DOCUMENT RESUME

ED 195 916 CG 014 871

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TITLE The Effect of Contextual Organization on Spatial Memory of Middle Aged and Older Adults.
PUB DATE Sep 80
NOTE 27p.; Paper presented at the Annual Convention of the American Psychological Association (88th, Montreal, Quebec, Canada, September 1-5, 1980).

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Adult Development; *Age Differences; Cognitive Processes; Comparative Analysis; Females; *Memory; Middle Aged Adults; Mnemonics; Older Adults; *Performance Factors; *Recall (Psychology); *Retention (Psychology)

ABSTRACT

Although age-related memory differences in adulthood occur in a variety of memory tasks, most of these tasks represent uncommon memory demands. An investigation of everyday memory demands explored the effect of contextual organization on memory performance of middle aged (N=20) and older (N=20) women. Tasks involved reconstruction of spatial arrays, with replacement of objects in either a contextually organized panorama or a noncontextually organized bank of cubicles. Performance of the middle aged subjects did not differ between the two tasks. Older subjects performed as well as middle aged subjects in the contextually organized panorama reconstruction, but exhibited a marked deficit in reconstruction of the noncontextually organized version. The pattern of performance and strategy use supports the conclusion that in a task which allows the use of existing contextual organization as a memory aid, age differences in memory performance disappear. Age differences in adult memory performance may be limited to tasks which remove previously learned relationships between items, requiring subjects to invent an organizational structure to facilitate recall. Such tasks are probably unrepresentative of the memory problems met in everyday life, especially by older adults. (Author)

The Effect of Contextual Organization on Spatial Memory of Middle Aged and Older Adults

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This report is partially based on an M.S. thesis submitted by the first author to the University of Utah. Portions of this paper were presented at the meetings of the American Psychological Association, Montreal, 1980. We are grateful to the women who participated as subjects in this study, and to E. Beier, L. Cooper, D. P. Hartmann, W. A. Johnston, J. Skeen, and M. Worsley for their comments and suggestions at various phases of the study. Requests for reprints should be sent to Barbara Rogoff, Department of Psychology, University of Utah, Salt Lake City, UT 84112.

Running Head: Contextual Organization in Spatial Memory

The Effect of Contextual Organization on Spatial Memory of Middle Aged and Older Adults

Pervasive age-related memory differences in adulthood appear with a variety of memory tasks. Compared with younger and middle aged adults, older adults perform less well on memory span, paired associate learning, and free recall tasks (Craik, 1977; Hartley, Harker, & Walsh, 1980). However, nearly all investigations involve memory for isolated bits of information on which organization must be imposed. Such tasks simplify recall units to minimize the effect of previously learned associations and require the subject to design memory strategies to organize the unrelated stimuli. Older subjects have difficulty imposing organization on this kind of input. However, they can apply organizational strategies provided by the experimenter, though less effectively than younger adults (Canestrari, 1968; Denney, 1974; Erber, 1976; Mueller, Rankin, & Carlomusto, 1979; Perlmutter, 1979).

Since remembering lists of independent items is an uncommon memory demand outside of school or psychological tests, a possible explanation for the poorer performance of the aged is that the task demands are divorced from memory skills employed by older adults in everyday life. In investigations of memory with children, age differences are less pronounced with tasks representative of ordinary memory demands (Brown, 1975; Flavell, 1970). Gerontologists are just beginning to explore ways of making tasks more representative of everyday adult experiences (Hartley, Harker, & Walsh, 1980; Schaie, 1978).

In everyday memory, information to be remembered is interrelated in a meaningful context (Cole & Scribner, 1977; Goody, 1977; Rogoff, in press; Rogoff & Waddell, Note 1). Cross-cultural accounts indicate that subjects who have difficulty with traditional memory tasks show excellent memory for integrated,

intrinsically interesting material (Bartlett, 1932; Cole, Gay, Glick, & Sharp, 1971). Anecdotal material (e.g., Levy-Bruhl, 1926) suggests that traditional people display excellent memory for spatial information, and some recent cross-cultural studies have demonstrated impressive performance on spatial memory tests by nonWestern people (Kearins, Note 2; Kleinfeld, 1971; Wagner, 1978). Rogoff and Waddell (Note 1) found that Mayan children, whose performance was poorer than U.S. children on recall span tasks, did slightly better than U.S. children on a spatial reconstruction task. They suggested that it was the contextual organization of the spatial information which facilitated memory performance by subjects who did poorly on standard tests minimizing the relations between items.

