The role of the physical context in supporting young children’s use of spatiotemporal organization in recall

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Four experiments were conducted to investigate the role of the physical context in supporting 3- to 5-year-olds’ use of spatiotemporal organization in recall. Children were familiarized with several target items and their corresponding landmarks arranged along a path in a model park. After familiarization, an experimenter removed the target items from the park. In Experiment 1, 3- and 4-year-olds recalled the missing items with the park either in view or out of view. When the park model was in view, 4-year-olds used the order of the items along the path to structure their recall. In Experiment 2, 4- and 5-year-olds recalled the missing items with the landmarks arranged either in the same order as in familiarization or in a new order. Children used the order of landmarks along the path at test to structure their recall, even though the order of landmarks changed from familiarization to test. Experiment 3 was identical to Experiment 2, except that the path was removed from the park. Five-year-olds used the order of landmarks along the path at test to structure their recall when the order of landmarks remained the same from familiarization to test, but had much more difficulty doing so when the order of landmarks changed from familiarization to test. Using a more difficult task, Experiment 4 revealed that spatiotemporal organization was positively related to amount recalled. Together, these findings suggest that the structure of the physical environment plays an important role in supporting young children’s use of spatiotemporal organization in recall.

The ability to recall information in an organized manner plays an important role in a variety of everyday memory tasks. For example, an adult might use the layout of his home to make an inventory of his belongings (see Plumert, 1994). Likewise, a child might use the seating arrangement in a classroom to recall the names of her classmates.

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(see Chi, 1978). Many studies have been conducted over the last several decades aimed at understanding the various factors that play a role in older and younger children’s strategy use (e.g. Best & Ornstein, 1986; Bjorklund, 1987; Chi, 1985; Gutten tag, 1984; Plumert, 1994; Plumert & Strahan, 1997; Schneider, 1986; Schneider & Pressley, 1989). For example, age changes in the knowledge base (i.e. what children know and how their knowledge is organized) are associated with age changes in strategy use (e.g. Best & Ornstein, 1986; Bjorklund, 1987; Chi, 1985). More recently, researchers have noted that the supportiveness of the task context plays an important role in children’s deployment of mnemonic strategies (Folds, Footo, Gutten tag, & Ornstein, 1990; Gutten tag, 1984; Plumert, 1994; Plumert & Strahan, 1997). Despite this wealth of information about the factors that influence strategy use in younger and older children, relatively little is known about the early use of organization during recall and how rudimentary strategies emerge over development (see also Ornstein, Baker-Ward, & Naus, 1988).

Research on the development of early strategy use has addressed two key issues. One of these is whether young children are strategic in the sense that they show deliberate attempts to remember information. Indeed, research suggests that very young children engage in strategy-like behaviours when asked to remember the location of a hidden object (e.g. DeLoache, Cassidy, & Brown, 1985; Wellman, Ritter, & Flavell, 1975). For example, children as young as 18 months of age often talked about or pointed to the hiding location of a toy during a delay period (DeLoache et al., 1985). Moreover, children were more likely to successfully retrieve a toy if they exhibited deliberate attempts to remember during the delay period. Other research indicates that young children behave differently when memory demands are present (e.g. Wellman et al., 1975). Specifically, 3-year-olds engaged in deliberate, memory-like behaviours (e.g. gazing at the to-be-remembered location) to help them remember the location of a hidden object when they were instructed to remember, but not when they were instructed to wait. Together, these findings suggest that deliberate remembering begins to develop around the age of two or three.

Research on early strategy use has also addressed the question of whether young children are strategic in the sense that they use specific mnemonic strategies to aid remembering. In general, it appears that young children rarely use mnemonic strategies (e.g. rehearsal, categorical organization, and spatial organization) spontaneously (Allik & Siegel, 1976; Flavell, Beach, & Chinsky, 1966; Hagen, Hargrove, & Ross, 1973; Kingsley & Hagen, 1969; Ritter, 1978; Ryan, Hegion, & Flavell, 1970; Salatas & Flavell, 1976; Williams & Goulet, 1975). For example, Flavell et al. (1966) showed 5-, 7-, and 9-year-olds pictures to remember and found that most of the 9-year-olds displayed evidence of rehearsing, whereas very few of the 5-year-olds used rehearsal. Likewise, Slatas and Flavell (1976) found that although young children could be trained to use categorical clustering, they rarely used categorical clustering strategies spontaneously. The general conclusion from this early work is that although young children can be trained to use mnemonic strategies, they usually do not produce them on their own (for an exception, see DeLoache & Todd, 1988).

A central issue these findings raise is how do children move from early manifestations of deliberate remembering to later mature use of mnemonic strategies? Clearly, there is a substantial gap between these early and later manifestations of competency. That is, children spontaneously exhibit deliberate attempts to remember around the age of two or three and yet do not spontaneously use simple mnemonic strategies such as rehearsal until the age of seven or eight. How might we reconcile this
discrepancy? Recent proposals about the development of mnemonic strategies suggest that children’s strategy use unfolds gradually over time, starting with more supportive contexts (Folds et al., 1990; Plumert & Strahan, 1997). In other words, mnemonic strategies first appear in contexts that provide external supports for using such strategies and only later appear in contexts that provide limited or no external supports for strategy use. Moreover, strategy deployment becomes increasingly deliberate and refined as children gain experience with executing particular strategies in more supportive contexts. For example, Miller, Seier, Barron, and Probert (1994) found that utilization deficiencies disappeared when 5- and 6-year-old children were provided with a story about a familiar rather than an unfamiliar context. Likewise, Plumert and Strahan (1997) found that 10-year-olds used spatial clustering in a more complex task if first given experience with using spatial clustering in a simpler task. From this perspective, the context plays a central role in promoting developmental change in strategy use.

What aspects of the context might play a role in supporting how young children remember information and use their rudimentary strategies? One potentially important source of external support for organizing information during recall is how children experience the items to be remembered during learning. In the traditional free recall paradigm, children are presented with a set of items in a random fashion, either one at a time or as a group. In the case of organizational strategies, the task for the child is to impose a structure on the items that can be used to guide later recall. Not surprisingly, children under the age of 10 rarely spontaneously organize the items into groups at recall. However, when younger children are encouraged to sort the items into categories during learning, they are much more likely to use categorical organization at recall. For example, 4- and 6-year-olds who were instructed to ‘remember and sort’ items at presentation exhibited more categorical clustering (i.e. categorical organization) during recall than did children who were instructed to ‘remember and play with’ items at presentation (Sodian, Schneider, & Perlmutter, 1986). These findings suggest that if children experience items to be remembered in an organized fashion during learning, they are much more likely to recall those items in an organized fashion during test.

