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ABSTRACT

Children's memory for spatial locations in a room designed to look like a grocery store was examined. In the first of two studies, 48 preschoolers completed a memory task for spatial locations problem and an incidental recall task in two room arrangements varying in logical organization. Memory for spatial locations was higher in a clustered and logical arrangement than in a nonclustered and random arrangement. In the second study, a total of 74 kindergartners and first and second graders were assessed for knowledge of classification, spatial operations, field dependence and independence, and memory for locations of items in a logically organized room arrangement. Memory for the general area of the room in which objects belonged was expected to relate to knowledge of classification, while memory for more specific locations was expected to be related to knowledge of spatial operations and field independence. Surprisingly, most children performed well on memory for general location, leading to the rejection of the first hypothesis. Consistent with the second hypothesis, results of a multiple regression showed that memory for specific spatial location was related to spatial operational knowledge, strong performance on the Children's Embedded Figures Test, and the strategy used to complete the reconstruction. When children were asked to recall the contents of the space, performance was related to age and accuracy on the spatial reconstruction. (31 references) (RH)

Young Children's Memory for Spatial Locations in Organized and Unorganized Rooms

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Running Head: Memory for Organized and Unorganized Rooms

Abstract

Children's memory for spatial locations in a room sized space designed to look like a grocery store was examined in two studies. In Study 1, 48 3- and 4- year olds completed a memory for spatial locations problem and an incidental recall task in two room arrangements varying in logical organization. In the clustered arrangement items were categorized logically in space. In the non-clustered arrangement the same items were randomly arranged. Memory for spatial locations was higher under the clustered than the non-clustered arrangement although organization had no effect on recall. In Study 2, 74 children in kindergarten, 1st and 2nd grades were assessed for knowledge of classification, spatial operations and field dependence/independence along with memory for the locations of items in a logically organized room arrangement. Memory for the general area of the room in which objects belonged was expected to be related to knowledge of classification while memory for more specific location was expected to be related to knowledge of spatial operations and field independence. Surprisingly, most children performed extremely well on memory for general location, leading to the rejection of the first hypothesis. However, consistent with the second hypothesis, results of a multiple regression showed that memory for specific spatial location was related to spatial operational knowledge, higher performance on the CEFT, and to the strategy children used in completing the reconstruction. Children were also asked to verbally recall the contents of the space. Performance on the incidental recall task was related to age and accuracy on the spatial reconstruction. Results are discussed in terms of Piagetian theory and current research on children's environments.

Young Children's Memory for Spatial Locations in Organized and Unorganized Rooms

Early childhood practitioners have long noted the importance of the physical environment for optimizing young children's learning. More recently, environmental and developmental psychologists have also focused their attention on the physical environment with an eye towards the identification of environments enhancing young children's development (e.g., Liben, 1988; Weinstein & David, 1987). A range of specific environments have been studied including one of the most salient environments in the lives of young children, classrooms.

An environmental design principle often cited in the literature for early childhood practitioners and discussed by researchers addressing the physical environment of the classroom concerns the organization of classrooms into well defined learning or activity centers (Harms & Clifford, 1980; Weinstein, 1987). Typically, such activity areas contain learning materials related to common educational or curriculur goals along with a physical arrangement which articulates spatial boundaries. Examples would include the block area, the sociodramatic play area, library corner and so forth. A variety of rationales have been offered for such environmental organizations. These include pragmatic classroom management concerns (see, for example, Leavitt & Eheart, 1985, p. 33) as well as arguments that such classrooms can enhance children's cognitive functioning. For example, Nash (1981) found that creative productivity and performance on a variety of language skills improved in well organized as opposed to "randomly" organized classroom spaces. Along somewhat similar lines, the High/Scope preschool curriculum guide informs teachers that organizing the environment logically into well defined interest areas can enhance young children's early classification and categorization skills

(Hohman, Banet & Weikart, 1972, p. 202). While there is some data documenting the effectiveness of well defined learning centers from a classroom management perspective (e.g., Weinstein, 1977), there is surprisingly little data to back up claims that children can remember where things belong better in logically organized as opposed to unorganized rooms or that such arrangements can facilitate classification skills.

However, recent work in children's spatial memory development may shed some light on the relationship between environmental organization and young children's representational abilities. Working from a constructivist perspective, Golbeck (1983; 1985a) has argued that young children's memory for logically organized spaces meshes with their emerging cognitive skills. Golbeck defined logical organization as the clustering together in space of objects sharing functional or abstract properties. Such clustering might be seen in the arrangement of merchandise in department stores, the placement of furnishings into appropriate rooms of the house, or the grouping of furniture into learning centers of a classroom (Golbeck, 1985a). Clustering simplifies spatial representational demands created by the environment because contents of the environment can be classified or categorized together. Hence, environmental clustering enables the individual to use logical as well as spatial knowledge for representing the spatial setting.