Memory for organized spatial information requires recall of items already embedded in a structured context, where the interrelations among items can be used as an aid to recall (vonWright, Gebhard, & Karttunen, 1975). Subjects can use schemata representing their knowledge of the usual relationships displayed in scenes to organize memory for items positioned in the scene (Biederman, 1972; Friedman, 1979; Mandler, 1979). Contextual spatial organization has been shown to influence memory for objects. Subjects remember organized scenes better than unorganized arrangements (Hock, Romanski, Galie, & Williams, 1978; Mandler & Robinson, 1978) and items presented as interacting with each other better than noninteracting stimuli (Horowitz, Lampel, & Takanishi, 1969; Wollen, Weber, & Lowry, 1972).

The present study explores adult age differences in memory for contextually versus nonco textually organized spatial information. Its purpose was both to advance knowledge regarding memory functioning of aged adults and to test the effect of contextual organization on spatial memory. Results of gerontological

studies of visual/spatial memory using noncontextually organized line drawings or designs are generally congruent with the results of verbal memory studies, which show poorer performance in older adults (Arenberg, 1978; Botwinick & Storandt, 1974; Craik, 1977; Harkins, Chapman, & Eisdorfer, 1979; Harwood & Naylor, 1969). It remains to be seen whether adding contextual organization changes the pattern. Our hypothesis was that age differences would be small for the spatial memory task when items were organized in a meaningful context and large when items were noncontextually organized.

This prediction was based on an earlier study by Rogoff and Waddell (Note 1) suggesting that contextual spatial organization is a strategy which people are accustomed to applying to everyday memory problems. The majority of the memory problems faced by middle aged and aged people, or modern and traditional people, involves remembering material which is organized in a complex and meaningful fashion, rather than lists of items which have been stripped of organization. Rogoff and Waddell offer the example of remembering the arrangement of the top of a desk, where a serial listing of items is usually insufficient, since items are spatially arranged in three dimensions, and items overlap one another and bear multiple relationships to each other. Despite outward appearances, there is usually some conceptual order to the array which aids in remembering the location of objects.

The present investigation compares middle aged and older adults' reconstructive memory performance as a functionof the availability of contextual organization cues, in the attempt to make use of task requirements similar to everyday memory demands. Performance is compared in two conditions: reconstructing the placement of objects in a contextually organized panorama containing numerous associative cues and in a setting which was less contextually organized than

the panorama but with equivalent cue richness and task demands. It was predicted that older adults would exhibit a marked performance decrement compared to middle aged adults in the noncontextually organized condition, but would perform as well or almost as well as the middle aged adults on the contextually organized task. Both age groups were expected to perform better on the contextually organized task than on the noncontextually organized version.

Method

Materials

The contextually organized task involved a 60 by 90 centimeter three-dimensional panorama containing mountains, houses, a street, a parking lot, and a church (Figure 1). The noncontextually organized task used a bank

Insert Figure 1 about here

of cubicles which was a 90 by 90 centimeter set of shelves with vertical dividers forming 27 cubbyholes varying in size to accomodate duplicates of all the props from the panorama. These props were dispersed in the cubicles rather than

Insert Figure 2 about here

placed in a contextually organized configuration. Some of the cubicles were empty, just as some areas of the panorama were relatively free from associative cues (Figure 2).

Two standard sets of thirty items were selected from a 120-item pool of three-dimensional miniature objects (cars, animals, furniture, people, household items, etc.) pretested for familiarity to the subject population. The same two sets of objects and order of presentation were used in both the panorama and the cubicles tasks.

Subjects

Twenty middle aged (31-59 years, $\bar{X}$ = 45) and 20 older (65-85 years, $\bar{X}$ = 71) community dwelling adult female volunteers were recruited from local church groups. All subjects reported being in good health and had sufficient auditory and visual acuity to manage the physical demands of the task. The middle aged subjects had completed an average of 14.4 years of formal education (range = 9-16); the aged subjects averaged 12.3 years of schooling (range = 8-18). Ten middle aged and ten aged subjects were assigned to each task.