Another aspect of the context that may play an important role in supporting young children’s strategy use is the physical environment. In the traditional free recall paradigm, all physical cues pertaining to the items are removed prior to recall. Thus, the task for the child is to remember the items in the absence of any physical cues that were present during learning. Young children may find it particularly difficult to deploy strategies under these conditions because the demands of the situation exceed their limited information-processing resources. In fact, an investigation by Hazen and Volk-Hudson (1984) suggests that the presence or absence of physical cues during recall can play an important role in facilitating young children’s recall. In one experiment, 3- and 4-year-olds were asked to recall pictures of familiar objects contained within an array of boxes. For half of the children, the boxes remained in view while they attempted to recall the items, and for the other half, the boxes were removed from view while they attempted to recall the objects. They found that 4-year-olds, but not 3-year-olds, recalled more items when the boxes were left in front of them than when they were removed. In another experiment, 3- and 4-year-olds played with a variety of toys in small playroom. The child and the experimenter left the playroom and later returned to find many of the objects missing. Children were then asked to help the experimenter make a list of the missing objects. Children performed this task either while sitting in the playroom or while sitting outside of the playroom. They found that both 3- and 4-year-
olds recalled significantly more objects when they recalled the items inside the playroom. Thus, it appears that very young children can use the physical context in which items are encountered to enhance their recall of those items.

One important question that remains unanswered is how the physical context influences young children’s ability to organize information at recall. In particular, can young children detect ordered structure in their environment and use that ordered structure to support the organization of remembered information? Hazen and Volk-Hudson (1984) suggest that young children may have benefited from the physical context because it supported their use of a rudimentary spatiotemporal strategy. In other words, children may have ordered their recall of the missing objects by systematically scanning around the room. From this perspective, the physical environment served both to cue and to organize recall. Similar ideas have been proposed to account for how adults organize their verbal descriptions of spatial layouts (e.g. Levelt, 1982; Linde & Labov, 1975; Ullmer-Ehrich, 1982). For example, Ullmer-Ehrich (1982) found that people often described the furniture in their dormitory room by taking the listener on a mental gaze tour around the room (e.g. ‘There is a desk to the left of the door. Next to it is a bed. Next to the bed is a chair. Next to the chair is a bookcase.’). Thus, it appears that adults can mentally scan a physically absent space to support their use of a spatiotemporal organizational strategy. Although younger children have difficulty with mentally scanning a physically absent space (see Gauvain & Rogoff, 1989), they may be able to visually scan a physically present space to support their use of spatiotemporal organization. There is some evidence to suggest that older children capitalize on physical cues to support their use of rehearsal strategies (Ornstein, Medlin, Stone, & Naus, 1985). That is, 7-year-old children included more different items in their rehearsal sets when provided with visual access to previously presented items. At present, however, very little is known about whether young children can use visual access to a physically present space to support their use of spatiotemporal organization in recall.

The goal of the present investigation was to examine whether 3- to 5-year-old children can use the physical context to both cue and organize their recall. Specifically, we were interested in how young children coordinate the use of (1) individual landmarks as cues for recalling missing objects and (2) the order of landmarks along a path as a cue for organizing objects during recall. In a series of four experiments, children were familiarized with a series of landmarks (e.g. pond, merry-go-round, and bench) arranged along a winding path through a tabletop model of a park. Small target objects were placed with the landmarks. After familiarization, the target objects were removed, and children were asked to recall the missing items. In Experiment 1, we examined how the physical context serves to cue and organize recall. In particular, we investigated whether the presence or absence of the physical context influenced 3- and 4-year-olds’ ability to recall the missing items in the order in which they were encountered along the path through the park. Thus, children recalled the missing items with the park model either in view or out of view. Based on the work of Hazen and Volk-Hudson (1984), we expected that children who recalled the missing items with the park model in view would recall more objects than children who recalled the items with the park model out of view. Additionally, we expected that children would be more likely to recall the missing items in the order in which they were encountered along the path when the park model was in view. The goal of Experiments 2 and 3 was to further investigate young children’s use of the physical context to support their use of spatiotemporal organization in recall. In Experiment 2, we investigated whether
young children used spatiotemporal organization to structure their recall when the arrangement of landmarks along the path changed from learning to test. In Experiment 3, we investigated whether young children used spatiotemporal organization to structure their recall when the path connecting the landmarks was absent. In Experiment 4, we examined the relationship between spatiotemporal organization and amount recalled using a more difficult task.

EXPERIMENT 1

Method

Participants
Twenty-eight 3-year-old and twenty-four 4-year-old children were recruited for this experiment. Three 3-year-olds were excluded from the final analyses due to failure to cooperate, and one 3-year-old was excluded due to maternal interference. The final sample consisted of twenty-four 3-year-old children, with an average age of 3 years and 5 months ($SD = 2.98$, range = 3;3 to 3;11), and twenty-four 4-year-old children, with an average age of 4 years and 7 months ($SD = 4.18$, range = 4;0 to 5;1). There were 14 females and 10 males in the 3-year-old group and 13 females and 11 males in the 4-year-old group. Forty-six children were recruited from a local daycare. Six children were recruited through a child subject database maintained by the Department of Psychology. Parents of these children received a letter describing the study, followed by a phone call inviting them to participate. Children from the daycare were tested at their daycare, and children from the child subject database were tested in the laboratory. Most of the children were Caucasian, from middle- to upper middle-class families.

Apparatus and materials
A 60-cm $\times$ 81-cm tabletop model of a park served as the experimental space. The model contained a white winding path with 10 landmarks located along the path (see Fig. 1). The landmarks included a merry-go-round, tree, swing set, trashcan, bench, sandbox, picnic blanket, pond, table, and soccer net. There were also 10 small target items that were positioned on or next to the 10 landmarks. The target items included a bicycle, dog, hat, pop can, book, pail, basket, duck, apple, and ball. A small doll figure was used during the familiarization phase, a girl doll figure for females, and a boy doll figure for males.