Drawing upon Piaget and Inhelder's (1968/73) constructivist approach to memory, as well as Mandler's work on spatial memory (1979; 1983), Golbeck (1983) examined the role of classification operations in memory for a room-sized space which varied in logical organization. Subjects at three levels of operativity in classification reconstructed from memory one of two arrangements; a clustered environment, including 16 items of furniture grouped by color and surface pattern; and a non-clustered environment, including the identical pieces of furniture positioned randomly. In addition to finding that the clustered arrangement was easier to remember than the non-clustered arrangement, the results supported the hypothesis that knowledge of classification would enhance memory for the locations of furniture in the room. While this study demonstrated that classification knowledge is related to memory for an environmental arrangement organized by color and pattern it is unclear, if this relationship extends to other types of clustered settings, such as that found in a well organized early childhood classroom. Furthermore, it is unclear if preschool aged children would benefit from such environmental organization for remembering spatial location.

STUDY 1

The purpose of Study 1 was to more closely examine young children's ability to make use of environmental organization for representing locations in a room size space. The role of logical clustering in the environment was examined in the present study with a slightly different type of arrangement, one not neccesarily relying upon multiple classification skills. Children were asked to remember the locations of objects in a mock grocery store. The grocery store arrangement was used because a typical grocery store possesses a logically clustered type of organization with grocery items grouped and categorized. This organizational pattern is much like that of the well organized early childhood classroom. Memory for spatial location was examined here by asking children to reconstruct the arrangement of objects in the store. The mock grocery store here was set-up in two conditions, a logically organized, clustered, arrangement with items grouped (e.g., paper products, cookies, fruit, and cereals) and an unorganized arrangement, with the same items located randomly on the grocery store shelves. Findings from both memory for two dimensional graphic stimuli (e.g., Mandler, 1983) as well as memory for large-scale space (Golbeck, 1983; 1985) led to the expectation that young children would more accurately remember the location of objects in the organized arrangement. In addition to assessing children's final product, the strategy children used for completing the reconstruction task was monitored.

A second focus of this study was children's incidental recall of information about a space. Verbally recalling information about a space and reconstructing the spatial position of items within space draw upon different, although possibly complementary, skills. While reconstructing an environmental arrangement draws upon spatial knowledge, the spatial demands of the verbal recall task are less clear. Past work (e.g., Lange, 1979) suggests that mode of presentation as well as context can influence recall. Of interest here was the amount of information about the space children recalled under the clustered and non-clustered condition.

Method

Subjects. The subjects were 48 children attending a university laboratory preschool. The subjects were divided into two age groups, one approximately 3 years of age (38 mos. to 47 mos.) and the other, approximately 4 years of age (50 mos. to 61 mos.). Half the subjects in each group were male. One four year old male refused to complete the experimental procedure so the final sample included 47 children.

Stimulus Materials. Stimuli for the memory tasks included 36 grocery store items from four categories of merchandise; cookies, fruit, paper products and breakfast cereals. Groceries were chosen for their distinctiveness and because they seemed likely to be familiar to young children unable to read labels. Within each category were three types of items; and each item was presented in triplicate. Real items, as opposed to replicas, were used. All packages were colorful and either included salient pictures of the package's contents or were wrapped in cellophane.

Both the reconstruction and the recall tasks were conducted in an empty room close to the classroom. Four banks of shelves, each containing three shelves were used for the grocery store. [Each measured 76 cm wide by 116 cm high and 29 cm deep and contained three shelves on which each of the three types of items within each category could be arranged.] Shelves were arranged on two sides of a rectangular floor area. Two sets of shelves were placed next to each other on each of the two long sides of the rectangular area. A distance of approximately 200 cm separated the two sets of shelves (on the opposite sides of the rectangular area). In addition, a wire basket was located in the center of the room and a small cash register was placed on a table at one end of the testing area.

Design. The design was a four-way mixed model analysis of variance; 2 (age) X 2 (sex) X 2 (task order) X 2 (task condition), with repeated measures on the last factor. Task was counterbalanced within each sex by age grouping. Subjects were presented with each condition on different days separated by approximately two weeks.

Reconstructive Memory Task. Subjects completed the reconstruction task under both the Clustered and Non-clustered format. For both conditions, identical items (e.g., the three boxes of chocolate chip cookies) were placed on the same shelf. However, in the Clustered condition, all items from a particular category (e.g., cookies) were placed on the same rack or bank of shelves. In the Non-clustered condition, items within categories were mixed across racks. Items were randomly assigned to racks and to shelves within racks with the constraint that a single shelf not contain more than one type of item.

Procedure. Under both conditions, subjects entered the testing room with the shelves partially arranged. One item was preplaced on each of the 12 shelves. The remaining items were in the wire basket in the center of the room. The experimenter said to the subject, "This is a pretend grocery store and we are going to play a remembering game. I'll tell you how to play the game, but first, I'd like you to help me finish stocking the shelves. Do you know what it means to stock the shelves? You pick something out of the basket, and I'll tell you where it belongs and we will keep doing that until we've put everything in place. Okay, pick something." The experimenter then asked the subject to label the item. If the subject did not have a label, the experimenter provided one, while pointing out distinctive features on the package. Care was taken to use the same label in all cases where the child did not generate his or her own. The child was asked to repeat the label and the experimenter pointed to the correct shelf location for the item. This was repeated until all items were positioned.

