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Flexibility in Children's Use of Spatial and Categorical Organizational Strategies in Recall

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Two studies investigated flexibility in children's use of spatial and categorical clustering strategies in recall. In Study 1, 10-, 12-, 14-, and 16-year-olds and adults recalled the furniture from their home. Ten-year-olds organized furniture categorically, and 16-year-olds and adults organized items spatially. Twelve- and 14-year-olds exhibited equal levels of spatial and categorical organization. Study 2 investigated how encoding experiences and the recall task influenced the degree of spatial and categorical organization in 10- and 12-year-olds' recall. When recalling objects, 10- and 12-year-olds exhibited higher levels of categorical than spatial organization. When recalling objects and their locations, 12-year-olds exhibited more spatial than categorical organization. Results are discussed in terms of age and task influences on flexibility of strategy use.

The finding that children's memory performance increases when items are clustered categorically during retrieval has stimulated a great deal of interest in how organizational strategies emerge throughout the course of childhood (e.g., Belmont & Butterfield, 1977; Cole, Frankel, & Sharp, 1971; Frankel & Rollins, 1985; Lange, 1973; Moely, Olson, Halwes, & Flavell, 1969; Ornstein, Naus, & Liberty, 1975; Schneider, 1986). Although research in this area has provided insight into how children's use of categorical clustering strategies develops, few studies have investigated the development of other organizational strategies and how children and adults use their repertoire of organizational strategies to meet the demands of varying task conditions. In particular, little is known about the use of spatial location as a principled means of grouping objects in free recall. In most memory paradigms the objects are not given distinctive stable positions within a spatial framework, and thus subjects cannot use location to organize recall. In everyday encounters with objects, however, individuals often make note of where objects are in addition to what kinds of objects they see. Presumably, both types of information are available for organizing one's recall of those objects. The primary purpose of the studies reported here is to provide a broader picture of the development of organizational strategies by observing the conditions under which children of differing ages use categorical and spatial clustering strategies when both are simultaneously available for recalling a set of objects.

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A major hallmark of cognitive development is the ability to apply strategies flexibly and appropriately. As others have observed, young children and novices often have difficulty knowing when and how to apply problem-solving procedures (Brown, Bransford, Ferrara, & Campione, 1983; Shaklee, 1979; Siegler, 1986). Over time, children become increasingly discriminating in their use of strategies, both in applying strategies to a broader range of problems and in restricting their use of strategies to appropriate situations. According to Siegler and Shipley's (in press) model, these advances are the result of competition among available strategies. As children try out different strategies, they learn about which strategies are most effective for solving particular problems. Effective strategies are more likely to be used for solving those problems in the future, and less effective strategies tend to drop out over time. In the addition of small numbers, for example, children move toward increasing use of the most efficient addition strategies, and they move toward use of faster strategies on simple problems and more time-consuming and effortful strategies on difficult problems (Siegler, 1986).

In everyday memory situations, there are a variety of possible organizational strategies from which to choose. Studies of children's recall of classmates' names, for example, have shown that 6- to 10-year-olds use race, gender, seating arrangement, reading group, and social relationships to organize their recall (Bjorklund & Zeeman, 1982, 1983). In these studies, each child received a clustering score for each type of organizational scheme, and to examine whether children exhibited some form of organization in their recall, the researchers entered only the child's highest clustering score into the analyses. However, with the exception of clustering scores based on classroom social organization, scores for specific types of organizational strategies were not compared across ages. Therefore, although these results showed that young children use some form of organization in their recall, they tell us little about how use of organizational strategies change with age or the factors that influence choice of organizational strategy.

One potentially useful avenue for studying flexibility in deployment of memory strategies is to provide children with a limited number of possible organizations and observe how their use of those strategies varies with age and task demands. Accordingly, the present investigation was concerned with children's use of categorical clustering strategies and spatial clustering strategies. As mentioned previously, much of the past work on the development of organizational strategies has focused on children's use of categorical clustering strategies. Numerous studies have revealed that spontaneous use of categorical clustering undergoes considerable development between 10 and 12 years of age (Frankel & Rollins, 1985; Lange, 1973; Moely et al., 1969). Children under 10 or 11 years of age will organize their recall categorically if the items in each category are highly associated (e.g., dog and cat) but not when the items are not highly associated (Frankel & Rollins, 1985; Lange, 1973). As children's knowledge about categorical relations and their awareness of categorical clustering strategies develop, however, they become more adept at using categorical organization to structure their recall. It is not known, however, whether similar processes underlie other types of organizational strategies.

The extent to which children use spatial organization to structure their free recall has not been well-documented. As a result, information about children's use of spatial clustering comes primarily from studies of search organization and spatial direction-giving (Cornell & Heth, 1986; Plumert, Pick, Marks, Kintsch, & Wegesin, 1994; Wellman, Somerville, Revelle, Haake, & Sophian, 1984). These studies have revealed that there are developmental changes in how children apply spatial clustering strategies. One of the first ways in which children use their spatial clustering skills is in organizing their searches for objects. For example, 4- and 5-year-olds, but not 3-year-olds, are capable of spatially organized searches in situations in which there are relatively few locations that are subdivided into a small number of spatial clusters (Wellman et al., 1984). Studies of the development of children's spatial direction-giving skills have shown that 6-year-olds are capable of verbally describing object locations in a spatially organized manner if specifically prompted to do so (Plumert et al., 1994). By 8 years, children's spontaneous descriptions of spaces become much more spatially organized (Gauvain & Rogoff, 1989). Taken together, these studies suggest that as children grow older they become increasingly able to use spatial organization to guide their activity within the physical environment and to structure their communication about locations. One goal of the first study reported here was to investigate developmental changes in children's use of spatial organization in recall.