Design and procedure
The session was divided into a familiarization and a recall phase. During familiarization, children learned the order of the target items and landmarks along the path. First, an experimenter asked the child to name, in order, all of the large landmarks and target items along the path. If children had difficulty naming an item correctly, the experimenter provided the correct label. Next, the experimenter took a doll figure on a walk through the park, noting all of the target items and their landmarks in a short narrative. We selected objects that were thematically related to landmarks and
embedded the order of landmarks in a narrative to support children's recall. Previous research indicates that presenting information in a meaningful manner facilitates young children's recall (e.g. Brown, 1975; Herman & Roth, 1984). We used the following narrative:

Susie has never been in this park before, and she wants to see all the things that are in the park. The first thing she sees on her walk is a bicycle leaning against a merry-go-round. The next thing she sees is a dog tied to a tree. She walks a little further down the path, and she sees a hat on a swing. Next she sees a pop can on a trashcan. She walks a little further and she sees a book someone left on a bench. Then she sees a pail in a sandbox. As she walks a little further, she sees a picnic basket on a blanket. Next she sees a duck in a pond. She walks a little further and sees an apple on a picnic table. Finally, she sees a soccer ball in a soccer net.

The child then was asked to point out the landmarks and target items as the doll encountered the items on a second walk though the park. The experimenter moved the doll along the path as the child noted the objects. The experimenter corrected any mistakes made by the child. Finally, children were instructed to 'take a good look at the park because they would need to remember all of those things later'. The duration of the familiarization phase was approximately 3 min.

The recall phase occurred immediately after familiarization. First, children were asked to turn away from the park model while a second experimenter removed all of the target items. When children faced the model again, the first experimenter exclaimed, 'I think [the second experimenter’s name] took some things from the park! Can you help me remember what's missing? What did [the second experimenter's name] take away?' Half of the children at each age were randomly assigned to one of two experimental conditions: model present or model absent. Children in the model
present condition were allowed to look at the park model while they recalled the items. Children in the model absent condition saw the park without the target items for approximately 30 s, and then the model was covered with an opaque cloth. Thus, the park model was out of view while they recalled the items. Children in both conditions sat facing one end of the path (see Fig. 1). The experimenter sat to the child’s right. If children paused for 15–20 s without recalling any additional items, the experimenter prompted the children by restating the question. The session ended when children failed to recall any more items after prompting. The first experimenter recorded the order in which children recalled the items.

Scoring
Children received two scores: one reflecting the number of items recalled and the other reflecting the organization of their recall. We measured recall organization by calculating Spearman rank-order correlation coefficients between the path order and each child’s recall order. This recall organization measure reflected the extent to which children’s recall order corresponded to the order in which they encountered the items along the path through the park. For analysis purposes, we converted the recall organization scores to absolute values because we were interested in children’s use of spatiotemporal information to organize their recall, regardless of whether they ordered the items from first to last or last to first.

Results
Number of objects recalled
The first question we addressed was whether the number of items children recalled differed by age or condition. The number of items recalled was entered into an Age (3 years vs. 4 years) × Condition (model present vs. model absent) analysis of variance (ANOVA). This analysis yielded significant effects of age, $F(1, 44) = 13.62, p < .001$, and condition, $F(1, 44) = 60.38, p < .0001$. Not surprisingly, 4-year-olds ($M = 7.5, SD = 2.0$) recalled more than did the 3-year-olds ($M = 5.9, SD = 2.4$), and children of both ages recalled more items when the model was in view ($M = 8.4, SD = 1.5$) than when it was hidden from view ($M = 5.0, SD = 1.9$).

Organization of recall
The primary question of interest was whether children used the order of landmarks along the path to structure their recall. We addressed this question in two ways. First, ordering scores were entered into an Age (3 years vs. 4 years) × Condition (model present vs. model absent) ANOVA. This analysis yielded a significant Age × Condition interaction, $F(1, 41) = 5.22, p < .05$. (Two 3-year-olds and one 4-year-old from the model absent condition were omitted from this analysis because they recalled only two items. Recalling only two items necessarily results in a perfect ordering score because items can only be recalled in a forward or a backward direction.) Simple effects tests revealed a main effect of condition for the 4-year-olds, $F(1, 21) = 6.18, p < .05$, but not for the 3-year-olds, $F(1, 20) = .51, ns$. As shown in Fig. 2, 4-year-olds in the model present condition had significantly higher ordering scores than did 4-year-olds in the
model absent condition. Ordering scores did not differ significantly between 3-year-olds in the two conditions. It is also important to note that 4-year-olds had higher ordering scores than 3-year-olds in the model present condition, $F(1, 22) = 4.44, p < .05$, but the two age groups did not differ in the model absent condition $F(1, 19) = 1.28, ns$.

We also examined the number of children in each age group and condition who had ordering scores that were significantly above chance (Olds, 1938, 1949). First, all of the children with above-chance ordering scores ordered the objects from first to last. Second, none of the 3-year-olds in the model absent condition and only one 3-year-old in the model present condition (8%) had ordering scores significantly above chance. Likewise, none of the 4-year-olds in the model absent condition had ordering scores above chance. In contrast, eight of the 4-year-olds in the model present condition (67%) had ordering scores that were significantly above chance. Finally, chi-square analyses revealed that the number of 3-year-olds in the two conditions with above-chance ordering scores did not differ significantly, $\chi^2 (1) = 1.04, ns$. In contrast, significantly more 4-year-olds in the model present condition than in the model absent condition had above-chance ordering scores, $\chi^2 (1) = 12.00, p < .001$.

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1 Each individual ordering score (i.e. rank-order correlation) was compared with the value of the rank-order correlation that would be expected by chance at the 5% level (two-tailed test) given the number of items the child recalled (Olds, 1938, 1949). Note that because there were only a very small number of items to be recalled, only very high ordering scores qualified as above chance. For example, if a child recalled all 10 items, his or her ordering score would have to exceed .648 to be above chance. If a child recalled only 7 items, however, his or her ordering score would have to exceed .786 to be above chance.
Relations between number of items recalled and ordering scores

To investigate whether there was any relation between the number of items recalled and the degree of organization during recall, we computed correlations between the number of items recalled and ordering scores. For 3-year-olds, the association between the number of items recalled and ordering scores was negative, $r (n = 22) = - .40$, $p = .07$, indicating that 3-year-olds who had higher ordering scores tended to recall fewer items. Quite likely, this negative association resulted from the fact that many 3-year-old children recalled very few items. Recalling very few items (e.g. 3 or 4) necessarily results in a high rank ordering score. For 4-year-olds, in contrast, the association between the number of items recalled and ordering scores was positive, $r (n = 23) = .40$, $p = .056$, indicating that 4-year-olds who had higher ordering scores tended to recall more items. Given that 4-year-olds’ ordering scores in the two conditions differed, the relations between the number of items recalled and ordering scores were investigated within each condition. For 4-year-olds in the model present group, there was a non-significant positive relation between number of items recalled and ordering scores, $r (n = 12) = .44$, $p = .15$. The correlation between the number of items recalled and ordering scores for 4-year-olds in the model absent group revealed a non-significant negative correlation, $r (n = 11) = -.51$, $p = .11$. Again, this negative association is probably because several 4-year-olds in the model absent condition recalled very few items. Although one cannot make strong conclusions based on these results, it appears that 4-year-olds in the model present group benefited from using spatiotemporal organization.

