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Transfer in Young Children's Understanding of Spatial Representations

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MARZOLF, DONALD P., and DELOACHE, JUDY S. *Transfer in Young Children's Understanding of Spatial Representations*. *CHILD DEVELOPMENT*, 1994, 65, 1–15. The creative and flexible use of symbols is a unique human ability. In order to use a symbol, one must understand the basic relation between the symbol and what it represents. How do young children come to appreciate such relations? One possibility is that insight into one symbolic relation helps children appreciate different ones. The 3 studies presented here support this possibility. In Experiments 1 and 2, both 2.5- and 3.0-year-old children showed transfer from an easy task that required appreciation of a model-room symbolic relation to a more difficult one, one that children their age typically do not appreciate. In Experiment 3, 2.5-year-olds showed transfer between symbol types: Experience with a model-room relation helped them appreciate a map-room relation. These transfer effects are consistent with the claim that early experience with symbolic relations contributes to symbolic sensitivity, a basic readiness to recognize that one object or event may stand for another.

Symbolic representations of the world are powerful cognitive tools. Drawings, models, maps, pictorial street signs, and graphs convey important information about the things they represent. We can learn new information about objects and places that we have not actually experienced by examining the symbols that represent them. For example, models of organs such as the human eye are used in science courses to teach anatomy. Tourist maps are consulted to plan visits to historical sights and amusement parks. In such cases, symbols provide useful information about aspects of the real world with which we are unfamiliar.

For a symbol to be informative, one has to be aware of the basic fact that the symbol corresponds to a specific state of affairs in the real world. Without this insight, the representational power of the symbol is lost. For example, if a young child is not aware that a detailed model of the human body can "stand for" his own body, then the child will not draw valid inferences from the model about how his own body is constructed. In-

sight into the representational nature of symbols is essential to being an efficient symbol user. Therefore, understanding how young children achieve this insight is important.

During the first years of life, children begin to understand and use a variety of symbol systems. Picture books provide exposure to drawings and photographs. Preschoolers begin to appreciate the symbolic function of print, as is evident when they ask, "What does that say?" or when they claim that the scribbles they just drew spell their names (Goodman, 1986). They learn to identify letters and numbers and to count (Fuson, 1988; Gelman, 1978; Gelman & Gallistel, 1978; Wynn, 1990).

This article focuses on the possible effect that experience with one symbol system or one type of symbol-referent relation may have on understanding others. DeLoache (1990) has suggested that insight into any symbolic relation may contribute to a general symbolic sensitivity—a basic readiness to recognize that one object or event may

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stand for another. Specifically, we investigated whether or not appreciation of a relatively easy symbol-referent relation would help children gain insight into subsequent, more difficult ones.

Our research program has focused on young children's understanding of various symbols, particularly scale models and pictures (DeLoache, 1987, 1989, 1991; DeLoache, Kolstad, & Anderson, 1991). In the model task, children are asked to retrieve a toy hidden in a room based on where they see a miniature toy hidden in a model of the room. Success at this task indicates that the child appreciates something about the model-room correspondence. One of the benefits of studying scale models is that they require children to draw novel inferences about a relatively unfamiliar symbol system, inferences that can reveal an explicit understanding of the symbol-referent correspondence.

Our first evidence of symbolic sensitivity came from the occurrence of transfer in a series of studies investigating the dual representation hypothesis. We have proposed (DeLoache, 1991; DeLoache & Marzolf, 1992) that success in the model task requires representing the model in two different ways at the same time: (1) as an independent entity in its own right—an attractive real object that can be played with and manipulated—and (2) as a symbol for the room. A series of studies has provided support for this hypothesis. Two-and-a-half-year-old children performed much better when they were shown where a toy was hidden in a room via a picture compared to a scale model (DeLoache, 1987, 1991). This is because pictures do not require dual representation in the way that models do. Although pictures are real, tangible objects, their primary function is to stand for something else; they are not attractive or interesting as objects.

In addition to this picture-superiority effect, evidence was found for transfer from pictures to models. In one study (DeLoache, 1991), half the children received the model task first and the picture task second, and the other half received the reverse order. An intriguing task \times order interaction occurred. Children who were tested with the picture task first and then the model task performed much better on the model task (63%) than did the subjects who received the opposite order (20%). It appeared that understanding the picture as a symbol for the room helped them appreciate that the model corre-

sponded to the room. Thus, insight into one symbolic relation seemed to transfer to a different one.

This transfer effect was not highly specific in that similar results were obtained when the two tasks were conducted in different rooms. The picture task was administered in one room, involving a particular set of correspondences, and the model task was administered in a second room, involving a different set of correspondences. It is clear that children did not transfer an appreciation of a specific set of item correspondences. Rather, they apparently recognized the symbolic potential of a different set of items.