The ways in which children of differing ages modify their use of organizational strategies to meet the demands of the task is central to understanding developmental changes in the flexibility of strategy use. One aspect of the task known to influence children's use of categorical clustering strategies is encoding experiences. When young children are encouraged to sort items into categories before recalling them, their use of categorical clustering during recall increases (Moely et al., 1969; Sodian, Schneider, & Perlmutter, 1986). By extension, if children have more than one organizational strategy at their disposal, encoding experiences may bias them toward relying more on one strategy than on the others. For example, children who experience objects grouped by category at encoding may exhibit more categorical clustering at recall than do children who experience objects grouped by spatial location during encoding. One goal of the second study presented here was to systematically investigate how exposure to spatial or to categorical organization during encoding affects children's use of spatial and categorical clustering strategies at recall.

Another aspect of the task that may influence children's use of categorical and spatial clustering strategies is whether or not the recall task involves a spatial component. Specifically, children may be more likely to organize their recall spatially if the task involves recalling objects with their locations than recalling objects alone. Trying to remember the location of an object may cue children to think about other nearby objects. Consistent with this idea, von Wright, Gebhard, and Karttunen (1975) found that when asked to recall the names and locations of items together, children tended to cluster the items by location. Previous investigations of adult spatial memory by Clayton and Chattin (1989) and McNamara, Altarriba, Bendele, Johnson, and Clayton (1989) have shown that spatial priming for familiar items only occurs when the judgment involves a spatial component. Names of adjacent states, for example, did not prime each other when the task involved discriminating state from nonstate names. Spatial priming effects were found only when subjects were asked to judge which of two states was closer to a third. These findings show that identity and location information are more or less likely to be used depending on whether the judgments involves a lexical or a spatial decision. Another aim of the second study reported in this article was to examine how children's use of spatial and categorical clustering strategies is influenced by the presence or absence of a spatial component in the recall task.

Two studies were conducted to investigate the development of flexibility in children's use of spatial and categorical organizational strategies. Study 1 examined the emergence of the spontaneous use of categorical and spatial clustering strategies in children's recall of a familiar set of items. The purpose of Study 1 was to investigate how children's use of spatial and categorical organizational strategies changes with age. This issue was addressed by asking 10-, 12-, 14-, and 16-year-olds and adults to recall the furniture from their home. Making a furniture inventory from memory is a particularly useful task for investigating spatial and categorical organizational strategies because furniture items can be grouped either by category (e.g., tables, chairs, beds, or dressers) or by spatial region (e.g., kitchen, living room, bedroom, or laundry). Furthermore, because adults and children have repeated experience with their furniture, both the locations and types of furniture in their home are very well known to them. This age range was chosen because research on the development of categorical organizational strategies has shown that spontaneous use of categorical clustering strategies appears between 10 and 12 years of age.

The goal of Study 2 was to investigate how encoding experiences and the nature of the recall task influence children's use of spatial and categorical clustering strategies. It was hypothesized that as children become more flexible in their deployment of organizational strategies, they should be more likely to tailor their use of spatial and categorical organizational strategies to fit the demands of the task. Ten- and 12-year-olds helped an experimenter hide 16 categorizable objects in four rooms and were later asked to recall those objects and their locations. The effect of encoding experiences on retrieval organization was examined by showing children the objects grouped by category or the set of hiding places in each room before hiding the objects. To explore how the nature of the recall task influences choice of organizational strategy, the experimenter asked all of the children to recall the objects and their locations after they recalled the names of the objects.

Study 1

Method

Subjects

Forty-one 10-year-olds, thirty 12-year-olds, thirty-three 14-year-olds, thirty-eight 16-year-olds, and 30 adults served as subjects. They were drawn from two 4th-, 6th-, 8th-, and 10th-grade classrooms and one college classroom. All adults were volunteers from a child psychology course. There were 25 male and 16 female subjects in the 10-year-old group, 15 male and 15 female subjects in the 12-year-old group, 18 male and 15 female subjects in the 14-year-old group, 17 male and 21 female subjects in the 16-year-old group, and 11 male and 19 female subjects in the adult group. The mean ages of the children were 10 years 0 months (range = 9 years 6 months to 10 years 6 months), 12 years 1 month (range = 11 years 1 month to 12 years 7 months), 14 years 4 months (range = 13 years 8 months to 15 years 6 months), and 16 years 4 months (range = 15 years 5 months to 17 years 3 months).[1] The mean age of the adults was 22 years 10 months (range = 20 years 3 months to 37 years 1 month).

Procedure

Both children and adults were group tested as part of a classroom activity. The first task was to recall as many pieces of furniture from their home as they could remember. Subjects were given several sheets of paper containing numbered lines on which to write down their responses. Subjects were instructed to "write down as many pieces of furniture from your home as you can think of." The experimenter also emphasized that it was up to each individual to decide which objects in his or her home were furniture. The instructions given to the adults and children were identical except that children were asked to write down one or two words to describe each piece of furniture as it was recalled. This was necessary to ensure that they would be able to identify each individual piece of furniture when they were asked later to write down where each item was located. Two experimenters assisted individual children with spelling by printing the word in question on a small piece of paper. The spelling aid was removed immediately after children copied the word onto their paper. Subjects who finished early were instructed to turn their paper over and wait quietly. When everyone finished recalling their furniture, they were given the second task of writing down the room in which each piece of furniture was located. No time limits were imposed on subjects for completing either of the two tasks. The time taken to recall furniture varied between 10 and 30 min, and the time taken to recall the locations of the furniture varied between 5 and 20 min.