The experimenter then said, "Okay, now we're going to play a remembering game. I'm going to take the things off the shelves and I'm going to ask you to put them back, all by yourself. Do you think you can do that? Before I take them off, I want you to look closely at everything." The experimenter pointed to the first rack and asked the subject to name the item on each shelf. The experimenter moved around the space clockwise pointing to each of the shelves in turn, from the top to the bottom of each rack, and asked the subject to label each item.

When the subject agreed that (s)he could remember everything, (s)he was directed to sit behind a partition and to play with the toy cash register while items were removed from the "shelves of the store." Sixty seconds later the subject returned to the space and was told to put things back, just the way they were before.

The order in which items were replaced, the total time for completion of the reconstruction and item placement were recorded.

Recall Task. The recall task was conducted immediately following the reconstruction. The experimenter sat with the subject behind a partition, out of view of the "store" and said, "Can you tell me all the things that were in the store?" This was followed up with, "Can you think of anything else?" One subject refused to participate in the recall task.

Results

Reconstruction Task. Two measures were devised for scoring the reconstruction task, memory for the correct rack or General Location, and memory for the correct rack and shelf within the rack, or Specific Location. General Location Accuracy was determined by counting the number of individual items returned to the correct rack for each subject. Specific Location accuracy was determined by counting the number of items returned to both the correct rack and shelf within the rack. Possible scores for each ranged from 0 to 36. Scores on General Location and Specific Location were each analyzed in a mixed-model analysis of variance including Age, Sex, Task Order and Task Condition. The last factor was a repeated measure.

Group means and standard deviations for General Location can be found in Table 1. Results for General Location showed a main effect for Task condition, $F\ (1,39) = 17.24$, $p < .001$, with performance in the Clustered condition higher than the Non-clustered ($M = 29.8$ vs. 23.6). There were no other effects or interactions.

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Group means and standard deviations for Specific Location can be found in Table 1. Results for Specific Location also showed a main effect for Task Condition $F(1,39) = 3.88$ $p < .05$ with performance in the Clustered condition higher than the Non-clustered format ($M = 22.6$ vs. 19.3). Again, there were no other main effects of interactions.

To further clarify improvements in memory under the clustered format, reconstructions were scored for the category arrangement of the racks. Among the 3 year olds, 10 of the 24 subjects placed items in correct categories. Among the 4 year olds, 15 of the 23 subjects completing the task placed items in categories. These findings suggest that although the children as a group were benefitting from the organization of the space, many children still committed errors in categorization or clustering within the space.

An effort was made to analyze strategies children employed for completing the reconstruction by examining the order in which items were returned to the shelves. However, no distinctive patterns could be identified.

Recall. The verbal recall task was scored by determining the total number of items correctly recalled, excluding intrusions, repetitions, and general category labels (e.g., cookies). These were analyzed in a mixed model analysis of variance including age, task order, sex and condition. The last factor was a repeated measure. The results showed a main effect for age, $F(1,38) = 24.04$, $p < .001$, with the four years olds outperforming the three year olds ($M = 6.18$ vs. 2.85). However, there was also an interaction between age and sex. Unlike the three year old group, where males and females performed comparably, among the four year olds, females outperformed their males peers (7.17 vs. 5.00). There was no effect for task condition on the recall task.

Discussion

Study 1 was designed to examine preschoolers ability to make use of a logically organized or clustered arrangement to remember spatial location. The results demonstrate that children as young as three years of age can make use of the a "clustered" organization in the environment to remember where things belong. These findings suggest that preschoolers can indeed make use of physical arrangements in the classroom, such as "learning centers" or "activity centers", traditionally used in well designed early childhood classrooms, to help them remember locations for items in the classroom.

While these preschoolers were able to benefit from the clustered organization of the room to remember where things were located, it is important not to over estimate their competence on this task. A large minority of the four year olds still failed to logically categorize items, failing to return all items to their appropriate rack or category grouping. This pattern of performance is hardly surprising among children in this age group, who lack a firm differentiation between logical and spatial knowledge (Inhelder & Piaget, 1964/69; Nicolopoulou, 1988; Piaget & Inhelder, 1948/1956). Indeed, there are parallels between performance of young children in logical sorting problems and the reconstruction task here used here (Inhelder & Piaget, 1964/69). Prior to consistently grouping items by category, rough approximations of categories are evident. Children can generally keep track of the defining criteria of the category but occasionally forget, and place an item in the wrong grouping. Such fluidity of thought characterizes pre-operational thinking.

Furthermore, while the preschool children in Study 1 benefitted from environmental organization in their memory for locations, no such differences were found in their incidental verbal recall. Although recall improved between the three and four year old groups, the organization of the context, or items to be remembered, had no effect upon the performance of these preschoolers. This finding is consistent with past work on children's memory (Bjorklund, 1989) which shows a pronounced age improvement during the early childhood years in memory performance.

STUDY 2

While findings from Study 1 show that even young children can make use of environmental clustering to remember spatial location, the mechanisms underlying this effect are unclear. The purpose of Study 2 was to examine correlates of success on reconstructive memory within a clustered arrangement. It was hoped that such an approach would help to identify emerging cognitive skills particularly important for remembering the spatial environment. Logically organized spaces, such as well organized early childhood classroom spaces, or the clustered grocery store set up in Study 1, are especially interesting because presumably they draw upon both logical and spatial knowledge. In past work, the relationship between children's emerging cognitive skills and memory for location has been examined in highly contrived experimental arrangements. One purpose of this study was to reconsider these relationships in a somewhat more life-like setting, the clustered grocery store arrangement used in Study 1.