Transfer effects such as these mark the existence of increasingly decontextualized knowledge structures (Brown, 1981; Brown, Bransford, Ferrara, & Campione, 1983; Brown & Campione, 1984; Rozin, 1976). The picture-model transfer suggests that experience with symbols may lead children to appreciate that potentially useful symbolic relations occur in a variety of situations. To what extent can past symbolic experience make young children more sensitive to the symbolic potential of a new situation? The purpose of the studies presented in this article is to examine symbolic sensitivity further by assessing transfer in different tasks and at different ages.

In the first two experiments, transfer within a given symbol system (scale models) was examined for two different age groups. In Experiment 1, we focused on 2.5-year-old children. They were first given a relatively easy model task (one on which 2.5-year-olds normally succeed) followed by a more difficult model task (one that children of this age typically fail). We expected the children to succeed on the difficult task based on their experience with the easy one.

In Experiment 2, transfer from one scale model to another was again explored, but with older children (3.0-year-olds). If transfer is a general mechanism for insight into symbolic relations, then one might expect it to occur at different ages. Subjects were given a model task on which 3.0-year-olds normally succeed, followed the next day by a more difficult task that children of this age typically fail. As in Experiment 1, we hypothesized that appreciation of the easy model-room correspondence would facilitate an appreciation of the difficult one.

In Experiment 3, we examined transfer between different symbolic media. The pic-

ture-model transfer effect described earlier indicated that insight into a symbolic relation in one medium (picture-room) transferred to a similar relation in a different medium (model-room). Experiment 3 also assessed transfer across media, but this time from a perceptually faithful representation (a scale model) to an abstract one (a map).

Experiment 1

The purpose of Experiment 1 was to test for transfer by 2.5-year-old children from a relatively easy model task to a subsequent, more difficult one. Difficulty was a function of the degree of physical similarity between the two spaces. This manipulation was based on the finding that the degree of difference in size between a model and the room it represented had a dramatic effect on children's performance (DeLoache et al., 1991, Experiment 2): When the two spaces were highly similar in scale (i.e., model-to-room area ratio = 1:2), 2.5-year-old children's performance was much better (75%) than when they were dissimilar in scale (i.e., model-to-room area ratio = 1:16) (41%).

A group of 2.5-year-old children was tested twice over a 2-day period, first with a model and room that were similar in scale and then with spaces that were dissimilar in scale. A control group was given the more difficult, dissimilar-scale task twice. This approach enabled us to make three different comparisons in evaluating transfer. The first was between the performance of the two groups in the difficult task on day 1. This was simply to verify that the two tasks did, as expected, differ in difficulty. The second comparison was between the day 2 performance of the transfer group and the day 1 performance of the control group. This comparison revealed to what extent their prior experience with the easier model task helped the children in the transfer group, relative to a group of children with no previous model task experience. The third comparison was of the day 2 performance of both groups. This provided an estimate of how much of the facilitation in the transfer group's performance was specifically due to having had success in an easy task first. Testing the control group twice in the difficult task thus controlled for nonspecific improvement due to familiarity with general aspects of the task, the setting, the experimenters,

and so forth. This control group thus provided a very conservative assessment of transfer.

Method

Subjects.—Subjects were 24 2.5-year-old children (29.5–31.5 months, $M = 30.5$ months). Both sexes were equally represented. The subjects for this and the subsequent experiments were recruited primarily through records of newspaper birth announcements, and they had never participated in a previous model or picture study. The sample was predominantly white and middle class. Twelve subjects (six girls and six boys) were randomly assigned to the transfer ($M = 30.5$ months) and the control ($M = 30.4$ months) conditions.

Materials.—The experimental materials included a small scale model and two larger rooms. The model (63 × 48 × 38 cm) served as the smaller space in both the similar- and dissimilar-scale tasks. The smaller of the rooms was identical to the model, except that it was almost twice as large (92 × 70 × 61 cm). With a room-to-model area ratio of approximately 2:1, the model and the small room were the spaces used in the similar-scale task. The larger room was big enough (2.57 × 1.85 × 1.88 m high) for a child and an adult to move around in. With a room-to-model area ratio of about 16:1, the model and the large room were the spaces used in the dissimilar-scale task. These tasks are the same as those used in DeLoache et al. (1991, Experiment 2).

All three spaces were constructed of opaque white fabric supported by a framework of plastic pipes. The larger room had an opening in the middle of one wall that provided entry. There was a plastic window in the adjacent wall to the right of the door. The model and smaller room had only three walls so that their contents were accessible to the children. The spaces were furnished with a dresser and a shelf unit made of cardboard, a chair covered with fabric, a small chair pillow, a floor pillow, a basket, and a rug. The furniture was scaled to the size of the spaces.¹ The objects in all three spaces were perceptually similar. For example, all three floor pillows were made of the same green material, the chairs were covered with the same fabric, and so on.

¹ The miniature floor pillow in the model measured 14 × 14 cm. The small floor pillow in the small room measured 19 × 19 cm. The large floor pillow in the room measured 56 × 62 cm.

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For both tasks, a miniature plastic dog (3 cm high) was the target object in the model. For the similar-scale task, a plastic toy dog (7 cm high) was the target object in the small room, and for the dissimilar-scale task, a stuffed toy dog (15 cm high) was the target object in the large room. In both tasks, the larger toy was referred to as Big Snoopy and the miniature one as Little Snoopy.