Coding

A list of 17 possible furniture categories were used to code subjects' recall protocols (see the Appendix). These categories were validated by an independent sample of 14 adults. The adults were given the list of categories and 90 different exemplars drawn from the protocols of a random sample of twelve 10- and 12-year-olds and adults who participated in the study. The adult raters were asked to make judgments about which one of the categories best fit with each exemplar. The adult raters were encouraged to do their best to fit each item into one of the categories, but they were allowed to use the *other* category if they thought none of the categories could be used to describe a particular item. Agreement for the 17 categories was high, ranging from 79% to 100% (M = 90%). Three categories out of the 17 that are not strictly speaking furniture categories (plumbing fixture, major appliance, and recreational/electronic equipment) were included because they appeared in a large number of recall protocols. The percentage of nonfurniture items generated by the 10-, 12-, 14-, and 16-year-olds and adults was 19%, 15%, 9%, 13%, and 7%, respectively.

A categorical clustering score and a spatial clustering score were computed for each subject's furniture recall to assess the degree of categorical and spatial organization present. The clustering measure used here was the *adjusted ratio of clustering* (ARC) score (Roenker, Thompson, & Brown, 1971). Basically, this score represents the proportion of observed number of category (or room) repetitions in relation to the total possible number of repetitions corrected for chance. A score of 1.00 represents perfect clustering and a score of 0.00 represents no above-chance clustering. Because scores below zero essentially represent no above-chance clustering, all negative scores were set to zero. ARC scores in this study ranged from 0.00 to 1.00. Items were excluded from subjects' recall protocols if they did not fit into a furniture category (e.g., pet cage, rug, or fireplace), were listed in plural (chairs, dressers, or end tables), or it was impossible to determine where they were located. The average percentage of items excluded for the 10-, 12-, 14-, and 16-year-olds and adults was 17%, 17%, 9%, 10%, and 1%, respectively. The majority of excluded items were nonfurniture objects that occurred near the end of subjects' recall protocols.

Results

The major analysis centered around the question of whether the five age groups differed in the extent to which they used categorical and spatial clustering strategies to organize their recall. This issue was addressed by comparing the five age groups' categorical and spatial ARC scores. A secondary analysis compared the number of furniture items the five age groups generated. Correlations were also computed between clustering scores and number of items generated to examine the relation between organization and level of recall.

Recall Organization

In the examination of the degree of spatial and categorical clustering in subjects' recall protocols, a 5 (age) × 2 (type of clustering) repeated measures analysis of variance (ANOVA) was carried out on subjects' spatial and categorical ARC scores with the first factor as a between-subjects variable and the second as a within-subjects variable. This analysis yielded significant main effects of age, $F(4, 167) = 9.60, p < .0001$, and type of clustering, $F(1, 167) = 31.07, p < .0001$. Both of these effects, however, were subsumed under a significant Age × Type of Clustering interaction, $F(4, 167) = 28.91, p < .0001$.

Simple effects tests were carried out on spatial and categorical clustering scores at each age to test whether categorical and spa-

[1] Five additional 10-year-olds and 6 additional 12-year-olds were dropped because their responses were unscoreable. Recall protocols were deemed unscoreable when children failed to provide clear labels for rooms listed. Most commonly, this problem occurred when children did not differentiate between bedrooms.

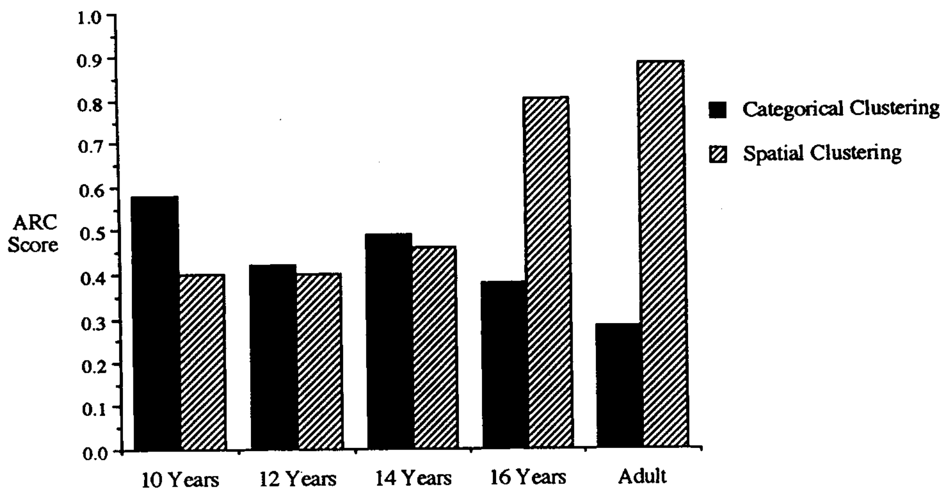

Figure 1. Mean categorical and spatial clustering scores for recalling furniture as a function of age. ARC = adjusted ratio of clustering.

tial clustering scores were significantly different at each age level. These simple effects tests revealed main effects of type of clustering for the 10-year-olds, $F(1, 167) = 9.72$, $p < .01$; 16-year-olds, $F(1, 167) = 50.36$, $p < .0001$; and for adults, $F(1, 167) = 81.79$, $p < .0001$. As shown in Figure 1, 10-year-olds' categorical clustering scores were significantly higher than their spatial clustering scores. In contrast, 16-year-olds' and adults' spatial clustering scores were higher than their categorical clustering scores. Twelve- and 14-year-olds' spatial and categorical clustering scores were nearly identical.

Number of Furniture Items Generated

A 5 (age) × 2 (sex) ANOVA was conducted on number of items generated to compare the number of furniture items the three age groups generated. This analysis yielded a significant main effect of age, $F(4, 162) = 23.85$, $p < .0001$. The mean number of furniture items the 10-, 12-, 14-, and 16-year-olds and adults generated was 28, 35, 30, 53, and 59, respectively. Follow-up tests using Tukey's honestly significant difference (HSD) revealed that the 16-year-olds and the adults produced more items than did the 10-, 12-, and 14-year-olds. There were no significant differences between the number of items the 10-, 12-, and 14-year-olds produced.