Golbeck (1983) found operativity in classification was related to memory for general location, but there was no relationship between classification and memory for more specific spatial position within the general area. While memory for general location may be related to classification skills, memory for more specific spatial position should be related to Euclidean spatial knowledge. (Piaget & Inhelder, 1948/56; Piaget, Inhelder & Szeminska, 1960). This hypothesis was supported in a second study by Golbeck (1985b). Children's ability to represent an invariant vertical, a tree, on the side of a hill, was related to memory for specific spatial position, in a room sized spatial memory task. In the present study, children were asked to complete a reconstructive memory task similar to the one used in the clustered condition of Study 1. It was expected that knowledge of classification operations would be related to memory for general location, while memory for more specific location would be related to emerging spatial knowledge.

A second focus of the present study was the strategy children employed for completing the memory task. Skeen and Rogoff (1987) found that children in the early elementary school years misapply list learning strategies for remembering spatial information. It seemed possible that within an organized space, the use of a linear rehearsal strategy might distract a child from the use of a more appropriate categorization strategy. The sequence of item placement in the reconstruction task was monitored as an indicator of strategy.

A third focus of this study was children's incidental recall of information about a space. Given the large literature on children's use of clustering strategies in recall (Bjorklund, 1988; Lange, 1979), it seemed reasonable that classification operations might play a role in verbally recalling the contents of a space. Furthermore, classification operations might serve to organize children's recall. If knowledge of classification aids in the storage of information about an organized environment, classifiers should remember more than non-classifiers about a logically clustered setting. On the other hand, it has also been argued that young children make use of associative relationships to organize memory (Lange, 1979). If this is the case, young children performing well on the reconstruction task may use their spatial image of the physical arrangement to aid recall.

A fourth focus of this study was an exploratory investigation of the role of individual differences in memory for the spatial environment. The cognitive style of field independence has been associated with success on a variety of spatial tasks (Kogan, 1983). However, this topic has received little attention from researchers interested in the development of large-scale spatial representation. Witkin and Goodenough (1981) have argued that the ability to cognitively restructure a stimulus array accounts for the relationship between performance on spatial visualization tasks and the embedded figures problems typically used to assess cognitive style. Cognitive restructuring skills increase with age, although children's relative standing with respect to their peers remains fairly constant over time (Witkin, Oltman, Raskin, & Karp, 1971). Since it was expected that children performing well on a test of field independence would also perform well on a spatial reconstruction problem, restructuring skills should predict memory for specific spatial position. However, restructuring skills would not be expected to be relevant for recalling the contents of the space and cognitive restructuring ability should not be related to verbal recall.

In sum then, within an organized environment, knowledge of classification was expected to predict children's ability to remember the general locations of objects while spatial knowledge and cognitive restructuring ability were expected to predict memory for more specific spatial position in the room. Knowledge of classification was also expected to enhance recall of the contents of the room and was therefore expected to be related to both the total number of items remembered as well as the organization of those items in recall. Finally, relationships between performance on the spatial reconstruction task and verbal recall were examined.

Method

Subjects. The subjects were 74 children in kindergarten, first, and second grades from a middle class suburban school district in central New Jersey. Subjects were drawn from kindergartens and three combined first and second grade classes The kindergartners included 17 males and 12 females with mean ages of 68.8 and 71.8 mos. respectively (range = 64 mos. to 76 mos.) The group of "first grade" age included 10 males and 17 females with mean ages of 82.9 and 82 mos. (range = 76 mos. to 87 mos.). The group of "second grade" age included 11 males and 9 females with mean ages of 96.5 and 92.1 mos. (range = 86 mos. to 103 mos.).

Procedural Overview. All children were tested individually in two sessions. During the first session, children were assessed for classification and spatial knowledge. During the second session, the memory problems were presented and children were assessed for cognitive restructuring ability.

Classification. Knowledge of classification was assessed with four hierarchical classification problems. (Hierarchical classification incorporates the ability known as class inclusion.) Tasks were modeled after those described by Dean, Chaubaud & Bridges (1981) and are based on Inhelder & Piaget (1964/69). Each task consisted of four problems. On two problems children were asked if there were more objects in the superordinate or a subclass, and in two, if there were fewer objects in the superordinate or a subclass. On one "more" and one "fewer" problem, the subclass ratio was 3:1, and on the remaining two problems, was 2:2. Two tasks included drawings of children, boys or girls. Two tasks included drawings of houses varying in color, green or red. For each problem, children were asked to; a) count the number of items in both subclasses, b) count the number of items in the superordinate class, c) judge whether there were more or less in the superordinate or subordinate classes and d) explain.

Spatial Knowledge. Children were asked to complete two spatial tasks; 1) the representation of invariant verticals, or trees, on the sides of a hill, a standard assessment of children's knowledge of verticality and 2) the duplication of spatial position. Both these problems presumably require the use of an underlying coordinate system of horizontals and verticals for representing spatial relationships. The spatial positioning task was presented first with the verticality task immediately following it.