The study was conducted in a large room. For both tasks, the model was situated to the left of and in the same spatial orientation as the larger space. For the similar-scale task, a small room divider separated the two spaces. In both cases, the interiors of the two spaces could not be viewed simultaneously.

Procedures.—All subjects were tested on each of 2 days, with no more than 1 day between the two testing sessions. The subjects in the transfer condition received the similar-scale task on the first day and the dissimilar-scale task on the second day. The subjects in the control condition received the dissimilar-scale task on both days. Everything else was exactly the same for both conditions.

The same procedures were followed for both tasks. After becoming acquainted with the experimenter, the child was given an extensive orientation, during which the correspondence between the room and model was explicitly described and demonstrated. First, the child was shown the room and introduced to the toy dog, referred to as Big Snoopy. The room was described as Big Snoopy's room. The experimenter labeled every item of furniture in the room ("This is Big Snoopy's chair, this is his pillow," etc.). The experimenter then told the child that Big Snoopy's friend, Little Snoopy, had a room just like Big Snoopy's room, only smaller. The subject was taken to the model and shown the small toy dog. The experimenter labeled all the items of furniture in the model, commenting that each was "just like Big Snoopy's, only smaller." The experimenter and child then took the furniture from the model into the room. The experimenter pointed out individual correspondences by placing the items from the model next to the corresponding items in the room, commenting that "Little Snoopy's things are just like Big Snoopy's things, only smaller." The miniature furniture was then returned to the model.

In an effort to communicate that corresponding events occurred in the two spaces, the experimenter next asked the subject to

imitate the placement of one of the toys. The experimenter placed the small toy dog on the miniature shelves and instructed the child to place Big Snoopy "in the same place" in his big room. If the subject's response was incorrect, the experimenter named the relevant place and, if necessary, helped the child place the toy.

Following the orientation, there were four trials on which subjects were required to find the large toy in the room, based on where they had seen the miniature toy hidden in the model. On each trial the toy was hidden in a different location. The hiding places were in the basket, behind the dresser, under the floor pillow, and behind the chair. Half the children in each condition saw the miniature toy hidden in the model and first searched for the large toy in the room; half did the opposite. (For ease of communication, we describe only the case where the children saw the toy hidden in the model and retrieved the large toy in the room.) There were two orders of hiding places, counterbalanced with gender and hiding space.

Before the trials, the subject was told, "Wherever Little Snoopy hides in his little room, Big Snoopy likes to hide in the same place in his big room." For each trial, the child watched as the experimenter hid the miniature toy dog in the model. The experimenter never labeled the hiding place. The instructions were, "Watch, I'm hiding Little Snoopy here. See, Little Snoopy is hiding right behind [in, under] here. I'm going to help Big Snoopy hide in the same place as Little Snoopy, and then you can come find him." The subject waited by the model while the experimenter hid the large toy dog in the corresponding place in the room. The experimenter then returned and reminded the subject of the correspondence: "Remember, Big Snoopy's hiding in the same place as Little Snoopy." The child was led to the room and encouraged to find the hidden toy. This search was retrieval 1. Performance on retrieval 1 is the key in determining whether or not subjects appreciate the correspondence between the two spaces. If children are aware of the correspondence, they can infer where the large toy is hidden in the room based on where they saw the miniature toy hidden in the model. On the other hand, if children fail to appreciate the correspondence between the two spaces, retrieval 1 performance should be low.

The subject was instructed to find the

toy "right away." If he or she failed to search or searched in the wrong location, increasingly explicit prompts were given until the toy was found. The purpose of these prompts was to maintain a high level of motivation for the task. The first prompt was simply a reminder: "Remember, Big Snoopy is hiding in the same place as Little Snoopy." If needed, the second prompt was given: "Do you remember where Little Snoopy is hiding? Big Snoopy is hiding in the same place as Little Snoopy." Occasionally a subject would indicate that he or she had forgotten where the miniature toy dog was hidden. These subjects were taken back to the model and shown its location. If necessary, a third prompt, which labeled the hiding place, was given; "Little Snoopy is hiding behind [under, in] his [label]. Big Snoopy is hiding here in the same place." Finally, if necessary, the experimenter gestured to where the toy was hidden. Thus, on every trial, the subject found the hidden toy on retrieval 1.

After finding the toy, the child was taken back to the model and instructed to find the miniature toy that he or she had seen being hidden. This memory-based retrieval, referred to as retrieval 2, was necessary to insure that any difficulty on retrieval 1 was not simply due to forgetting where the other toy was hidden. If necessary, the subject was given increasingly explicit prompts until he or she found the toy.

Results and Discussion

The dependent variable was the number of errorless retrievals. Subjects were credited with an errorless retrieval if they found the toy in the first place they searched without receiving any prompts. (Although percentages are primarily used throughout the text and in the figures to facilitate comparison with other studies, the number of errorless retrievals was used for all statistical analyses. The corresponding means and standard deviations are provided in Table 1.) The results of Experiment 1 provided clear evidence of transfer.