There was also a significant Age × Sex interaction, $F(4, 162) = 2.74$, $p < .05$. Simple effects tests revealed a main effect of sex for the 10-year-olds, $F(1, 162) = 9.76$, $p < .01$, as a result of more items generated by 10-year-old girls ($M = 38$) than by 10-year-old boys ($M = 22$). Male and female subjects in the other age groups did not differ significantly.

Relation Between Organization and Recall

A series of correlational analyses were also conducted to examine whether the degree of categorical or spatial clustering was related to the number of furniture items generated. First, correlations were computed for each age between subjects' categorical ARC scores and the number of items they produced. None of these correlations were significant. The correlations for the 10-, 12-, 14-, and 16-year-olds and adults were .00, .33, −.06, .16, and −.09, respectively.

The parallel set of correlations computed between subjects' spatial ARC scores and number of items generated yielded a different pattern of results. The relation between spatial clustering and recall for 10-year-olds approached significance ($r = .30$, $p = .06$). The 12-, 14-, and 16-year-olds, however, showed a strong positive relation between the level of spatial clustering and number of items they generated ($r = .61$, $p < .001$; $r = .50$, $p < .01$; and $r = .45$, $p < .01$, respectively). The relation between organization and recall was not significant for the adult group ($r = -.05$), quite likely because their use of spatial clustering was near ceiling.

Discussion

These results suggest that when spatial and categorical clustering strategies are simultaneously available for recalling familiar information, there is a developmental transition from reliance on categorical to spatial organization between 10 and 16 years of age. At 10 years of age, children showed a clear preference for organizing their recall categorically. Twelve- and 14-year-olds had about equal levels of spatial and categorical clustering in their recall, but by age 16, adolescents exhibited a high degree of spatial organization in their recall. This pattern of results suggests that children's use of spatial organizational strategies changes between 10 and 16 years of age. Specifically, 10-year-olds seem to have difficulty using their spatial clustering skills to structure their recall of object names. Twelve- and 14-year-olds may be moving into a more transitional age in which they waver in their use of spatial and categorical organization. By 16 years of age, adolescents are clearly able to use what according to adult standards appears to be the most appropriate strategy for the task of recalling furniture.

Why do younger children prefer categorical organization over spatial organization? This phenomenon is intriguing because it seems more intuitively obvious to inventory furniture by recalling the items in each room than by recalling the items from each furniture category. One possible reason why younger children prefer categorical clustering strategies may be that knowledge about what an object is may be more closely linked with the task of recalling object names than is knowledge about where it is. Therefore, when faced with the challenge of recalling a large set of objects, younger children may use categorical clustering because it is more familiar and occurs more readily to them. As children grow older, presumably their spatial clustering skills become more flexible and hence they are able to apply spatial organizational strategies to a wider range of tasks. Study 2 was designed to explore further the factors that influence children's use of spatial and categorical organization.

Study 2

The goal of Study 2 was to investigate the extent to which younger and older children are able to modify their use of organizational strategies to fit the task demands. The basic procedure involved having 10- and 12-year-olds hide several categorizable objects at distinctive locations within several rooms and later recall the objects and the object locations.

Two factors that were predicted to influence the degree of spatial and categorical organization in subjects' recall were examined. First, to examine whether recalling only semantic information (i.e., names of objects) or both semantic and spatial information (i.e., objects and their locations) influences the degree to which recall is spatially or categorically organized, the experimenter asked the children to recall the objects and then to recall where each object was located. The results of Study 1 suggested that 10-year-olds had a strong bias to organize their free recall categorically. Twelve-year-olds, on the other hand, appeared to be about equally likely to use spatial or categorical organization to structure their free recall. Therefore, the ages of 10 and 12 were chosen because it was expected that when the task involves only a semantic component, both 10- and 12-year-olds should rely heavily on categorical organization. When the task involves a spatial component, however, 10-year-olds should have more trouble overcoming their bias to organize information categorically than should 12-year-olds. This suggests that 12-year-olds should rely more heavily on spatial than categorical organization than should 10-year-olds.

Second, to see whether patterns of recall organization would reflect the type of organization experienced during encoding, children saw the objects grouped by category or the locations grouped by room before hiding the objects. There was also a control condition in which children saw neither the objects nor the hiding locations before they hid the objects. It was expected that children who experienced the objects grouped categorically would exhibit the most categorical organization in their recall, and children who saw the hiding places grouped by room would exhibit the most spatial organization in their recall. Again, it was expected that the 12-year-olds would be more influenced by spatial encoding experiences than would the 10-year-olds.

Method

Subjects

Thirty 10-year-olds and thirty 12-year-olds participated in this study. The mean ages were 10 years 6 months (range = 10 years 1 month to 10 years 11 months) and 12 years 4 months (range = 11 years 11 months to 12 years 10 months). There were equal numbers of male and female subjects in each age group and experimental condition. The children were recruited through a university child research participant registry.

Design and Procedure

The basic procedure involved having the children hide several distinctive objects in four rooms and later recall the objects and the objects with their locations. They hid 16 toys from four categories: (a) vehicles (car, ambulance, truck, and plane); (b) clothing (dress, shorts, shoes, and shirt); (c) animals (giraffe, tiger, gorilla, and elephant); and (d) furniture (table, lamp, chair, and bed). One object from each category was hidden in each of four rooms in a nursery school setting.[2]

Before the session began, the experimenter instructed the subjects that they would be hiding 16 small toys and will later be asked to recall verbally the toys they hid and where they put each one. Children were randomly assigned to one of three experimental conditions. In the *category biased* condition, children were shown the objects grouped by category before they hid them. They were given as much time as they wanted to look at each group of objects before it was put away and the next group was taken out. In the *location biased* condition, children were shown the four hiding places in each room before they hid the objects. On entering each room, they were told the name of the room and then were shown the four hiding places. They were given as much time as they wanted to look at each hiding location and were asked to name the hiding places before leaving the room. In the *control* condition, children were not shown the objects or the actual hiding places before they hid the objects.