Verticality. Subjects were asked to represent invariant verticals in the physical world, specifically, trees on the sides of a hill. The task is similar to one described by Piaget and Inhelder (1948/56) and the procedure described by Liben (1981) was used. An isosceles triangle with bases of 45 degrees was drawn on a piece of paper measuring 21.5 cm x 28 cm. The paper was aligned with the edge of the desk. Subjects were encouraged to draw at least three trees on each side of the hill. Drawings were scored by measuring each tree's deviation from the true vertical in degrees off. The average deviation across all trees drawn for each subject served as the verticality score.

Duplication of Spatial Position. The subject was asked to position a small toy on a map board so as to match an identical arrangement on a model. This problem was based on Piaget and Inhelder's (1948/56) topographical positioning task. Two identical map-boards were created, each measuring 45 cm by 30 cm. Each map was divided by a twisting road. With the maps oriented in the same direction, but unaligned, the experimenter identified one as hers and one as the child's. The experimenter then located a toy horse on her map, handed the child an identical horse, and asked the child to locate the horse in just the same spot on his map. After two practice trials with feedback, 10 test trials were presented. Carbon paper was placed under the subject's map and each of the ten test responses was recorded with a stylus. Deviations from the correct location were later measured in centimeters and the mean deviation served as the spatial positioning score.

Memory Tasks: Overview. Stimuli for the memory tasks were similar to those used in the Clustered Condition of Study 1. An arrangement of 48 items representing four categories of grocery store merchandise; cookies, baking mixes, paper products and cereals was created. Within each category were three different types of items; and each item was replicated four times. Items within the cookie category included four boxes each of Oreos, chocolate chip cookies, and saltine crackers. Those within the baking mix category included four boxes each of brownie mix, marble cake mix, and white cake mix. Those within the paper product category included four packages each of toilet paper, paper towels, and facial tissue. Finally, items within the cereal category included four boxes each of Kellogs Rice Krispies, Kellogs Frosted Flakes, and Cheerios.

Items were arranged on the four racks of shelves used in Study 1 and described above. The four racks were located in a square shaped arrangement measuring 228.5 cm on each side, in an empty room in the school. Each rack always contained an entire category of food (e.g., cake, cereals, etc.) and each shelf contained four identical items.

Reconstructive Memory Task: Procedure. Upon entering the testing room children were told they were going to play a remembering game and that for this game they needed to pretend that they were in a little grocery store. Items were arranged on the shelves prior to the subject's entry. The subject was led to the center of the "grocery store" and his attention was directed to the top shelf of the rack nearest the door. The subject was asked to identify the items on the shelf. If he seemed uncertain, attention was directed to the picture on the box and the experimenter probed until a specific name for the item had been provided (e.g., chocolate cookie or Oreo, not just cookie). This procedure was repeated systematically, from the top to the bottom of each rack in a clockwise fashion around the room, as the subject was asked to identify all items on the shelves. The subject was then told that the experimenter was going to take everything off the shelves in the grocery store and the child would be asked to put things back in the same exact places. The experimenter directed the child to look at everything carefully, one more time, moving in a clockwise fashion around the room. The child was escorted out of the room, seated at a table and asked to make a drawing of the school while he waited. During the next three minutes the experimenter removed all the items from the shelves and randomly positioned them in two plastic laundry baskets in the center of the room. At the end of the three minute period the subject returned to the room and was asked to put things back on the shelves just the way they were before. Throughout the reconstruction activity, the experimenter sat ir a corner of the room uncbtrusively recording the order in which the subject placed items on the shelves.

Recall Task. The incidental recall task was given five minutes after the completion of the reconstruction task. The Children's Embedded Figures Test was used as a distractor task during this five minute period. The experimenter said to the subject, "I'd like you to think again about the little grocery store. Tell me what was in the grocery store." Responses were recorded by the experimenter. If the subject provided only a general category label (e.g., cookies), the experimenter immediately probed (e.g., anything special about the cookies?). If this failed to generate a more specific response there was no further probing. However, when the subject appeared to have stopped listing items, the experimenter said, "Can you think of anything else?" Due to scheduling problems, three subjects failed to complete the recall task.

Children's Embedded Figures Test. Following the reconstruction task, the experimenter presented a shortened form of the Chil(:en's Embedded Figures Test. This included two practice trials and the first 11 items. Procedures described in the test manual were followed. In addition to assessing cognitive style, the CEFT served as a distractor between the reconstruction and the incidental recall tasks. To control the duration of time between completion of the reconstruction and the beginning of the recall task, it was occasionally necessary to interrupt the CEFT. After five minutes had elapsed, if the child had not finished the CEFT, the experimenter stopped testing and asked the child to complete the incidental recall task. When the CEFT presentation was interrupted, remaining test items were administered after the Recall Task.

