lures, Discrimination between Reversals and Lures, and Orientation Memory (Measures *a*, *b*, and *c*) for Young and Elderly Participants in the Incidental and Intentional Conditions of Experiment 2

	Age and input condition			
	Young		Elderly	
Measure	Incidental (n = 42)	Intentional (n = 18)	Incidental (n = 52)	Intentional (n = 15)
Old-new discrimination				
Target-lure	.90 (.05)	.90 (.04)	.77 (.12)	.73 (.10)
Reversal-lure	.89 (.06)	.86 (.08)	.75 (.12)	.70 (.15)
Orientation memory				
Measure *a*	.81 (.10)	.80 (.08)	.58 (.09)	.60 (.09)
Measure *b*	.77 (.09)	.72 (.09)	.56 (.08)	.57 (.07)
Measure *c*	.82 (.09)	.77 (.10)	.57 (.09)	.58 (.10)

Note. Standard deviations are given in parentheses. Measure *a* is discrimination (A′) between targets and reversals; measure *b* is the probability of a correct orientation decision given recognition; measure *c* is the probability of a correct orientation decision given highly confident recognition.

Table 2

Probability of a Correct Orientation decision Given Highly Confident Recognition (Measure *c*) for Young and Elderly Participants in the Incidental and Intentional Conditions with Short versus Long Presentation in Experiment 2

	Age and input condition					
	Young			Elderly		
Presentation time	Incidental (n = 42)	Intentional (n = 18)	Difference	Incidental (n = 52)	Intentional (n = 15)	Difference
Short	.81 (.13)	.73 (.14)	.08	.57 (.12)	.51 (.13)	.06
Long	.84 (.H)	.81 (.11)	.03	.57 (.15)	.64 (.11)	−.07

Note. Standard deviations are given in parentheses.