Immediately after the instructions phase of the experiment, subjects hid the objects. A different random order and different hiding locations within the rooms were used for each subject to increase the generality of the findings. Hiding locations were chosen that had minimal associations with each other and with the objects. The hiding locations were always other objects that were used to occlude the target objects. For example, the red car may have been hidden under a bucket, in a teapot, or between some books. The experimenter always carried the objects in a box for the subjects so they could not be seen. Each time subjects finished hiding an object, the experimenter gave them the next object and told them in which room they should hide it. To control for the possibility that subjects in the location biased condition would show more spatial clustering simply because they knew the rooms better, the experimenter told subjects in the category biased and control conditions the names of the rooms the first time they entered them and asked them to briefly look around to familiarize themselves with each room. Subjects were instructed to hide the objects out of sight and were periodically reminded to keep trying to remember where they put each toy. After hiding all the objects, subjects were taken to each location again in the same order as they hid the objects to give them a second chance to see where each toy was located. This was done to increase the likelihood that subjects had sufficient knowledge of where each object was hidden so that later they could use a spatial clustering strategy if they chose to do so. When they arrived at each location, the experimenter asked the subject to name the object that was hidden at that location. If the subject could not remember the object or made two incorrect guesses, he or she was told to check the object.

After seeing the objects the second time, subjects were taken to a separate testing room and were given two recall tasks. The first task was to

[2] Two different room combinations were used: (a) Approximately half of the 10- and 12-year-olds hid objects in the fort room, space room, kitchen, and gym; and (b) approximately half of the 10- and 12-year-olds hid objects in the fort room, space room, kitchen, and camping room.

recall the toys they had hidden. The second task was to recall each object and where it was hidden. The entire session was tape recorded, and the experimenter also wrote down responses to each task whenever possible. Children received a small gift for participating in the study.

Coding

As in Study 1, a categorical ARC score and a spatial ARC score was computed for each subject's recall of the objects and for each subject's recall of the objects with their locations. Again, all negative ARC scores were set to zero.[3] ARC scores in this study ranged from .00 to 1.00.

Another approach to assessing spatial and categorical clustering is to perform a Monte Carlo simulation to determine whether clustering is significantly above chance. First, the number of objects from the same category or same room that followed each other in a given subject's recall was counted. The total number of run lengths of two, three, and four items was then determined. Two sets of run lengths were derived from each subject's recall of the objects and recall of the objects with their locations: one reflecting categorical clustering and the other reflecting spatial clustering. Second, a Monte Carlo simulation was carried out to determine the probability of obtaining a particular number of runs of two, three, and four items for a given number of total items recalled. Recall performance was classified as spatially or categorically organized if the number of runs of two, three, or four items was above that expected by chance. As in other studies using Monte Carlo simulations (e.g., Mandler, Fivush, & Reznick, 1987), p was set at .10.

Results

The first question of interest was whether experiences during encoding and the nature of the recall task influenced the degree of spatial and categorical clustering in children's recall. This was addressed in two ways: The first was by determining whether the number of children in each condition exhibiting a significant degree of spatial or categorical clustering (as revealed through the Monte Carlo simulation) in the two tasks was more than that expected by chance. The second was by comparing children's spatial and categorical ARC scores across tasks and conditions. The results of the Monte Carlo analysis are presented first to provide an overview of the strategies used in the two tasks by children in each condition, and the ARC score analysis is presented second to provide a more detailed picture of recall organization in the different tasks and experimental conditions. Analyses of the number of items subjects recalled in the two tasks and correlations between number of items recalled and clustering scores were conducted to provide information about the relation between organization and recall.

Recall Organization

Monte Carlo analysis. As mentioned previously, a Monte Carlo simulation was used to determine which subjects exhibited a greater degree of spatial or categorical clustering than would be expected by chance. A binomial test ($p = .10$, $q = .90$) was then used to determine whether the number of 10- and 12-year-olds in each condition demonstrating a significant degree of spatial or categorical clustering was more than would be expected by chance ($\alpha = .05$). As seen in Table 1, when recalling objects alone, the majority of 10- and 12-year-olds organized their recall categorically regardless of condition. When asked to recall the objects and the objects with their locations, however, few of the subjects continued to use a categorical clustering strategy. Instead, far more subjects than would be expected by chance adopted a spatial clustering strategy. This result was consistent across ages and conditions, with the exception of the 10-year-olds in the category biased condition.

Table 1
Number of Subjects Exhibiting a Significant Degree of Categorical or Spatial Organization

	Objects		Objects with locations	
Age/condition	Categorical	Spatial	Categorical	Spatial
10 years				
Category biased	9**	0	3	1
Location biased	6**	0	0	4*
Control	9**	0	1	4*
12 years				
Category biased	10**	0	1	4*
Location biased	6**	2	2	7**
Control	9**	1	0	6**

Note. The number of subjects in each group (n = 10) exhibiting a significant degree of categorical or spatial clustering was compared against chance ($\alpha = .05$) using a binomial test ($p = .10$, $q = .90$).
* $p < .05$. ** $p < .001$.