Results

Knowledge of Classification. Performance on classification was scored from 0 to 4. Each of the four problems was scored as correct or incorrect. Responses to both the "more" and "fewer" questions were considered and if the subject failed to respond correctly to either question within each problem, the response was considered incorrect. Subjects failing all four problems were categorized as preoperational in classification (n=32). Those with scores of 1,2 or 3 were considered transitional (n= 25) and those with scores of 4 (n=17) were considered concrete operational. Overall, $M = 1.68$, s.d. = 1.67. A preliminary analysis showed that scores were related to age, $r(74) = .54$, $p < .001$, and that there were no differences between males and females.

Verticality. As described above, the drawings of trees on the sides of a hill were scored by measuring each tree's deviation from the true vertical in degrees off. The average deviation for each subject served as the verticality score. Overall, $M = 21.05$, s.d. = 14.47. Scores were not related to age, $r(74) = -.02$. There were no differences between males and females.

Duplication of Position. As described above, the positioning task was scored by measuring the distance in centimeters between a correct placement of the toy horse and the actual placement. Since their were 10 trials per subject, an average score was computed for each subject.

Overall, $M = 4.03$, s.d. $= 3.02$. Scores were correlated with age, $r(74) = -.51$, $p < .001$. There were no differences between males and females.

Children's Embedded Figures Test. One point was earned for each of the 11 problems solved correctly--that is for correctly identifying the hidden figure. Overall, $M = 6.35$, s.d. $= 2.35$. Scores were correlated with age, $r(74) = .40$, $p < .001$. There were no differences between males and females.

Memory: Reconstruction Task. With three exceptions, all subjects returned the four identical items to a shelf and placed items (although not necessarily the correct items) in previously occupied locations. The reconstructions by the 71 subjects meeting this requirement were coded in two ways, general location accuracy and specific location accuracy. The three subjects failing to return four identical items to previously occupied places all placed one or more items on the top of the shelf rack, leaving an empty shelf. For these subjects, reconstructions were scored in terms of the relationships between the shelves (i.e., top, middle and bottom) rather than precise position.

General Location. A general location score was computed by determining the number of items returned to the correct rack, (Note: the correct rack was also the correct category). Specific location within the rack was irrelevant. Surprisingly, 68 of the 74 subjects returned all items to the correct rack. All six failing to return items to the correct rack also failed to categorize them.

Specific Spatial Location. A specific spatial location score was computed for those subjects returning items to the correct general location. This score was based on the number of items returned to their correct shelves within each rack. Since there were three shelves on each rack, there were two degrees of freedom for each category of items . (If two shelves were arranged correctly, the third was necessarily correct.)

Two points were therefore earned for each accurately arranged rack. Since there were four racks, eight was the maximum possible score. Overall, M = 7.32, s.d. = 1.01. Memory for Specific Location was not related to age, r (68) = .02.

Reconstruction Strategy. As described earlier, the strategy children employed for completing the reconstruction was monitored for what it might reveal about the use of mnemonic strategies. It became apparent that children employed markedly different approaches for completing the reconstruction. Some children appeared to be quite "shelf bound" in their reconstruction. These children appeared to look at a shelf and decide what belonged in the spot and then began searching through the baskets of grocery items to find the item. If a child was using a listing strategy (e.g., Skeen & Rogoff, 1987), this might be what one would expect to see. Other children appeare more "basket bound." These children picked up whatever item was on top of the pile in the basket and positioned it on the shelf. The first approach took longer. The second approach was more time efficient but also demanded more flexibility since items were placed in the baskets in the center of the room randomly. The variety of different items positioned during the first 12 placements reflected these two strategies for reconstruction. A completely "shelf bound" child would have located only three different types of items since there were four items of each type on each shelf. A "basket bound" child would have placed many different types of items in the first 12 positionings. Overall, M = 6.19, s.d. = 2.10. This strategy was not related to age, r (74) = -.01.

Recall. Two scores were computed for the incidental recall task; the total number of items recalled and the categorical clustering present in the recall list. Total recall was the number of items listed by the child excluding intrusions and repetitions. Category labels (e.g., cookies), that did not yield more specific responses after the experimenter's probe were also excluded from the total score. Overall, $\underline{M} = 8.63$, s.d. $= 3.08$. Recall was correlated with age, $\underline{r}(71) = .46$, $\underline{p} < .001$. To measure clustering in recall, the Ratio of Repetition [r/(n-1), where r = number of intra-category repetitions and n = the total number of items recalled] (Bousfield, 1953) was computed. While there are some problems with interpreting this measure with children (see Frankel & Rollins, 1982), it was used to provide a rough estimate of the degree of clustering in recall. The subject receiving a total recall score of 1 was dropped from this analysis. Overall, $\underline{M} = .54$ and s.d. $= .18$. Clustering in recall was related age $\underline{r}(70) = .42$, $\underline{p} < .001$.

Relationships between Operativity, Restructuring Ability and Memory: General Location. It was hypothesized that memory for General Location would be related to children's knowledge of classification. However, performance was unexpectedly high on this measure of memory. All but six subjects returned all items to the correct rack of shelves. Of the six making errors, four had failed the assessment for classification, one was transitional and one had passed. Since the vast majority of children at each level of operativity returned all items to the correct rack, these results do not support the hypothesized relationship between classification knowledge and memory for General Location.