To check that the population used in the study exhibited the usual age-related performance differences on a traditional memory task, a serial recall task was administered to eight middle aged (30-58 years, $\bar{X}$ = 45) and eight older (66-82 years, $\bar{X}$ = 71) women selected randomly from the same subject pool. The task used was a reconstruction version of serial recall tasks used to assess age-related differences in recall span memory (Botwinick & Storandt, 1974; Craik, 1968; Drachman & Leavitt, 1972). Twenty-five objects from the panorama and cubicles tasks were placed in a semicircular line on a flat, unmarked surface. After a delay, the subject attempted to reconstruct the serial arrangement. Consistent with the findings of traditional gerontological memory studies, middle aged subjects placed more objects in the correct order than did older adults (t (14) = 5.02, $p < .01$). Our sample appears to be comparable on a standard memory task to those used in previous studies.

Procedure

Subjects were tested individually in their church meeting room, with either the panorama or the bank of cubicles. The 120 items comprising the object pool were spread out randomly on a table adjacent to the panorama or bank of cubicles.

Each subject was first asked to name each object in the 120-item pool. This provided them with exposure to both target and nontarget items, reducing the effectiveness of a recognition strategy for later item selection.

The subjects were instructed to watch as some of the items were placed in the panorama (or cubicles), in order to be able to reconstruct the array. After the reconstruction procedure was explained and illustrated with examples, nearly all of the subjects readily placed practice objects in the appropriate locations. Target objects were placed one at a time in the array as the subject watched, and then the subject studied the arrangement as long as she liked. After a 5-minute break, the subject was given an unlimited amount of time to reconstruct the array with the correct items, which had been scattered among the other items in the original pool. Records were made of item selection and of order and location of placement, using a schematic map of the array. The subject's reconstruction was corrected while she watched, and the procedure was repeated with the second set of objects from the same 120-item pool.

Results

Object placement

Since patterns of performance did not differ between trials, and the number of objects correctly placed on the first and second reconstructions correlated .80 ($p < .01$), results from the two trials were pooled for subsequent analyses. Means and standard deviations of number of objects accurately placed and of various reconstruction errors appear in Table 1.

Insert Table 1 about here

Planned comparison analyses were used to test the prediction that performance in the conceptually organized condition would be similar for the two age groups

and that the aged adults would not perform as well in the noncontextually organized task as subjects in the other three conditions. The predicted interaction was confirmed for number of objects correctly placed as well as for most types of error examined: number of objects omitted, substantially misplaced, slightly misplaced, and mistakenly included. The pattern of performance for substitution of similar objects followed the same pattern except that the older adults made more substitution errors than the middle aged adults in the panorama as well as in the cubicles. Results of the planned comparisons, listed in Table 2, show that for each of the parameters except substitution of similar objects: 1) the performance of the middle aged subjects did not differ significantly between the panorama and the cubicles task, 2) the older adults' scores in the panorama task were not significantly different from the average scores of the middle aged subjects, and 3) the performance of older subjects in the cubicles task was significantly worse than the average level of performance of the older adults in the panorama condition and the middle aged subjects in both conditions. Thus, the prediction that age differences in performance would be reduced in

Insert Table 2 about here

the contextually organized panorama condition was supported. It is somewhat surprising, however, that contextual spatial organization did not significantly affect performance for the middle aged subjects. This may be partially explained by their placement strategies in the cubicles condition, discussed in the next section.

Placement strategies

Relative use of placement strategies is summarized in Table 3. The first strategy, spatial sequencing, examines the sequence of placement to evaluate

Insert Table 3 about here

the subjects' use of the spatial schema to order reconstruction. Subjects using the spatial sequencing strategy placed objects to form paths or fill up defined spaces within the panorama or cubicles. For example, they filled the interior of a house and then moved to the yard around the house. Their paths used the structure of the panorama (or cubicles) for ordering placement, and seldom involved linear paths. To avoid confounding this measure of strategy use with overall performance (number of objects correctly placed, which varied according to age and task), it was calculated as a percentage of items placed in spatial sequences out of total number of items placed. Ten percent of the subjects' records were scored independently by two coders, with a resulting percent agreement on occurence of paths of 92%. Use of the spatial sequencing strategy correlated positively with correct object placement (r = .48, p = .02 for middle aged; r = .44, p = .03 for older adults, combining tasks). Spatial sequencing was used more by middle aged than older adults, $F(1, 36) = 6.50$, $p < .05$, and in addition showed an age by task interaction, $F(1, 36) = 7.97$, $p < .01$. Further analysis of the interaction using Tukey's test revealed that the middle aged subjects used this strategy more overall, and used it more in the cubicles than in the panorama, while older subjects used spatial sequencing less in the cubicles than in the panorama. (The probability level for all Tukey's tests reported in this paper is $p < .01$.) The fact that middle aged subjects applied the spatial sequencing strategy more on the cubicles task than on the panorama may partially explain why their performance on the contextually organized task did not exceed their performance on the noncontextually organized task.