Clustering scores. The 10- and 12-year-olds' spatial and categorical ARC scores were entered into a 2 (age) × 3 (condition) × 2 (task) × 2 (type of clustering) repeated measures ANOVA with the first two factors as between-subjects variables and last two as within-subjects variables. This analysis yielded main effects of task, $F(1, 54) = 23.31$, $p < .0001$, and type of clustering, $F(1, 54) = 16.60$, $p < .001$. There was also significant interactions of Task × Type of Clustering, $F(1, 54) = 191.64$, $p < .0001$; Condition × Type of Clustering, $F(2, 54) = 7.56$, $p < .01$; and Condition × Task, $F(2, 54) = 6.91$, $p < .01$. The main effects and interactions were all subsumed under two significant three-way interactions of Condition × Task × Type of Clustering, $F(2, 54) = 3.28$, $p < .05$, and Age × Task × Type of Clustering, $F(1, 54) = 4.20$, $p < .05$. Therefore, the discussion centers around these two interactions.

Of primary interest was the significant interaction of Age × Task × Type of Clustering (see Figure 2). In the testing of whether 10- and 12-year-olds' spatial and categorical scores differed for the two tasks, simple effects tests were carried out on 10- and 12-year-olds' spatial and categorical clustering scores for each task. These tests revealed a significant interaction of Task × Type of Clustering for 10-year-olds, $F(1, 54) = 70.72$, $p < .0001$, and for the 12-year-olds, $F(1, 54) = 124.73$, $p < .001$. Additional simple effects tests of the Task × Type of Clustering for 10-year-olds revealed a significant effect of type of clustering for the object recall task, $F(1, 54) = 93.75$, $p < .0001$, but not

[3] When recalling the objects, none of the 10- and 12-year-olds had below-chance categorical clustering scores, but 67% of 10-year-olds and 70% of 12-year-olds had below-chance spatial clustering scores. When recalling the objects with their locations, 43% of the 10-year-olds and 70% of the 12-year-olds had below-chance categorical clustering scores, and 20% of 10-year-olds and 17% of 12-year-olds had below-chance spatial clustering scores.

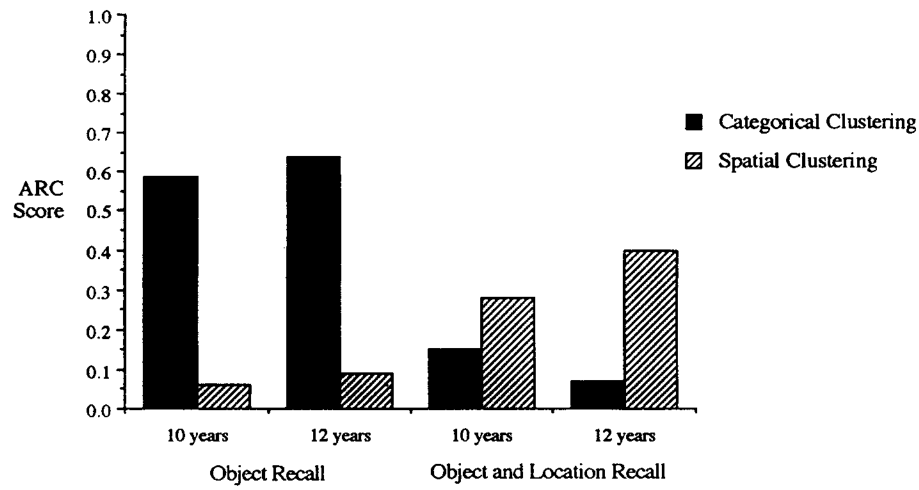

Figure 2. Mean categorical and spatial clustering scores as a function of age and recall task. ARC = adjusted ratio of clustering.

for the object and location recall task, $F(1, 54) = 2.72$, *ns*. Specifically, 10-year-olds had higher categorical than spatial clustering scores when recalling the objects, but there was no significant difference between their categorical and spatial clustering scores when recalling the objects with their locations. Additional simple effects tests of the Task × Type of Clustering for 12-year-olds revealed significant effects of type of clustering for the object recall task, $F(1, 54) = 100.72$, $p < .0001$, and for the object and location recall task, $F(1, 54) = 17.55$, $p < .001$. Twelve-year-olds had higher categorical than spatial clustering scores for the object recall task and higher spatial than categorical clustering scores for the object and location recall task. These results suggest that the presence of a spatial component in the recall task elicited mixed use of spatial and categorical organization from 10-year-olds and predominant use of spatial organization from 12-year-olds.

The second finding of interest was the Condition × Task × Type of Clustering interaction. In the determination of the influence of condition on spatial and categorical clustering scores for each task, simple effects tests were conducted for the object recall and object and location recall tasks. These tests revealed a significant interaction of Condition × Type of Clustering for the object recall task, $F(2, 54) = 15.70$, $p < .0001$, but not for the object and location recall task, $F(2, 54) = 1.31$, *ns* (see Figure 3). Thus, although overall spatial clustering scores were higher than overall categorical clustering scores in the object and location recall task, $F(1, 54) = 17.05$, $p < .001$, they were not influenced by condition. In contrast, additional simple effects tests of the Condition × Type of Clustering interaction for the object recall task yielded main effects of condition for both categorical clustering scores, $F(2, 54) = 20.46$, $p < .0001$, and spatial clustering scores, $F(2, 54) = 4.43$, $p < .05$. Follow-up tests using Tukey's HSD test ($\alpha = .05$) showed that children in the category biased condition had higher categorical clustering scores than did children in the location biased and control conditions, and that children in the control condition had higher categorical clustering scores than did children in the location biased condition. In contrast, children in the location biased condition had higher spatial clustering scores than did children in the category biased and control conditions. Spatial clustering scores for children in the category biased and control conditions did not differ significantly.