Figure 3. Percentage of children in Experiment 1 who recalled each object.
Recall of individual objects

Finally, we assessed children’s recall of the individual objects to determine whether some objects were remembered more easily than others. As shown in Fig. 3, there were clear serial position effects in children’s recall of the individual objects. Interestingly, serial position effects were far more pronounced for children in the model absent condition than in the model present condition. Chi-square analyses of the number of children in each condition who recalled each of the 10 objects revealed no significant difference between the two groups for the first object (bike), $\chi^2 (1) = 0.0, \text{ns}$, the second object (dog), $\chi^2 (1) = .784, \text{ns}$, the eighth object (duck), $\chi^2 (1) = .762, \text{ns}$, or the tenth object (ball), $\chi^2 (1) = .223, \text{ns}$. In contrast, significantly more children in the model present than in the model absent condition recalled the other objects (chi-square values ranged between $\chi^2 [1] = 4.46, p < .05$ and $\chi^2 [1] = 26.32, p < .0001$).

Discussion

As expected, children of both ages recalled more items when the park model was in view than when it was out of view. Clearly, children used the individual landmarks to cue their recall of the missing objects. This finding is consistent with research by Hazen and Volk-Hudson (1984), showing that children who recalled missing items inside the room in which they were originally encountered recalled more items than did children who recalled the missing items outside of the room. More importantly, we also found that the 4-year-olds who recalled the missing items with the park model in view had higher ordering scores than did the 4-year-olds who recalled the items with the park model out of view. Ordering scores for 3-year-olds in the two conditions were quite low. Together, these findings suggest that 4-year-olds in the model present condition used the order of landmarks along the path to structure their recall of the missing objects. Thus, it appears that visual access to a physically present space supports not only how much young children recall, but also how they organize their recall.

One issue these findings raise is which aspects of the physical context do young children rely on to support their use of spatiotemporal organization? Clearly, one important aspect of the physical context is the sequence of landmarks laid out along the path. In the present experiment, it appears that 4-year-olds in the model present condition relied on visually present information about the order of landmarks to structure their recall. However, because the landmarks along the path were laid out in the same order during both familiarization and test, these 4-year-olds may have relied on their memory for the order in which they originally learned the target items. Other studies have shown that very young children are adept at remembering temporal sequences even over long delays (e.g. Bauer, Hertsgaard, & Dow, 1994; Bauer & Mandler, 1992; Bauer & Shore, 1987; Fivush, 1984).

The purpose of Experiment 2 was to determine whether young children rely on visually present information about the order of landmarks to organize their recall of items associated with those landmarks. We examined this question by changing the order of landmarks along the path from familiarization to test. We tested 4- and 5-year-olds, rather than 3- and 4-year-olds, because the 3-year-olds in Experiment 1 showed no evidence of spatiotemporal organization in their recall. Children were assigned to one of two recall conditions: same order or new order. All children recalled the missing items with the park model present. For children in the same order condition, the landmarks were in the same order during the familiarization and test phases of the
experiment. For children in the new-order condition, the landmarks were in a different order during the test phase than during the familiarization phase. This manipulation allowed us to determine whether young children rely on visually present information about the order of landmarks to support their use of spatiotemporal organization. That is, if young children use visually present information about the order of landmarks, they should have high ordering scores regardless of whether the order of landmarks changes from learning to test. Alternatively, if young children’s use of spatiotemporal organization simply reflects memory for a learned temporal sequence, they should only exhibit high ordering scores when the order of landmarks along the path remains the same from familiarization to test.

EXPERIMENT 2

Method

Participants
Twenty-five 4-year-old and twenty-five 5-year-old children were recruited for this experiment. One 4-year-old was excluded from the final analyses due to experimenter error, and one 5-year-old was excluded for failure to cooperate. The final sample consisted of twenty-four 4-year-old children with an average age of 4 years and 7 months (SD = 2.72, range = 4;1 to 4;11), and twenty-four 5-year-old children with an average age of 5 years and 4 months (SD = 3.62, range = 5;0 to 6;2). There were 13 females and 11 males in the 4-year-old group, and 10 females and 14 males in the 5-year-old group. Thirty-nine children attended a local preschool, and 11 children were recruited through the same child subject database used in Experiment 1. Children from the preschool were tested at the preschool, and children from the child database were tested in the laboratory. Again, most children were Caucasian from middle- to upper middle-class families.

Apparatus and materials
The same park model was used as the experimental space. The landmarks, target items, and doll figures were the same as in Experiment 1.

Design and procedure
The session again was divided into a familiarization and recall phase. Familiarization was the same as in Experiment 1. Again, the recall phase occurred immediately after familiarization. Half of the children at each age were randomly assigned to either the same order or the new order condition. In both conditions, children recalled the items with the park model in view. The same-order condition was identical to the model present condition in Experiment 1 (i.e. the landmarks were arranged along the path in the same order in both the familiarization and test phases of the experiment). In the new-order condition, the order of the landmarks changed from familiarization to test. Specifically, while the experimenter removed the target items, he or she also arranged the landmarks in a random order. A different random order was used for each child. Thus, children in the new order condition recalled the target items while looking at a
new ordering of the landmarks along the path. As before, if children paused for 15–20 s without recalling any additional items, the experimenter prompted the children by restating the question. The recall phase ended when children failed to recall any more items after prompting.

Coding
Children again received two scores, one reflecting the number of items they recalled and the other reflecting the organization of their recall. For children in both conditions, we calculated Spearman rank-order correlation coefficients between the order of landmarks at test and each child’s recall order. This recall organization measure reflected the extent to which children’s recall orders corresponded to the order in which the landmarks were arranged during test. Children in the new-order condition received an additional recall organization score representing the correlation between the order of landmarks during familiarization and their recall order. This recall organization measure reflected the extent to which children’s recall orders corresponded to the order in which the landmarks were arranged during familiarization. Again, all recall organization scores were converted into absolute values.