The presentation order reproduction strategy involves placing objects according to the original order of object presentation. (For example, with the presentation sequence "bus-sheep-cabinet," presentation order reproduction is scored if at some point the subject consecutively placed the bus, sheep, and cabinet, or bus and sheep, or sheep and cabinet, in either that order or the reverse.) Use of this strategy was calculated as a percentage of objects placed. Presentation order reproduction correlated negatively with correct object placement, $r = -.44$, $p = .002$. Aged subjects used this strategy more than did middle aged subjects, $F(1, 36) = 15.92$, $p < .01$, and both age groups used it more in the cubicles than in the panorama, $F(1, 36) = 13.36$, $p < .01$.

Another measure of presentation order reproduction is the subject's exact duplication of order in placing the first three items presented. For the older adults, but not for the middle aged group, use of this strategy correlated negatively with correct object placement, $r = -.49$, $p = .01$. Analysis of the significant age by task interaction, $F(1, 36) = 10.95$, $p < .01$, with Tukey's test demonstrated that the aged subjects reproduced the exact order of the first three items more on the cubicles task than on the panorama and also more than the middle aged subjects on the cubicles task.

Study time

Amount of study time correlated positively with correct object placement for middle aged, $r = .62$, $p = .002$, but not for older subjects, $r = .13$, $p = .28$. On the first trial, middle aged subjects studied longer than aged subjects, $F(1, 35) = 6.49$, $p < .01$, and a significant age by task interaction appeared, $F(1, 36) = 3.45$, $p < .05$. Tukey's test for the first trial shows that the middle aged subjects studied both the panorama and the cubicles longer (averaging

217 and 242 seconds, respectively) than did the older subjects, who studied the cubicles significantly less than the scene (averaging 97 and 180 seconds, respectively). Though no significant differences appeared in comparisons of study time for Trial 1 and Trial 2 or for group comparisons within Trial 2 (due perhaps to the small number of subjects per group and the substantial variability in the data), it is interesting that older adults markedly increased their study time on the second trial (by an average of 49 seconds on the scene and 118 seconds in the cubicles task) while the middle aged subjects increased their study time minimally (10 seconds in each task).

Summary and Discussion

Marked age differences occurred in the number of items correctly recalled on the noncontextually organized reconstruction task. These results are congruent with the usual findings of age-related discrepancies in performance on memory tests, cited in the introduction. No performance differences between middle aged and older adults occurred on the contextually organized version of the task, contrary to the findings of most gerontological memory studies. The panorama task differs from tests used in previous investigations in the extent to which contextual organizational cues are inherent in the material presented. Traditional memory studies use material from which organization has been stripped, leaving the subjects to invent a mnemonic structure to aid recall. Research has demonstrated that older subjects have difficulty devising organizational strategies and imposing them on input (Erber, 1976; Mueller et al., 1979), and that their memory performance usually lags behind that of younger subjects even when strategies are supplied (Denney, 1974; Perlmutter, 1979).

The patterns of study time and strategy use in the present study suggest that age differences in mnemonic activity differ according to whether or not

the material to be remembered is contextually organized. Study times were comparable between middle aged and older subjects on the panorama task. However, on the first trial of the cubicles task the aged adults studied the arrangement about half as long as they studied the panorama, and less than half as long as the middle aged adults studied the cubicles. Although the older adults more than doubled their study time for the second cubicles trial, it was still less than the time spent by the middle aged subjects.

These differences in study time, coupled with the older subjects' performance deficits and their spontaneous comments on the difficulty of the cubicles task, suggest that they may have been overwhelmed by the complex demands of the noncontextually organized task and may have experienced difficulty devising strategies to apply to that task. On the cubicles compared to the panorama, the older subjects employed less spatial sequencing and more exact duplication of original placement order of the first three items. By contrast, the middle aged subjects used spatial sequencing more in the cubicles task than in the panorama without changing the extent of use of presentation order reproduction. This is especially interesting since spatial sequencing is positively related to correct object placement, while duplication of original placement order correlates negatively with good performance.