Specific Location. It was also hypothesized that memory for Specific Location would be related to spatial knowledge and performance on the CEFT. This hypothesis was tested by entering six variables into a multiple regression equation; the two measures of spatial operations (Verticality and Point Duplication), CEFT, age in months, sex, and a measure of the strategy used during reconstruction. Correlations between the variables are shown in Table 2. (The six subjects making errors in General Location were excluded from this analysis.)

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Insert table 2 about here

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The overall regression model was significant, $\underline{R} = .54$, $\underline{F}$ $(6,61) = 4.08$, $\underline{p} < .01$. One measure of spatial knowledge, Verticality, contributed significantly to the overall model, $\underline{t} = 2.64$, $\underline{p} < .01$; as did CEFT, $\underline{t} = 2.07$, $\underline{p} < .05$; and the measure of strategy, $t = 3.61$, $\underline{p} < .001$. It is noteworthy that Point Duplication was not a significant predictor of performance on Specific Location accuracy.

Recall. It was expected that recall of information about the room-sized space would be related to children's knowledge of classification. It was also tentatively hypothesized that recall would be related to performance on the spatial reconstruction task. These relationships were examined through a regression analysis. The correlation matrix is shown in table 3.

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Insert table 3 about here

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Classification knowledge, CEFT, sex, age in months, along with performance on the reconstruction task, were entered into a regression. (A revised three point reconstruction score was created for this analysis-- perfect reconstruction, correct categorization but errors in specific location, and category or general location errors.) While recall and classification were correlated ($\underline{r}=.34$), when entered into the equation with age, the relationship was no longer evident. The overall regression was significant, $\underline{R} = .59$, $\underline{F}$ $(5,65) = 7.10$, $\underline{p} < .001$. Both age, $\underline{t} = 2.87$, $\underline{p} < .01$ and performance on the reconstruction task, $\underline{t} = 3.02$, $\underline{p} < .01$, contributed significantly to the model.

Clustering in Recall. It was further expected that classification would relate to the incidence of clustering in the recall lists produced by children. Using the Ratio of Repetition as a clustering index, this hypothesis was examined through a regression. The correlation matrix is shown in table 4. Performance on classification and age were entered into the regression along with performance on the reconstruction task. The overall regression model was significant, $R = .43$, $F(3,66) = 5.38$, $p < .01$, however only age contributed significantly to the regression model, $t = 2.87$, $p < .01$.

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Insert table 4 about here

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Discussion

The purpose of this study was to examine factors related to young children's memory for an organized environment. A grocery store setting was chosen because it was both highly organized and meaningful to young children. A first goal here was to examine relationships between operativity and memory within this logically organized setting. It was expected that memory for the general locations of objects would be related to knowledge of classification while memory for specific location would be related to spatial knowledge. Although there was no support for the hypothesis concerning classification, the relationship between spatial operations and memory for specific location was consistent with expectations. While the zero order correlation was marginally significant, after controlling for age, strategy and sex the relationship was evident. This finding is consistent with past work examining spatial operational knowledge and representation of large-scale space (Golbeck, 1985b; Hart & Moore, 1973; Liben, 1988).

It was also expected that cognitive restructuring ability would be related to the spatial aspects of the reconstruction task. This hypothesis was also supported by the present data. This finding is interesting because it illustrates that individual differences in cognitive restructuring ability have implications for children's functioning in real world spatial problems and that these differences are apparent even in young children.

A final factor influencing children's performance in memory for specific spatial position was the strategy children used for completing the task. While strategy differences were correlated with accuracy, they were not correlated with age. A possible explanation for this strategy difference may be the misapplication of a mnemonic strategy children had learned in school. Skeen and Rogoff (1987) note that the utility of listing strategies as memory aids is typically taught implicitly in first and second grade. Since testing for this study was completed late in the school year, it seems quite possible that subjects were exposed to some type of instruction in this domain. The use of a listing strategy is consistent with the behavior of the "shelf bound" subjects in this study. In any event, a closer examination of conflicting strategies in spatial memory should be a focus of future research.

A second goal of this study was an examination of children's verbal recall for objects in an organized environment. It was expected that age and classification operations would predict the number of items recalled in an incidental memory task. Furthermore, it was tentatively hypothesized that performance on the spatial reconstruction task would be related to verbal recall. Results of the regression showed that age and performance on the spatial reconstruction task, although not classification operations, contributed to recall. It is noteworthy that verbal recall of items in the environment was related to performance on the spatial reconstruction task. Lange (1979) has argued that young children make use of associative relationships to aid recall. It may be that some type of visualization strategies contribute to performance on both the verbal recall and the spatial reconstruction task.

Perhaps the most surprising finding in this study is the high degree of accuracy on General Location. It does appear that a full fledged understanding of classification is not necessary for making sense of, and remembering, the organized grocery store arrangement. Indeed, many of the children failing the assessment for classification operations competently returned items to the correct racks.

General Discussion

Both early childhood practitioners and environmental psychologists have argued that the physical environment influences young children's cognitive functioning. Results from these two studies shed light on ways that the organization of the physical environment interacts with children's emerging cognitive skills to influence memory for spatial locations. Of particular interest here is logical organization, or the clustering together in space of objects sharing functional or abstract properties. An important instance of logical organization occurs in the early childhood classroom in classroom activity areas or learning centers (Weinstein, 1987).