Both groups always performed equally well on retrieval 2 (transfer group: day 1 = 88%; day 2 = 77%; control group: day 1 = 73%; day 2 = 79%). This result was consistent with previous model studies (DeLoache, 1987, 1989, 1991; DeLoache et al., 1991) in which retrieval 2 performance has always been very high. The children in both conditions and in both tasks were very good at remembering where the original toy was hidden. Therefore, poor performance on re-

TABLE 1
MEAN NUMBER OF ERRORLESS RETRIEVALS AND
CORRESPONDING STANDARD DEVIATIONS

	Retrieval 1	Retrieval 2
Experiment 1:		
Transfer group:		
Day 1	2.67 (1.23)	3.50 (.67)
Day 2	2.58 (1.31)	3.08 (.67)
Control group:		
Day 1	1.08 (.90)	2.92 (1.00)
Day 2	1.42 (1.00)	3.08 (.79)
Experiment 2:		
Transfer group:		
Day 1	3.50 (.71)	3.50 (.53)
Day 2	3.50 (.97)	3.80 (.42)
Control group:		
Day 1	1.20 (.79)	3.30 (.95)
Day 2	2.60 (1.08)	3.80 (.42)
Experiment 3:		
Transfer group: ^a		
Day 1	2.63 (.92)	
Day 2	3.13 (.99)	
Control group:		
Day 1	1.17 (1.53)	
Day 2	1.50 (1.68)	

^a The values presented here reflect only the children who were successful on Day 1.

trieval 1 could not be due to low motivation or to the children forgetting where the miniature toy was hidden, but rather would reflect failure to appreciate the correspondence between the two spaces.

The retrieval 1 data, which are the basis for evaluating the hypothesized transfer, are shown in Figure 1 as a function of day of testing for each group. The retrieval 1 performance of the transfer group on the similar-scale task was slightly lower (67%) than expected (75% in DeLoache et al., 1991, Experiment 2). However, this somewhat lower baseline is not problematic here, as it would only work against the hypothesized transfer.

The data were analyzed in a 2 (condition: transfer vs. control) \times 2 (gender) \times 2 (day) repeated-measures ANOVA, with day as a within-subjects variable. The main effect of condition was the only significant result, $F(1, 16) = 9.15, p < .01$. The transfer group performed significantly better on retrieval 1 than did the control group (66% vs. 31%, respectively), and condition did not interact with day.

Considering the results shown in Figure 1 in more detail reveals that the three comparisons relevant to assessing transfer are all as expected. First, the day 1 performance of

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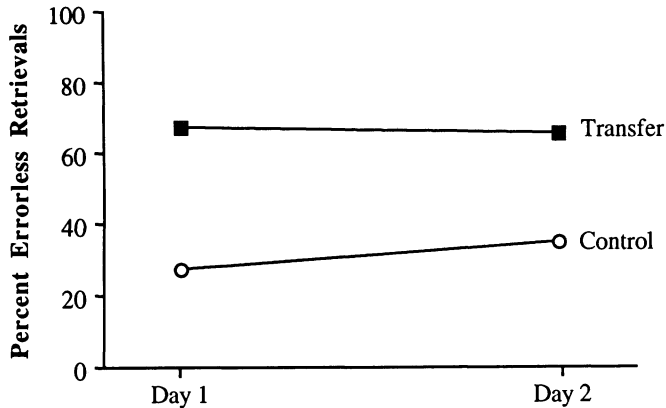


FIG. 1.—Experiment 1 retrieval 1 performance for each group as a function of day

the two groups makes it clear that the two tasks did, as expected, differ in difficulty. The transfer group performed much better on the similar-scale task than the control group did on the dissimilar-scale task (67% vs. 27%, respectively), $t(1, 22) = 3.60$, $p < .01$. This finding replicated both the pattern and absolute levels of performance reported by DeLoache et al. (1991, Experiment 2).

The most important comparisons concerned performance in the dissimilar-scale task. The transfer group's performance in this task on day 2 (65%) was significantly better than that of the control group on day 1 (27%), $t(1, 22) = 3.27$, $p < .01$. Thus, children who first experienced an easy model-room relation were more successful with a more difficult one compared to children who had no prior experience with a model task. Furthermore, the third comparison revealed that the transfer group also performed better on the difficult task (65%) than did the control group on day 2 (35%), $F(1, 22) = 2.45$, $p < .05$. This indicates that experience with the general procedures alone was not sufficient for transfer; rather, insight into a relatively easy model-room correspondence was required.

The transfer effect can be illuminated by examining the individual performance of the subjects in the transfer group. According to the transfer hypothesis, only if a child was successful on day 1 should he or she succeed on day 2; we would not expect children who did not appreciate the easy relation to recognize the difficult one. The transfer subjects were categorized as successful on day 1 if they had errorless retrieval scores of 75% or better (three or four trials correct). Seven of the 12 subjects met the success criterion,

and five did not (three had only one errorless retrieval, and two children had two).