Use of the spatial sequencing strategy is a measure of the extent to which subjects employed spatial organization in reconstruction. On the panorama task, where items were contextually organized, middle aged and older adults equally applied the spatial sequencing strategy and achieved comparable reconstruction performance. However, on the noncontextually organized version of the task, middle aged subjects used systematic spatial sequencing to a substantially greater extent and performed better than did older subjects. Age-related

performance deficits in reconstruction and strategy use were attenuated when material was contextually organized.

What accounts for the differences in performance on contextually organized vs. noncontextually organized materials? We predicted aged adults' successful performance and application of appropriate spatial sequencing strategies in the panorama task on the basis of similarity to everyday memory demands. Goody (1977) suggests that facility in standard psychological tests involving lists of decontextualized words stems from familiarity with lists and with the classification systems that lists promote (e.g., alphabetic, categorical). Goody suggests that facility with list memorizing is a product of literacy which may be irrelevant for people in oral cultures.

Several cross-cultural studies support the view that memory for contextually organized material is independent of skill at remembering lists of noncontextually organized materials. In a task similar to the panorama task used in this study, Rogoff and Waddell (Note 1) observed rehearsal of object names by about a third of the U.S. subjects but by only 1 of 30 Mayan subjects (the Mayan subjects performed slightly better than the U.S. subjects). It is likely that rehearsal of object names would not help substantially in reconstruction, since the objects were present at the time of the test, and the major part of the task was remembering their locations. Indeed, it is possible that a subject who has learned strategies for remembering lists of words would inappropriately impose those strategies on inherently organized material, to the detriment of performance.

Recent work by Kearins (Note 2) similarly suggests that successful reconstruction of spatial arrays is accompanied by remembering the "look" of the arrangement, rather than by the use of verbal listing strategies useful in standard memory tasks. Kearins noted that Aborigine subjects, who consistently

performed better than Australian White subjects, replaced items carefully and deliberately, while the White youth replaced the first four or five objects hastily and slowed for the remaining items, often changing the position of objects which had already been placed. When asked how they remembered the display, the Aborigine youth most frequently replied that they remembered the "look" of it, while the White subjects often referred to verbal listing strategies: "I tried to learn around the outside by saying the colours of the bottles" (p. 17).

Cohort differences similar to those between cultures may be responsible for differences in memory performance of middle-aged and older adults. Aged adults have fewer years of formal schooling, their experience with schooling is less up-to-date, and their current practice of school skills is limited (Labouvie-Vief, Hoyer, Baltes, & Baltes, 1974; Papalia & DelVento Bielby, 1974). Rogoff (in press) reports a consistent performance advantage of groups with greater schooling tested on standard memory tasks. In school, learning to impose organization on otherwise unrelated material (e.g., by clustering items by category or inventing associations) is an important mnemonic skill. Schooling is described by Piaget and Inhelder (1973) as a means of instructing children in memory strategies foreign to spontaneous, everyday use of cognitive schemata. Older adults have had no experience with school for forty years or more, while the college students who usually serve as the comparison group are near the peak of their academic skill development. In the present investigation, years of schooling correlated positively with memory performance, $r = .32$, $p = .02$. There are indications that schooling may have been helpful mostly in boosting performance on the cubicles task, while it may have hampered performance on the panorama reconstruction. While the number of subjects is too small to

test these task by age differences, the relationship is provocative. Schaie (1959) suggests that greater educational opportunities available to younger subjects gives them an advantage over older subjects in novel test situations. He urges gerontological researchers to maximize the external validity of their investigations by devising methods of evaluating intellectual functioning which tap abilities used by older adults in everyday life (Schaie, 1978).

The results of the present study suggest that the common age differences in memory performance may be limited to tasks which resemble school skills requiring structuring of unrelated items. Memory for contextually organized material seems to function somewhat independently of, and involve different skills than, memory for noncontextually organized materials. Age differences may be minimal in tasks which allow the contextual organization of the material to be used as a recall aid, since this is a well-practiced mnemonic activity in the everyday lives of old people as well as young.