Results

Number of objects recalled
The first question we addressed was whether the number of items children recalled differed by age or condition. An Age (4 years vs. 5 years) × Condition (same order vs. new order) ANOVA yielded no significant effects. Recall was generally quite high in both age groups and experimental conditions. On average, 4-year-olds recalled 8.92 (SD = 1.0) objects, and 5-year-olds recalled 9.33 (SD = .82) objects. Children in the same-order condition recalled a mean of 9.29 (SD = .81) objects, and children in the new-order condition recalled a mean of 8.96 (SD = 1.0) objects.

Organization of recall
The primary question of interest was whether young children rely on visually present information or on a learned temporal sequence to support their use of spatiotemporal organization in recall. Three different analyses were used to address this question. First, we examined whether young children who experienced the same order of landmarks from familiarization to test exhibited greater spatiotemporal organization in their recall than did children who experienced a different ordering of landmarks from familiarization to test. Test ordering scores (representing the correlation between order of items recalled and order of landmarks at test) were entered into an Age (4 years vs. 5 years) × Condition (same order vs. new order) ANOVA. This analysis yielded a marginally significant effect of age, $F(1, 44) = 3.70, p = .06$, indicating that 5-year-olds ($M = .73, SD = .32$) had higher ordering scores than did 4-year-olds ($M = .55, SD = .33$). More importantly, although ordering scores were somewhat higher in the same-order condition ($M = .71, SD = .34$) than in the new-order condition ($M = .56$,

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2 Again, because recall was near ceiling, we did not compute correlations between number of items recalled and organization of recall in this experiment. Likewise, we did not analyse recall of individual objects.
SD = .32), the two conditions did not differ significantly, \( F(1, 44) = 2.42, p = .13 \). This pattern held for both age groups. Ordering scores for the same-order and new-order conditions were, 61 (SD = .38) and .48 (SD = .27) for 4-year-olds, and .80 (SD = .28) and .65 (SD = .35) for 5-year-olds, respectively.

We also examined whether children in the new-order condition were more likely to use the order of landmarks during test than the order of landmarks during familiarization to structure their recall. (Children in the same-order condition were not included in this analysis because the order of landmarks was the same for familiarization and test). Familiarization ordering scores and test ordering scores were entered into an Age (4 years vs. 5 years) × Ordering Score (familiarization vs. test) repeated-measures ANOVA with the first factor as a between-subjects factor and the second as a within-subjects factor. This analysis yielded a significant effect of ordering score, \( F(1, 22) = 6.69, p < .05 \), indicating that children preferred to use the new ordering of landmarks over the old ordering. The mean test ordering score was .56 (SD = .32), and the mean familiarization ordering score was .34 (SD = .27).

Finally, we examined the number of children in each age group and condition who had ordering scores above chance. First, the objects were ordered from last to first in only three above-chance ordering scores. Two of these were familiarization ordering scores (one 4-year-old and one 5-year-old in the new-order condition), and one was a test ordering score (one 5-year-old in the new-order condition). Second, in the same-order condition, seven 4-year-olds (58%) and ten 5-year-olds (83%) had test ordering scores that were above chance. In the new-order condition, three 4-year-olds (25%) and seven 5-year-olds (58%) had test ordering scores that were above chance, whereas none of the 4-year-olds and only three of the 5-year-olds (25%) had familiarization ordering scores that were above chance. (One 5-year-old in the new-order condition had familiarization and test ordering scores that exceeded chance). Finally, chi-square analyses revealed that the number of 4-year-olds in the two conditions who had test ordering scores that were above chance did not differ significantly, \( \chi^2 (1) = 2.74, \text{ ns} \). Likewise, the number of 5-year-olds in the two conditions who had above-chance test ordering scores did not differ significantly, \( \chi^2 (1) = 1.82, \text{ ns} \).

**Discussion**

The results of this experiment show that young children rely on visually present information about the ordering of landmarks to support their use of spatiotemporal organization during recall. Regardless of whether the order of landmarks along the path at test was the same as or different from familiarization, ordering scores did not differ significantly. Moreover, in the new-order condition, children’s recall orders corresponded more closely to the order of the landmarks during test than during familiarization. Thus, children’s use of spatiotemporal organization reflects reliance on visually present spatiotemporal information rather than on rote learning of sequences. Interestingly, the use of spatiotemporal organization was high, even though recall was near ceiling. This indicates that children used the physical environment not only to cue their recall of the individual items, but also to organize their recall of the items.

A note of caution about these results is warranted, however. In particular, although over half of the 5-year-olds in the new-order condition had test ordering scores that were above chance, only one quarter of the 4-year-olds in the new-order condition had
above-chance test ordering scores. In contrast, when the order of landmarks remained the same from familiarization to test, over half of the 4-year-olds had above-chance ordering scores. Thus, 4-year-olds might best be characterized as transitional with respect to their use of spatiotemporal organization in this task context. Five-year-olds, however, clearly rely on visually present information about the order of landmarks to support their use of spatiotemporal organization during recall.

Another aspect of the physical context that young children might have relied on to support their use of spatiotemporal organization was the path itself. That is, the winding path connecting the landmarks may have played an important role in helping children extract information about the order of landmarks from the physical environment. This seems especially likely in cases where the landmarks do not lie along a straight path. In these cases, it may be very difficult for young children to systematically use spatiotemporal information. In Experiment 3, we examined the role of the path in helping young children extract spatiotemporal information from the physical environment by removing the white path from the park model. The landmarks remained in the same positions as in the previous experiments. As in Experiment 2, children were assigned to one of two recall conditions: same order or new order. Only 5-year-olds were tested in this experiment because so few 4-year-olds in the new-order condition exhibited above-chance spatiotemporal organization in their recall. If the path connecting the landmarks plays an important role in helping young children extract spatiotemporal information from the physical environment, then children should have difficulty using spatiotemporal organization to structure their recall, particularly in the new-order condition.

**EXPERIMENT 3**

**Method**

**Participants**
Twenty-seven 5-year-old children were recruited for this experiment. Three children were excluded because of experimenter error. The final sample consisted of 24 children, with an average age of 5 years and 7 months ($SD = 1.77$ months; range = 5;0 to 5;9). There were 12 females and 12 males. All children were recruited through a child research participant database maintained by the Department of Psychology at the University of Iowa. Again, most children were Caucasian from middle- to upper middle-class families.

**Apparatus and materials**
The park model was identical to that used in the previous experiments, except that the white path was removed.

**Design and procedure**
All aspects of the procedure were identical to that used in Experiment 2. Again, half of the children at each age were randomly assigned to either the same order or the new order condition.
Coding
The coding and scores were identical to those in Experiment 2.