Of the seven children who were successful on the easy task, five also succeeded on the difficult task. Thus, most subjects who understood the model-room correspondence in the similar-scale task also appreciated that relation in the dissimilar-scale task. In contrast, of the five subjects who did less well on the similar-scale task (i.e., 0, 1, or 2 trials correct), none succeeded on the dissimilar-scale task. Thus, those children who did not recognize the model-room correspondence in the similar-scale task also failed to do so in the dissimilar-scale task. No subjects were unsuccessful on the easy task and successful on the difficult task; thus, not one of the children performed contrary to our prediction.

Overall, then, five of the 12 2.5-year-olds in this study achieved a high level of success on a task that children of that age normally fail. Having first interpreted a scale model as corresponding to a slightly larger space, these children were sensitive to its relation to a much larger space. In the previously reported picture-model transfer (DeLoache, 1991), it was also approximately half the children who showed strong evidence of transfer. The magnitude of these transfer effects is revealing. Some very young children are helped to appreciate a nonobvious symbol-referent relation by prior experience with a more transparent one. However, detecting such relations is basically difficult and uncertain for this age group, and some of them remain impervious to either relation.

Experiment 2

Experiment 1 showed that 2.5-year-old children are able to transfer their insight into

one scale model task to a more difficult one. Experiment 2 was designed to test for a similar effect in older children. To the extent that symbolic sensitivity is a general, and potentially powerful, mechanism for symbolic development, transfer effects should be found in children of various ages.

We followed the same approach in Experiment 2 as that adopted in the first study, that is, we looked for transfer from a task that is relatively easy for 3.0-year-olds to a task that is relatively difficult for that age group. Physical similarity was again manipulated, but this time the similarity of the objects within the two spaces was varied. This difficulty manipulation was based on the report by DeLoache et al. (1991, Experiment 1) that 3.0-year-old children were successful (77%) when the corresponding objects within two spaces were perceptually similar (e.g., a large blue chair in the room and a miniature blue chair in the model), but were unsuccessful (21%) when the objects were dissimilar (e.g., a large blue chair in the room and a miniature gray chair in the model). Thus, in the current study, a transfer group was given a similar-objects model task, followed the next day by a dissimilar-objects task. As in Experiment 1, a control group received the difficult task both days. We again hypothesized that success in the easier task would lead to better performance in the more difficult one.

Method

Subjects.—Subjects were 20 3.0-year-old children (36.0–40.5 months, $M = 37.8$ months). Both sexes were equally represented. Ten subjects (five girls and five boys) were randomly assigned to the transfer condition ($M = 38.1$ months) and 10 to the control condition ($M = 37.4$ months).

Materials.—The experimental materials included the same large-scale artificial room used in Experiment 1, but a different small-scale model. The model was a small white cardboard box (69.9 × 45.7 × 38.1 cm high) with one side cut out of it.²

As in Experiment 1, the artificial room was furnished with a dresser and a shelf unit made of heavy cardboard, a chair covered with fabric, a small chair pillow, a floor pillow, a basket, and a rug. For the similar-objects task, the miniature objects in the model were highly similar in appearance to their corresponding items of furniture in the

room. For example, the floor pillow in the room and the miniature floor pillow in the model were made of the same green material, the large dresser and the miniature dresser were made of the same brown cardboard, and so on. For the dissimilar-objects task, the objects in the model were much less similar in appearance to their corresponding items in the room. For example, the miniature chair in the model was covered with a gray material, while the large chair in the room was covered with a blue material; the miniature dresser was blue and white, while the large dresser was brown; and so on. The appropriate toy dogs were used in each space, and the model was again situated to the left of and in the same spatial orientation as the room.

Procedures.—The basic procedures for this experiment were identical to those of Experiment 1. The subjects in the transfer condition received the similar-objects task on the first day and the dissimilar-objects task on the second day. The subjects in the control condition received the dissimilar-objects task on both days.

Results and Discussion

As in Experiment 1, both groups performed equally well on retrieval 2 (transfer group: day 1 = 88%; day 2 = 95%; control group: day 1 = 83%; day 2 = 95%). Therefore, poor performance on retrieval 1 could not be due to low motivation or to the children forgetting where the miniature toy was hidden.

Figure 2 shows the retrieval 1 performance as a function of day of testing for each group. These data were analyzed in a 2 (condition: transfer vs. control) × 2 (gender) × 2 (day) repeated-measures ANOVA, with day as a within-subjects variable. The main effect of condition was significant, $F(1, 16) = 35.31, p < .001$, with the transfer group performing better overall than the control group (88% vs. 48%, respectively). The main effect of day was also significant, $F(1, 16) = 6.76, p < .05$, with better performance on day 2 (73%) than on day 1 (61%). The group × day interaction was also significant, $F(1, 16) = 6.76, p < .05$; there was no change over days in the transfer group, whereas the control group improved from day 1 to day 2.