Primacy Effects

Although the preceding analyses clearly show that subjects used organizational strategies to aid their recall, it is also of interest to know whether subjects attempted to recall the items in the order in which they were hidden. Because there were 16 objects, the chance that the first item recalled was the first item from the original hiding sequence was 1 out of 16. Binomial tests ($p = .06$, $q = .94$) were used to determine whether more 10- and 12-year-olds than expected by chance initiated their recall with the first item from the original hiding sequence. For the object recall task, 13% of 10-year-olds and 30% of 12-year-olds exhibited a primacy effect. Only the number of 12-year-olds exceeded that expected by chance. For the object and location recall task, 30% of 10-year-olds and 30% of 12-year-olds exhibited a primacy effect. More subjects in each age group recalled the first object hidden than expected by chance. It should also be noted that use of the original hiding order dropped off very quickly after the first item. For example, none of the 12-year-olds and only 1 of the 10-year-olds began their recall of the objects with the first and second items of the hiding route.

Number of Items Recalled

A 2 (age) × 3 (condition) × 2 (task) repeated measures ANOVA was carried out on the number of objects children recalled with the first two variables as between-subjects variables and the third as a within-subjects variable. This analysis yielded a significant main effect of task, $F(1, 54) = 9.67$, $p < .01$. This effect, however, was subsumed under a significant Condition × Task interaction, $F(2, 54) = 4.58$, $p < .05$. Simple effects tests

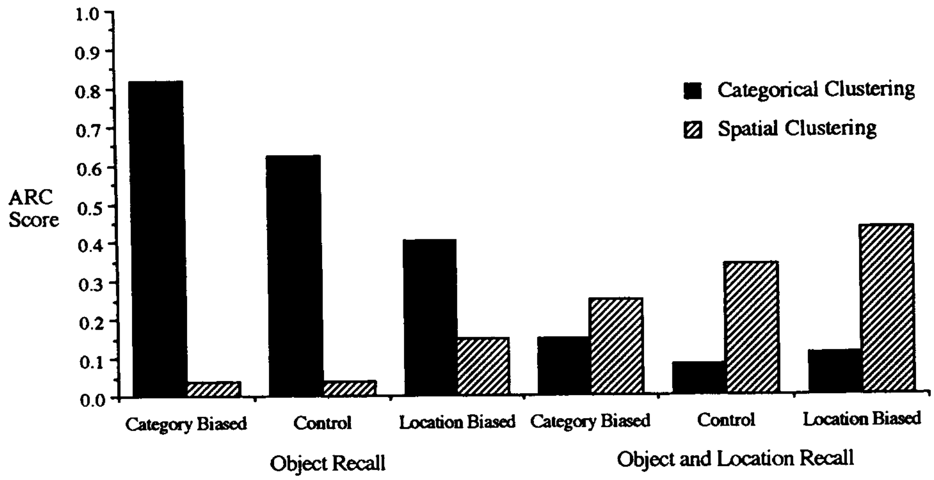

Figure 3. Mean categorical and spatial clustering scores as a function of encoding condition and recall task. ARC = adjusted ratio of clustering.

showed a significant effect of task for the category biased condition, $F(1, 54) = 17.66, p < .001$. Children in the category biased condition recalled significantly more items when recalling the objects than when recalling the objects with their locations (*M*s = 14.6 vs. 12.3, respectively). Children in the location biased and control conditions did not recall significantly more items when recalling the objects than when recalling the objects with their locations (*M*s = 14.2 vs. 14.2 and *M*s = 14.4 vs. 13.9, respectively).

Relation Between Organization and Recall

A series of correlational analyses were also conducted to examine whether the degree of categorical or spatial clustering was related to the number of items recalled in the two tasks. First, because the clustering analyses showed that children used categorical organization to recall the objects, correlations were computed for the 10- and 12-year-olds' categorical ARC scores and the number of items they recalled in the object recall task. Neither of these correlations were significant ($r = .20$ and $r = .22$ for 10- and 12-year-olds, respectively). Similarly, because children predominantly relied on spatial organization to recall the objects with their locations, a parallel set of correlations were computed between subjects' spatial ARC scores and number of items recalled in the object and location recall tasks. Again, the relation between organization and recall was not significant for the 10- or the 12-year-olds ($r = .24$ and $r = .17$, respectively).

Discussion

These results support the idea that 12-year-olds were more adept at responding to the changing demands of the task than were the 10-year-olds. Although both 10- and 12-year-olds exhibited more categorical than spatial clustering when recalling the objects, only the 12-year-olds exhibited more spatial than categorical clustering when recalling the objects and their locations. The fact that 10-year-olds exhibited about equal amounts of spatial and categorical organization when recalling the objects with their locations suggests that they had difficulty overcoming their bias to organize their recall categorically. It is unlikely that this effect is due to 10-year-olds' inability to remember the object locations, because there was no difference in the number of items 10- and 12-year-olds recalled in either of the two tasks.

Recall organization was also influenced by the prior experiences subjects were given with either the objects or the hiding locations. Subjects who saw the objects grouped by category before hiding them showed a greater degree of categorical clustering in their object recall than did either the subjects who saw the hiding places first or those who were given no experience with either the objects or the hiding locations. Conversely, subjects who first saw the hiding places room by room showed a greater degree of spatial clustering than did subjects in the other two conditions when they recalled the objects. Thus, similar to studies showing that sorting items during learning phases helps young children categorize during recall (Moely et al., 1969; Sodian et al., 1986), choice of spatial or categorical strategies for organizing recall can also be influenced by the nature of subjects' prior experience.