Results

Number of objects recalled
As in Experiment 2, recall was very high. A one-way ANOVA comparing the number of items recalled in the two conditions yielded no significant effects. Children in the same-order condition recalled a mean of 9.92 (SD = .29) objects, and children in the new order condition recalled a mean of 9.75 (SD = .45) objects.

Organization of recall
The primary question of interest was whether children could extract information about the ordering of landmarks to support their use of spatiotemporal information in recall when only an imaginary path connected the landmarks. As in Experiment 2, three analyses were used to address this question. First, we examined whether children who experienced the same order of landmarks from familiarization to test exhibited greater spatiotemporal organization in their recall than did children who experienced a different ordering of landmarks from familiarization to test. Test ordering scores (representing the correlation between order of items recalled and order of landmarks at test) were entered into a between-subjects ANOVA. This analysis revealed that children in the same-order condition had significantly higher ordering scores (M = .89, SD = .20) than children in the new-order condition (M = .52, SD = .30), F(1, 22) = 12.91, p < .01. Second, we examined whether children in the new-order condition were more likely to use the order of landmarks during test than the order of landmarks during familiarization to structure their recall. Familiarization ordering scores and test ordering scores were entered into a repeated-measures ANOVA. As in Experiment 2, children in the new-order condition were significantly more likely to structure their recall using the order of landmarks during test than familiarization, F(1, 11) = 6.38, p < .05. The mean test ordering score was .52 (SD = .30), and the mean familiarization ordering score was .28 (SD = .25). Thus, children’s recall orders corresponded more closely to the order of landmarks at test than at familiarization.

Finally, as in Experiment 2, we examined the number of children in each condition who had ordering scores above chance. First, all of the children in both conditions with above-chance ordering scores ordered the objects from first to last. Second, in the same-order condition, 11 children (92%) had test ordering scores that were above chance. In the new-order condition, only 3 children (25%) had test ordering scores that were above chance, and only 1 child (8%) had a familiarization ordering score that was above chance. Chi-square analyses revealed that the number of children in the two conditions who had test ordering scores that were above chance differed significantly, \( \chi^2 (1) = 10.97, p < .001. \)

3 Again, because recall was near ceiling, we did not compute correlations between number of items recalled and organization of recall in this experiment. Likewise, we did not analyse recall of individual objects.
Comparison of Experiments 2 and 3

Finally, we directly compared ordering scores in Experiments 2 and 3 to further examine the impact of the path on children’s use of spatiotemporal organization in recall. Only 5-year-olds were used in these analyses because 4-year-olds were not tested in Experiment 3. First, test ordering scores were entered into a Condition (same order vs. new order) × Experiment (2 vs. 3) ANOVA. This analysis revealed a main effect of Condition, $F(1, 44) = 10.04, p < .01$, again indicating that children in the same-order condition had significantly higher ordering scores ($M = .85, SD = .25$) than did children in the new-order condition ($M = .58, SD = .33$). There was no interaction between condition and experiment, however. Thus, although children in the new-order condition in Experiment 2 had higher scores ($M = .65, SD = .35$) than did children in the new-order condition in Experiment 3 ($M = .52, SD = .30$), this difference was not significant. Likewise, although children in the same-order condition in Experiment 3 had somewhat higher ordering scores ($M = .89, SD = .20$) than children in the same-order condition in Experiment 2 ($M = .80, SD = .28$), this difference was not significant.

Second, we examined whether children in the new-order condition in Experiment 2 were more likely than children in the new-order condition in Experiment 3 to use the order of landmarks during test than the order of landmarks during familiarization to structure their recall. Familiarization ordering scores and test ordering scores were entered into an Experiment (2 vs. 3) × Ordering Score (familiarization vs. test) repeated-measures ANOVA. This analysis yielded only a significant effect of ordering score, $F(1, 22) = 11.35, p < .01$, again indicating that children’s recall orders across the two experiments corresponded more closely to the order of landmarks at test ($M = .58, SD = .33$) than at familiarization ($M = .31, SD = .26$). There was no interaction between experiment and ordering score, $F(1, 22) = .17, ns$, indicating that the magnitude of the difference between test and familiarization ordering scores was very similar across the two experiments (Experiment 2 = .31 and Experiment 3 = .24).

Finally, we also compared the number of children with above-chance test ordering scores in Experiments 2 and 3. In the same-order condition, the number of children in Experiments 2 (83%) and 3 (92%) who had above-chance test ordering scores did not differ significantly, $\chi^2(1) = .38, ns$. In the new-order condition, the number of children in Experiments 2 (58%) and 3 (25%) who had above-chance test ordering scores approached significance, $\chi^2(1) = 2.74, p < .10$. Thus, it appears that the absence of the white path made it more difficult for children in the new-order condition to use the order of landmarks during test to organize their recall.

Discussion

The results of this experiment suggest that the path itself played an important role in young children’s ability to use the order of landmarks to structure their recall, particularly when the order of landmarks changed from familiarization to test. Unlike Experiment 2, test ordering scores were much higher in the same-order condition than in the new-order condition. Likewise, the number of children with above-chance test ordering scores was much higher in the same-order condition than in the new-order condition. The comparison of Experiments 2 and 3 also indicated that when the order of landmarks remained the same from familiarization to test, the absence of the path had relatively little impact on 5-year-old children’s ability to use information about the
order of landmarks to structure their recall. In fact, the level of spatiotemporal organization in the same-order condition was virtually identical across the two experiments. When the order of landmarks changed from familiarization to test, the absence of the path attenuated 5-year-old children’s use of spatiotemporal information to organize their recall. More specifically, although test ordering scores in both experiments corresponded more closely with the order of landmarks at test than at familiarization, only 25% of children in Experiment 3 had above-chance test ordering scores compared with 58% of children in Experiment 2. Thus, it appears that the path connecting the landmarks played an important role in helping children extract information about the order of landmarks from the physical environment.

As in Experiment 2, recall was near ceiling and did not differ by condition. Test ordering scores were much higher in the same-order condition than in the new-order condition, however. Together, these findings suggest that children in the new-order condition relied on the landmarks to support their overall level of recall but not to support the organization of their recall. Thus, the results of this experiment support the proposal that the physical environment used in these experiments served two functions: (1) to enhance children’s recall of individual items, and (2) to organize the order in which children recalled those items.