We again consider three different comparisons. On day 1, the expected difference in performance occurred: The transfer group

² The artificial room and model used in Experiment 2 here were used in the high object/low surround similarity condition of DeLoache et al. (1991, Experiment 1).

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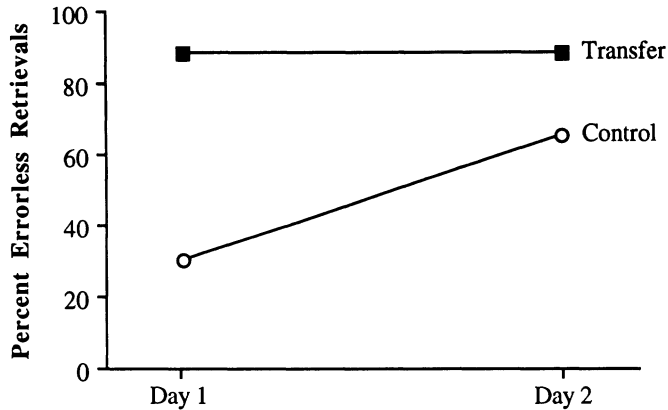


FIG. 2.—Experiment 2 retrieval 1 performance for each group as a function of day

performed much better on the easy (similar-objects) task than the control group did on the difficult (dissimilar-objects) task (88% vs. 30%, respectively), $t(1, 18) = 6.87, p < .001$. This finding replicated the previous result with these tasks (DeLoache et al., 1991, Experiment 1), both in relative and absolute levels of performance.

The second comparison revealed that the children in the transfer group performed better on the difficult task than children who had no experience with any model task. The transfer group's day 2 performance in the dissimilar-objects task was extremely good (88%), and it was better than that of the control group on day 1 (30%), $t(1, 18) = 5.81, p < .001$. Thus, children who first appreciated the easy model-room relation on day 1 also recognized the difficult relation on day 2, whereas children who had no model experience did not.

The final comparison to evaluate transfer was between the transfer and control groups on day 2. The transfer group achieved a very high score on the dissimilar-objects task (88%), but it was only marginally better than that of the control group on day 2 (65%), $t(1, 18) = 1.96, p = .065$. The reason this difference was not greater was that the performance of the control group increased over days, $t(1, 9) = 3.28, p < .01$.

As in Experiment 1, the individual performance of the subjects in the transfer group was consistent with the transfer hypothesis. Of the nine subjects who were successful on the similar-objects task (i.e., errorless retrievals on at least three of the four trials), eight were also successful on the dissimilar-objects task. The remaining child had only two errorless retrievals on the eas-

ier task, yet succeeded on the difficult one. It is interesting to note that this child's two successes were on the last two trials of the similar-objects task, suggesting that the child may have come to appreciate the relevance of the model halfway through the task.

An unexpected, but potentially interesting, result from this study was the improvement shown over days by the control group. Even though these children were not very successful in their initial exposure to this difficult model task, they still seemed to profit from it. Note that the same was not true of the younger subjects in Experiment 1; those children showed the same poor performance on both days of the (for them) more difficult task.

What was responsible for the improved performance of the 3.0-year-olds in the present study? One possibility, of course, is that it was mainly due to nonspecific aspects of the situation; that is, the children may simply have been more comfortable in the unfamiliar lab and with the previously unknown experimenters on the second day, less distracted by the novel surroundings and objects, and so forth. A different but related possibility is that familiarity with aspects of the tasks not specific to their symbolic nature contributed to the improvement. In all these studies, children came to the same building, interacted with the same experimenter, played a game that had to do with finding a Snoopy toy hidden in a room, and so forth. It is not clear, however, why these factors would be of more benefit to the older children than to the younger ones.

An important difference between the two age groups is, of course, general cognitive maturity, which may in some way en-

able the older children to benefit from the task that is initially impenetrable to most of them. We think that, in addition to general cognitive differences, the different levels of symbolic experience the two age groups have enjoyed could be an important part of why the 3.0-year-olds reaped more benefit from their participation in the control group in Experiment 2 than did the 2.5-year-olds in Experiment 1. Three-year-olds have had 6 more months of experience than 2.5-year-olds have had with symbolic media, such as pictures, books, and television. They may consequently have greater sensitivity to the symbolic potential of new stimuli and situations. Thus, although the model-room relation initially eludes both age groups, a second exposure is adequate to cause at least some of the older children to detect it. The unexpected increase in the performance of the control group in Experiment 2 is thus consistent with the concept of symbolic sensitivity. Future research will follow up this possible relation between age and ease of symbolic transfer.

Experiments 1 and 2 demonstrated transfer for children of different ages and with different model tasks. Transfer is not limited to highly specific tasks or to children at a particular point in development. Experiment 3 investigated transfer between symbolic media, namely, from a highly iconic symbol (a scale model) to a more abstract one (a map).