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Table 1

Means (and standard deviations) of number of objects correctly placed, omitted, and erroneously placed

	Middle Aged Adults		Aged Adults	
Number of	Scene	Cubicles	Scene	Cubicles
Objects Correctly placed	44.7 (6.2)	43.5 (8.8)	42.9 (6.3)	21.5 (7.2)
Omissions	5.1 (5.3)	5.4 (4.4)	7.0 (4.3)	15.4 (4.6)
Extraneous inclusions	0.3 (0.5)	0.7 (1.0)	0.7 (1.2)	5.3 (7.0)
Location errors-- substantial	0.1 (0.3)	1.7 (2.3)	1.0 (0.9)	6.6 (4.7)
Location errors-- minor	8.3 (2.1)	7.4 (3.3)	6.3 (2.8)	10.6 (3.1)
Substitutions of similar items	1.6 (1.5)	1.7 (1.5)	2.6 (1.5)	3.6 (1.6)

Table 2

Planned comparisons of objects correctly placed, omitted, and erroneously placed

	Middle aged adults on panorama vs. cubicles	Older adults on panorama vs. average for middle aged adults	Older adults on cubicles vs. average of the other 3 conditions
Objects correctly placed	$F(3,36) = 0.17$	$F(3,36) = 0.32$	$F(3,36) = 3.39^{*}$
Omissions	0.71	0.53	3.38*
Extraneous inclusions	0.15	0.10	2.82*
Location errors--substantial	1.14	0.09	6.24**
Location errors--minor	0.54	1.26	3.06*
Substitutions of similar items	0.18	4.11*	4.69**

*$p = .05$

**$p = .01$

Figure Captions

Figure 1. Illustration of the panorama.

Figure 2. Illustration of the bank of cubicles.

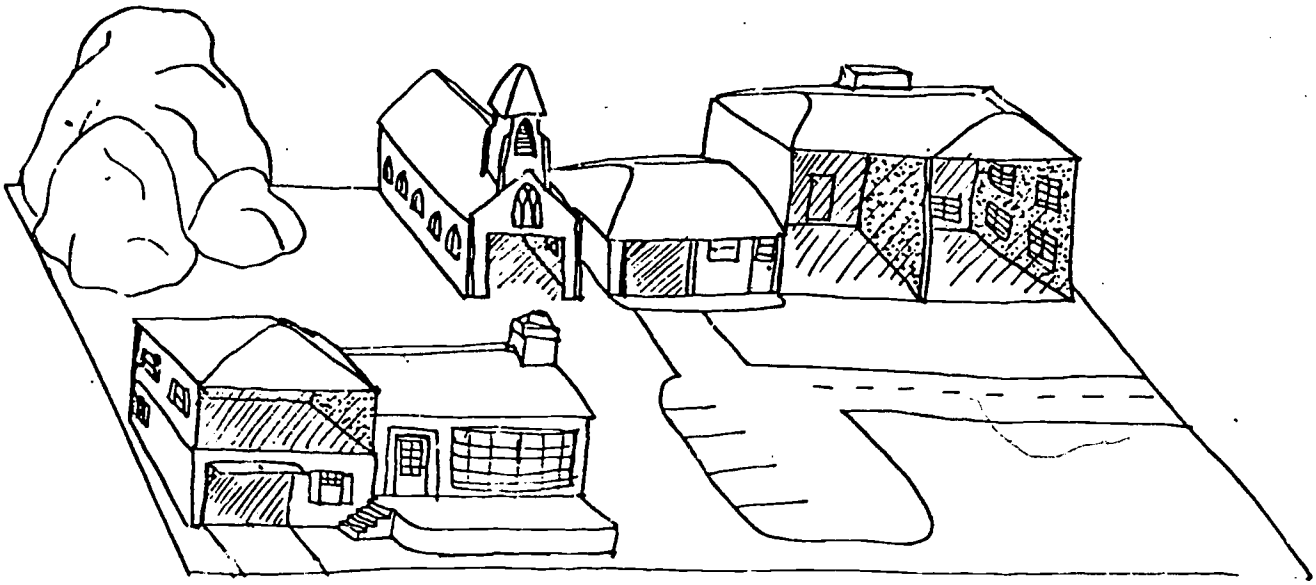

Table 3

Means (and standard deviations) for use of reconstruction strategies

	Middle Aged Adults		Aged Adults	
Strategy	Scene	Cubicles	Scene	Cubicles
Spatial sequencing (%)	60.97 (21.56)	73.96 (15.33)	56.64 (16.62)	43.44 (9.41)
Presentation order reproduction (%)	2.28 (1.76)	5.88 (1.92)	6.23 (1.60)	9.97 (6.01)
Exact order of first three items	.60 (.70)	.30 (.67)	.20 (.42)	1.40 (.97)