Findings from Study 1 demonstrated that even three and four year olds benefit from the logical clustering, or grouping, of objects in a room sized space. More specifically, these children were more likely to remember the spatial location of an object if they had seen the item in a logically organized as opposed to an unorganized set up. This finding has clear implications for classroom practice. Other things being equal, children are more likely to remember where an object can be found if they have previously seen that object in an organized arrangement. Crayons located with other drawing materials are easier to find than crayons kept next to the box of dress-up clothes. Since so many early childhood programs make use of open ended curricula and at least talk about the importance of fostering independent activity on the part of children (e.g., NAEYC 1988) it is critical to structure the learning environment to facilitate such activity. An important component of independent activity is obtaining materials needed to complete desired goals and tasks. Findings from Study 1 underscore the importance of appropriately designed physical arrangements for meeting these educational goals.

Having established that even three and four year olds can make use of logical organization to remember spatial locations, the purpose of Study 2 was to examine the relationships between emerging logical and spatial operations, cognitive style, and children's memory for spatial locations in an organized environment. Given the focus on emerging operative knowledge, kindergarten, first and second graders were the target of study. In retrospect, it may not be surprising that subjects in Study 2 showed near ceiling performance in memory for the general room area in which objects belonged. There seems to be a clear developmental trend demonstrated across the subjects in the two studies, with children becoming increasingly accurate at categorizing objects in space.

However, a more interesting finding in Study 2 was the complex relationship between spatial operations, cognitive style, age, and strategy in children's memory for spatial locations. First, it is noteworthy that cognitive style and operativity in spatial operations were better predictors than was age of children's performance on this spatial memory task. Clearly, age alone was not very helpful in understanding children's performance on this task. Second, while these children were quite good at remembering the general room area in which things belonged, when it comes to more detailed spatial knowledge, they showed a wider range of variation in their performance. It seems that the most proficient children were those who were most advanced in spatial operational knowledge and who functioned in a field independent manner. Finally, the role of strategy in completing the reconstruction task must be mentioned. Those children who appeared to study the empty shelves, rather than simply picking up the item at the top of the basket, appeared to perform more poorly. Earlier, it was suggested that children studying the empty shelves may have been using an inappropriate mnemonic strategy--a strategy that worked well in other situations but was simply not adaptive in this task. This finding is provocative, but clearly needs to be examined further before any firm conclusions can be drawn.

The implications from Study 2 are somewhat less obvious for early childhood educators than those of Study 1. However, if individual differences in spatial knowledge and cognitive style influence children's memory for their environments, teachers would do well to attend to such thinking abilities in context more closely. This approach is consistent with current thinking in cognitive development from both Piagetian and Vygotskian perspectives (e.g., Brown & Reeve, 1987).

Taken together, the results of the these to studies demonstrate the complex interplay between the physical environment and the knowing individual. Both characteristics of the environment as well as developmental and individual differences in children's spatial knowledge and cognitive style influence their memory for the environment. Future research needs to be directed towards teasing apart these complex relationships in ways that can be helpful to teachers.

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Table 1

Study 1: Performance on Reconstructive Memory Task

Mean Scores (and Standard Deviations)

General Location

	Clustered		Non-Clustered		Combined
Three's	28.6	(9.3)	21.3	(9.5)	24.9
Four's	30.9	(6.9)	26.0	(9.0)	27.8
Combined	29.8	(8.2)	23.1	(9.4)	

Specific Location

	Clustered		Non-Clustered		Combined
Three's	20.9	(11.0)	16.9	(10.9)	18.9
Four's	24.4	(9.1)	21.8	(10.2)	22.4
Combined	22.7	(10.2)	18.7	(10.7)	

Table 2

Study 2: Zero Order Correlation Coefficients for Predictions Concerning Reconstruction: Specific Location Accuracy

N=68

	Specific Locat	Sex	Strate	Vert	Point Loc	Age
Sex	-.18*					
Strategy	.35***	.01				
Verticality	.20**	.01	-.16*			
Point Loc	-.15	-.04	-.06	-.07		
Age	.02	.02	-.10	-.04	-.46***	
CEFT	.19*	-.05	-.05	-.12	-.26**	.34***

Note: Analysis excludes subjects making errors in General Location

* $p < .1$
** $p < .05$
*** $p < .001$

Table 3

Study 2: Zero Order Correlations for Predictions Concerning Accuracy in Total Recall

(N = 71)

	Recall	Reconstruc	Class	Age	CEFT
Reconstruction	-.39***				
Class	.34***	-.20**			
Age	.46***	-.10	.52***		
CEFT	.34***	-.25**	.35***	.37***	
Sex	.15*	-.03	-.01	.08	.02

* $p < .1$
** $p < .05$
*** $p < .01$

Table 4

Study 2: Zero Order Correlations for Predictions Concerning

Clustering in Recall

(N=70)

	Clustering	Classif	Age
Classif	.29***		
Age	.42***	.54***	
Gen Loc	-.17*	-.19**	-.09

* $p < .1$
** $p < .05$
*** $p < .01$