Experiment 3

In our previous research, most of the pictures and models used have been perceptually similar to their referents. In the standard model task, the corresponding objects within the two spaces share three-dimensionality, similarity in surface appearance, category membership, and the same verbal label (e.g., chair). Maps, on the other hand, are more abstract representations; even if items on a map share some physical attributes (e.g., color) with their referents, they are unlikely to be as perceptually faithful as the realistic pictures and models we have used in the past. For example, a blue square on a map is not iconic in relation to the chair it represents to the same degree that a picture of the chair is. Nor does the blue square share dimensionality and category membership with its referent, as does a miniature chair.

In this experiment, we examined 2.5-year-old children's understanding and use of

a simple map. Map use (Blades & Spencer, 1986; Bluestein & Acredolo, 1979; Liben & Downs, 1989; Presson, 1982) has not been examined in children this young, mainly because older children have performed poorly in such tasks. In a study by Bluestein and Acredolo (1979), most 4-year-old children, but only a few 3-year-olds, were able to use a simple color map to find a toy hidden in a room, a task very similar to the one used in the present study. However, according to the transfer hypothesis, we might expect very young children to perform well on a map task if they first have experience with a symbolic relation they understand. The transfer task for Experiment 3 required children to use a simple map to find a toy hidden in a room.

Pilot testing with a small number of children revealed that 3.0-year-olds readily used this map, but that 2.5-year-olds did not. The success of the 3.0-year-olds was surprising given that this age group did poorly in the similar task used by Bluestein and Acredolo (1979). We consider why our task may be easier for children in the Results and Discussion section of this experiment.

Since 3.0-year-old pilot subjects were able to use our map, the subjects for this study were 2.5-year-olds. The children in the transfer group were given the similar-scale model task on which children of this age typically succeed (the same task used in Experiment 1), followed by the map task. A control group received the map task on both days. As in the previous experiments, we hypothesized that experience with a relatively easy model-room relation would help children appreciate the symbolic function of a map.

Method

Subjects.—Twenty-four 2.5-year-old children served as subjects in this study (29.0–32.5 months, $M = 30.8$ months). Both genders were equally represented. Twelve subjects were randomly assigned to the transfer ($M = 31.0$ months) and control ($M = 30.6$ months) conditions. One additional male subject was excluded due to extreme inattentiveness during testing.

Materials.—The materials used in the similar-scale task of Experiment 1 were used for the model task in the present study. For the map task, the large artificial room from Experiment 1 and a map of the room (Fig. 3) were used. The map, which measured 33.0×24.8 cm, was an aerial view of the room. The figures on the map were simple

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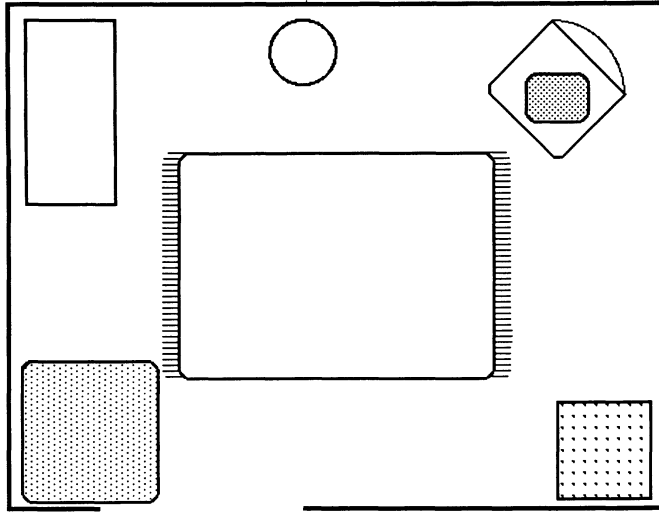


FIG. 3.—Drawing of map used in Experiment 3. The actual map was in color

outline shapes colored to match the objects they represented. The figures were drawn to scale and were in the same spatial arrangement as the objects in the room. For example, a green square in the lower left corner of the map represented the green floor pillow in the front left corner of the room, a red circle along the middle of the top border of the map represented the red basket located halfway along the back wall of the room, and so on. This map thus had some degree of iconicity, but was still much more abstract than the models and pictures used in our previous transfer studies. The map was located on a table outside and to the left of the room, and it was always in the same orientation as the room.

Procedures.—Subjects were tested on each of 2 days. Children in the transfer condition received the model task on day 1 and the map task on day 2. Children in the control condition received the map task on both days.

Several changes in the procedures were necessitated by the fact that there was no hidden toy on the map. In order to make the model and map task as similar as possible, no miniature toy was hidden in the model either. Only one toy dog, referred to as Snoopy, was used. It was present in the room for both tasks. (No miniature dog was ever used.) Because there was no miniature toy in the model or on the map, all subjects were shown where the toy was hidden in the model or map and searched for the toy in the room (rather than half the subjects being

shown where the toy was hidden in the room and searching for the miniature toy in the model). The experimenter simply pointed in the model or on the map where the toy was hidden, saying, "This is where Snoopy is hiding in his room." (We know from previous research that it makes no difference whether the toy is actually hidden or the experimenter simply points to the relevant hiding place. DeLoache [1991, Experiment 1] reported that 2.5-year-old children's performance on the model task was the same whether the relevant information was provided by pointing in the model or by hiding a miniature toy.) Finally, since the subjects did not see a toy hidden, but rather were shown where the toy was by pointing, there was no retrieval 2.