**EXPERIMENT 4**

A final issue concerns whether children’s use of spatiotemporal organization served to enhance their recall. The preceding experiments clearly show that 4- and 5-year-old children used the order of landmarks along the visible path to structure their recall. The impact of spatiotemporal organization on the amount they recalled is less clear, however. In Experiment 1, 4-year-olds in the model present condition showed a positive, but non-significant correlation between ordering scores and number recalled ($r = .44, p = .15$). The number of observations used to compute this correlation was very small ($n = 12$), however. In Experiments 2 and 3, recall was at ceiling, making it impossible to examine the relation between spatiotemporal organization and amount recalled. Given the widely accepted notion that the function of memory strategies is to enhance memory performance (e.g. Flavell, Beach, & Chinsky, 1966, but also see Miller, 1990, for a discussion of utilization deficiencies), we thought it worthwhile to determine whether children’s use of spatiotemporal organization is related to the amount they recall.

Thirty-two 5-year-olds participated in the new-order condition from Experiment 2. As noted previously, reliance on the order of landmarks along the path when the ordering of landmarks changes from familiarization to test provides a strong test of young children’s use of spatiotemporal information to structure their recall. We chose to include only 5-year-olds in this experiment because the previous experiments revealed that 5-year-olds were more likely to use spatiotemporal organization in the new-order condition than were 4-year-olds. We introduced two modifications to our materials to eliminate ceiling effects in the number of objects children recalled. First, we increased the number of objects to be recalled from 10 to 12. Second, we selected landmarks and objects that were unrelated. All other aspects of the experiment were the same as in previous experiments. As reported below, the two modifications to our materials were successful in lowering children’s recall, making it possible to examine the relation between spatiotemporal organization and amount recalled.
Method

Participants
Thirty-two 5-year-old children were recruited for this experiment. The average age was 5 years and 6 months ($SD = .93$ months; range = 5;5 to 5;9). There were 15 females and 17 males. All children were recruited through a child research participant database maintained by the Department of Psychology at the University of Iowa. Again, most children were Caucasian from middle- to upper middle-class families.

Apparatus and materials
The park model was identical to that used in Experiments 1 and 2. The model contained a white winding path with 12 landmarks located along the path. Unlike the previous experiments, the landmarks and objects were unrelated. The landmarks included a bench, picnic table, swing, truck, trashcan, bush, slide, tricycle, teeter totter, wagon, ice cream stand, and sandbox. The 12 target items included a bear, basket, pot, guitar, shoe, comb, shovel, ball, phone, hanger, book, and skateboard. The landmarks and objects were randomly paired for each child. A small doll figure was used during the familiarization phase, a girl doll figure for females and a boy doll figure for males.

Design and procedure
All aspects of the design and procedure were identical to that used in Experiment 2, except that all children participated in the new-order condition, and they recalled 12 objects that were unrelated to the landmarks rather than 10 objects that were thematically related to the landmarks.

Coding
The coding and scores were identical to those in Experiment 2.

Results and discussion

Number of objects recalled
The mean number of objects recalled was 9.9 out of 12, $SD = 2.3$. Thus, increasing the number of items and using unrelated landmarks and objects was successful in lowering recall.

Organization of recall
The mean ordering score was .74, $SD = .33$, with 68% of children having ordering scores that were above that expected by chance (one child was excluded because he recalled only two items). Of the children with above-chance ordering scores, all but one ordered the items from first to last. As in Experiments 2 and 3, children were significantly more likely to structure their recall using the order of landmarks along the path at test ($M = .74$, $SD = .33$) than the order of landmarks along the path at familiarization ($M = .33$, $SD = .20$), $F(1, 30) = 39.88$, $p < .001$ (one child was excluded from this analysis because he recalled only two items). Thus, 5-year-old children again
relied on the available visible structure in the physical environment to guide their recall, even though that structure changed from familiarization to test.

**Relation between number of items recalled and ordering scores**

The primary question of interest was whether children’s use of spatiotemporal organization was related to the number of objects they recalled. As expected, the correlation between test ordering scores and number recalled was significant, $r (26) = .49$, $p < .01$. Six children were excluded from this analysis because they exhibited clear utilization deficiencies. Four of these children exhibited essentially perfect ordering scores (.98 or above) and yet missed between 25% and 33% of the items. One child had an ordering score of 1.0 and only recalled 2 items, and the other child had an ordering score of .80 and recalled only 4 items. The significant association between organization and recall suggests that children’s reliance on the order of landmarks along the path at test facilitated their recall of the missing objects. Likewise, the fact that a number of children exhibited utilization deficiencies indicates that spatiotemporal organizational strategies operate like other well-studied memory strategies (see Bjorklund, Miller, Coyle, & Slawinski, 1997, for a review of utilization deficiencies).

**GENERAL DISCUSSION**

This investigation underscores the importance of the physical context in supporting young children’s recall and organization of remembered information. In other words, young children can use the landmarks and their order along a path to systematically cue and organize their recall of objects associated with those landmarks. In Experiment 1, 4-year-olds who recalled the missing objects with the park model in view had significantly higher ordering scores than did the 4-year-olds who recalled the objects with the model out of view. Moreover, the majority of 4-year-olds in the model present condition had ordering scores that were above chance. With the exception of one child in the model present condition, ordering scores for 3-year-olds in Experiment 1 were all at chance. In Experiment 2, 5-year-olds clearly used the order of landmarks along the path to structure their recall, even when the order of landmarks changed from familiarization to test. In the new-order condition, children’s recall orders corresponded more closely with the order of the landmarks at test than at familiarization. In Experiment 3, 5-year-old children used the order of landmarks along an imaginary path to organize their recall of missing items when the order of landmarks remained the same from familiarization to test. When the order of the landmarks changed from familiarization to test, 5-year-old children had much more difficulty using the order of landmarks along an imaginary path to organize their recall of the missing items. In Experiment 4, 5-year-old children who used the order of landmarks along the path at test to structure their recall also recalled more items. Together, these findings clearly demonstrate that young children can use spatiotemporal structure in the physical environment to guide their recall.

What implications do the results of this investigation have for understanding the role of context in early memory development? Clearly, the present experiments show that visual access to the physical context during recall facilitates young children’s overall level of recall. As in Hazen and Volk-Hudson (1984), both 3- and 4-year-olds recalled
more items when the park was in view than when it was out of view. The results of the present investigation also extend Hazen and Volk-Hudson’s findings by showing that the presence of the physical context during recall facilitates young children’s organization of recall. In particular, 4- and 5-year-old children used the order of landmarks along the path through the park to order their recall of the missing objects. Importantly, the results of Experiment 4 showed that children who had higher ordering scores also recalled more items. These findings provide empirical support for Hazen and Volk-Hudson’s speculation that young children may have benefited from the physical context because it supported their use of spatiotemporal information to guide their recall. In other words, children could systematically scan a path around the room to cue their recall of the missing objects.