General Discussion

The results of the two studies presented here suggest that children's ability to select appropriate organizational strategies is a fairly late-developing skill. When asked to make a furniture inventory from memory, 10-year-olds relied more heavily on categorical than on spatial organization, 12- and 14-year-olds relied nearly equally on categorical and spatial organization, and 16-year-olds and adults relied almost exclusively on spatial organization. If adult performance is used as the standard for assessing the appropriateness of particular organizational strategies for specific recall tasks, 10-year-olds clearly appeared to have difficulty with finding the appropriate organizational strategy for recalling their furniture. In contrast, 16-year-olds seemed to have no trouble generating the appropriate strategy for the furniture recall task. The 12- and 14-year-olds, however, appeared to be at a transitional age with respect to spatial and categorical organizational strategies. This conclusion is supported by the fact that there was a strong correlation between spatial clustering scores and the number of furniture items generated at 12 and 14 years of age. Moreover, the results of Study 2 suggest that 12-year-olds were more sensitive to the changing nature of the recall task than were 10-year-olds. Specifically, when recalling the names of objects they had previously hidden, 10- and 12-year-olds exhibited high levels of categorical clustering. When the recall task involved a spatial component, however, 12-year-olds exhibited significantly higher spatial than categorical clustering scores, but 10-year-olds showed no difference between their spatial and categorical clustering scores.

What accounts for the developmental changes in flexibility of strategy deployment observed here? One explanation consistent with Siegler and Shipley's (in press) model is that children's experiences with the effectiveness of particular strategies for specific recall problems leads to more discriminating strategy use. The finding from Study 1 that spatial but not categorical clustering scores were significantly related to number of furniture items generated supports this idea. Children's experiences with communicating about object locations may also be tied to their developing understanding of spatial organizational strategies. In fact, the task of recalling objects with their locations is similar to giving directions about how to find a set of objects. Consistent with this idea, 12-year-olds in Study 2 were more likely to organize their recall spatially when recalling the objects with their locations than when recalling the objects alone. Thus, as children gain experience with giving directions (Plumert et al., 1994) and describing spaces (Gauvain & Rogoff, 1989) in a spatially organized fashion, their ability to apply spatial clustering skills to more complex tasks such as recalling locations and recalling object names may also increase.

Another issue the results reported here raise is what kinds of retrieval processes underlie the use of spatial organizational strategies. As exemplified by the following 12-year-old girl's self-report of how she remembered where she put each object, these retrieval processes often seem to involve taking a mental walk.

> I would imagine myself walking into the room and then I'd remember where I put everything. Like I'd see the couch and I'd remember I put the elephant under the cushion. And I'd see the little place where the dolls were sitting on top of the cushion and I'd remember that I put the car underneath them. And I saw the wheelbarrow with the tools in it, and I saw the shelf that had the yellow bucket on it.

This example is particularly striking because it shows a complete reorganization of her initial experience with hiding the objects. In her case, and presumably for others as well, it appears that imagined movement was used to transform a difficult recall task into a recognition and recall task. By imagining walking into each room, she would mentally see the different locations that served to cue her about the objects and help organize her recall. Little is known, however, about the development of the ability to imagine moving through space and how such a process evolves into a heuristic for organizing knowledge of nonspatial information. Further research about the development of children's ability to use their knowledge of location to organize both spatial and nonspatial information may prove useful for understanding the development of organizational strategies.

Another issue these studies raise is to what extent children's use of recall strategies reflects an active, conscious process or the automatic activation of memory associations. The fact that the ability to select an appropriate organizational strategy seems to be a rather late-developing skill is consistent with Bjorklund's (1987) argument that true strategic processing does not appear until adolescence. In other words, the ability to choose appropriately among alternative strategies presupposes to some degree that children are able to consciously reflect on their repertoire of organizational strategies. Alternatively, younger children may prefer to use categorical rather than spatial clustering strategies because categorical organization is more familiar and hence easier to use than spatial organization. Numerous studies exist showing that when the mental effort required to use a strategy is reduced, the differences between younger and older children's recall decrease (DeMarie-Dreblow & Miller, 1988; Guttentag, 1985; Miller, Woody-Ramsey, & Aloise, 1991). Further studies may shed more light on this issue by systematically manipulating aspects of the task such as children's familiarity with the categories and spatial layout.

In conclusion, these experiments provide a broadened picture of the development of recall organization and an initial look at flexibility in deployment of recall strategies. In a general sense, these findings underscore the idea that knowledge is organized in relation to the task (Gauvain, 1993; Rogoff, 1985; Wadell & Rogoff, 1981) and provide a fruitful ground for further investigations of strategy deployment flexibility. For example, how do the strengths of different knowledge bases influence choice of recall strategy? How does children's sensitivity to the relevant aspects of the task influence their ability to use more sophisticated organizational strategies? Answers to these and other related questions may prove useful for understanding developmental changes in the capacity to apply organizational strategies flexibly and for describing general mechanisms available for accessing information from memory.

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Appendix
Furniture Categories

1. Couch (couch, davenport, love seat, sofabed, sofa).
2. Table (dressing table, harvest table, coffee table, table, workbench, tool bench, card table, picnic table, end table).
3. Chair (chair, rocking chair, bean bag, stool, piano bench, deck chair, recliner, bench, bar chair, La-Z-Boy, easy chair).
4. Shelf (shelf, bookshelf).
5. Cabinet (cabinet, file cabinet, stereo cabinet, china cabinet, liquor cabinet, VHS cabinet, sewing cabinet, case).
6. Mirror (mirror, looking glass).
7. Bed (bed, bunk bed, twin bed, double bed, futon, crib, king bed).
8. Dresser (chest, dresser, armoire, chest of drawers, bureau).
9. Lamp (lamp, standing lamp, chandelier).
10. Plumbing fixture (sink, bathtub, toilet, hot tub, shower).
11. Major appliance (refrigerator, stove, washing machine, oven, microwave, dryer, dishwasher).
12. Recreational/electronic equipment (Nintendo, Ping-Pong table, treadmill, VCR, TV, exercise bike, weight bench, stereo, pinball machine, computer).
13. Desk (desk, office desk, secretary).
14. Rack (coat rack, gun rack, magazine rack, shoe rack).
15. Wastebasket (wastebasket, trash can, garbage can).
16. Stand (TV stand, computer stand, photo stand, plant stand, nightstand).
17. Chest (chest, toy box, cedar chest, trunk, hamper).

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