The results of this investigation also show that the amount of support in the physical context influences how children organize their recall. Specifically, Experiments 2 and 3 demonstrated that the children benefited from a physical context that contained a familiar ordering of the landmarks. Indeed, even when the path connecting the landmarks was removed from the park model as in Experiment 3, 5-year-old children who recalled the missing items in the more supportive context (i.e. the same-order condition) were able to use the order of landmarks along an imaginary path to organize their recall. However, 5-year-old children who recalled missing items in the less supportive context (i.e. the new-order condition) had much more difficulty using the order of landmarks along an imaginary path to organize their recall. Thus, overall, the present results (1) indicate that the supportiveness of the physical context influences both how much children remember and how children structure their recall, and (2) are consistent with proposals suggesting that children’s strategy use unfolds gradually over time, starting in supportive contexts (e.g. Folds et al., 1990; Plumert & Strahan, 1997).

The finding that young children can use spatiotemporal information to organize their recall is also consistent with other research showing that preschoolers can use route knowledge in the service of other cognitive tasks. Specifically, Anooshian and her colleagues (Anooshian, Hartman, & Scharf, 1982; Anooshian, Pascal, & McCreath, 1984) have investigated how young children use route information to infer a critical search area for locating missing objects. In these studies, children played games at several locations along a route through their preschool playground. The experimenter took a picture of the children while they played at the first few locations. The experimenter then put the camera in her bag. At some later location, the experimenter reached into her bag to retrieve the camera and found it missing. She then asked the child to help her find the missing camera. Anooshian et al. (1982) found that 3- to 6-year-old children could infer a critical search area to find a missing object. In other words, they narrowed their searches to the area where the camera was last seen and first discovered missing. In addition, Anooshian et al. found that children who had good sequence recall also exhaustively searched the critical area with relatively few total search attempts. In contrast, for children who had poor sequence recall, there was no relation between sequence recall and search scores. Anooshian et al. argue that logical inferences led to better event recall only for children who had a good sequence memory, and propose that the quality of children’s spatial representations is a crucial factor in whether children will make a logical inference. Moreover, Anooshian and her colleagues (Anooshian et al., 1984) have proposed that the ability to represent route information internally can play an important role in problem-solving tasks. The results of the present experiment offer further support for this notion by showing that young children can use spatiotemporal information to organize their recall efforts.
What are the limitations of young children’s use of spatiotemporal information? First, it is important to note that the presence/absence of the entire physical context influenced young children’s use of spatiotemporal information to structure their recall. In particular, young children were able to use information about the landmarks and their order to enhance the amount of information recalled and the organization of the information recalled only when the physical context was present. When the park model was hidden from view in Experiment 1, not even the 4-year-olds exhibited evidence of spatiotemporal organization in their recall of the missing items. This pattern of results suggests that although young children can take advantage of the structure present in the environment to aid recall, they may have difficulty drawing on their mental representation of this structure to aid recall. This is consistent with the finding that 6-year-olds use the structure of the physical environment to organize their searches for hidden objects, and they have difficulty generating organized directions for finding hidden objects (Plumert, Pick, Marks, Kintsch, & Wegesin, 1994). This difficulty with using spatiotemporal organization to structure recall of information may stem from young children’s difficulty with representing imagined movement. Gauvin and Rogoff (1989) found that not until 9 years of age did children’s descriptions of spatial layouts contain characteristics of a mental tour.

Another possible limitation of young children’s use of spatiotemporal organization in recall is the extent to which they can generalize spatiotemporal organization to new situations. In Experiment 2, 5-year-olds clearly generalized spatiotemporal organization to a new ordering of landmarks along the path. Four-year-olds, however, appeared transitional with respect to their ability to generalize spatiotemporal organization to a new ordering of landmarks. Their ordering scores were somewhat higher when the ordering of landmarks along the path remained the same from familiarization to test. Moreover, when the path connecting the landmarks was absent, even 5-year-olds were limited in their ability to use the order of landmarks along an imaginary path to organize their recall. Five-year-olds were more likely to use the order of landmarks along an imaginary the path to organize their recall when the ordering of the landmarks was the same from familiarization to test. This pattern of findings suggests that the ability to generalize a spatiotemporal organization from one situation to another undergoes considerable development.

A final issue concerns whether children’s use of spatiotemporal information to structure their recall reflected a passive or an active process. In other words, to what extent were children being strategic in their use of spatiotemporal information? Typically, we think of strategies as deliberate, goal-directed mental operations that are directed at solving a problem (Harnishfeger & Bjorklund, 1990). In addition, strategy use is usually related to amount recalled. Thus, children who are strategic usually recall more than do children who are not strategic. Clearly, the results of Experiment 4 indicate that children who had higher ordering scores also recalled more items. Using this criterion, it appears that children were being strategic in their use of spatiotemporal organization. Moreover, the finding that a number of children in Experiment 4 exhibited significant utilization deficiencies indicates that children relied on spatiotemporal information to structure their recall. As with other more well-studied memory strategies, it appears that the demands of using a spatiotemporal organizational strategy lead to poorer recall for some children. Thus, it appears that young children can use spatiotemporal structure in the physical environment to actively guide their recall efforts.

Importantly, children could only implement a spatiotemporal organizational strategy...
when they could visually access the order of landmarks along the path. One implication of this finding is that young children’s reliance on visually accessible environmental structure represents an important step in early strategy development. In particular, the ability to systematically use a physically present context as a guide for organizing information may be a precursor to the ability to systematically use a remembered physical context (i.e., a mental representation of a physical context) for the purpose of organizing information. This proposal is consistent with a study by DeLoache and Todd (1988) showing that 4- and 5-year-olds spontaneously placed containers with the same contents in the same location to help them remember whether a container held a piece of candy or a peg. In this case, young children created a visually accessible physical context for themselves that facilitated their recall. Thus, it appears that strategy use emerges gradually over development, starting with reliance on physically present contexts and moving to reliance on remembered contexts.

In closing, the present investigation makes several contributions to the literature on early memory development. First, it appears that young children can use spatiotemporal information present in the physical environment to aid in organizing their recall of information. Second, the results of the present investigation underscore both the capabilities and limitations of young children with respect to early strategy use. And third, this investigation raises important questions about the role of the physical environment in promoting early memory development.

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References


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