Results and Discussion

The results of Experiment 3 are generally consistent with those of the previous two studies in that the overall performance of the transfer group (56%) was better than that of the control group (34%). However, although these differences were in the expected direction, the main effect of condition was not significant in a 2 (condition: transfer vs. control) \times 2 (gender) \times 2 (day) repeated-measures ANOVA, with day as a within-subjects variable. The only significant result was a main effect of gender, $F(1, 20) = 5.30, p < .05$, with girls significantly better than boys. Given that gender effects have almost never been found in the large number of previous model studies, the reliability of this effect in the present study is questionable.

Our comparison of groups on day 1 clarifies why the expected group difference was not significant in this study. The performance of the transfer group in the similar-scale task on day 1 was only 58%—lower than expected on what was assumed to be a relatively easy task for them. In contrast, the performance of the same age group in the identical task was 67% in Experiment 1 (transfer condition, day 1) and 70% in the DeLoache et al. study (1991, Experiment 2). It is not clear why the children in this study failed to do as well as those in the previous ones.

The relatively poor overall performance of the transfer group makes the assessment of transfer somewhat problematic; in any study, only if the transfer group is superior to the control group on day 1 could we expect them to be superior on the day 2 transfer task. A solution to this problem is to examine day 2 performance as a function of day 1 performance. It is only those subjects in the transfer group who showed some evidence of understanding the model-room relation on day 1 who we expect to show transfer to the map task. Thus, the map task performance of those transfer subjects who were successful on day 1 (conservatively defined as 50% or better) should be better than that of the control group on the map task. Eight of the 12 transfer children were successful on day 1; of the four unsuccessful subjects, three had one errorless retrieval and one child had none.

We compared the performance of the eight transfer subjects who were successful on day 1 to that of the control group (see Fig. 4). The difference between the two conditions was significant, $F(1, 16) = 8.436, p <$

.01, in a 2 (condition: transfer vs. control) \times 2 (gender) \times 2 (day) repeated-measures ANOVA, with day as the within-subjects variable. The more important result was that the transfer group (78%) performed significantly better than the control group (38%) on the map task on day 2, $t(1, 18) = 2.45, p < .05$.

It is possible that the omission of subjects in the previous analysis biased the results in favor of the transfer group. Perhaps the children retained in the transfer group were, on average, more intelligent or attentive than the children in the control group. In light of this possibility, consideration of the individual performance of all the children in the transfer group was especially important. Seven of the eight children who were successful on day 1 were similarly successful on day 2 (78%). In contrast, none of the four subjects who failed on the first day was successful on the second; in fact, these children achieved only one errorless retrieval among them on the map task (6%). According to a Fisher's test, the pattern of successful or unsuccessful performance on day 2 differed significantly as a function of day 1 success or failure ($p < .05$). Thus, not one child performed contrary to the predicted transfer effect.

In summary, although 2.5-year-old children do not normally appreciate the relation between the map used in this study and the space it represents, those children who had previously detected the correspondence between a model and a larger space did so. Insight into one type of symbol (i.e., a model) helped the children appreciate a different type of symbol (i.e., a map). The importance of insight is supported by the indi-

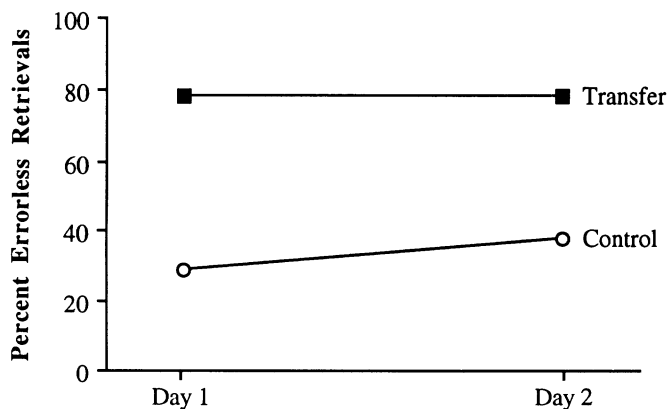


FIG. 4.—Experiment 3 performance for each group as a function of day

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vidual data that were presented. Only one of the total of 34 transfer subjects in the three studies succeeded on the second day transfer task without having performed very well on the first day. (As noted earlier, the single exception was one child who had scored 50% correct on day 1, getting the last two of four trials correct.) These results thus provide further evidence of the generality of symbolic sensitivity.

One notable aspect of this study was the success of such young children on the map task, both 3.0-year-old pilot subjects and the 2.5-year-olds in the transfer group. To our knowledge, this is the earliest evidence of map use. The success of the 3.0-year-old pilot subjects was surprising given that this age group did poorly in a very similar task reported by Bluestein and Acredolo (1979). We believe that this difference is most likely due to differences in the maps used for the two tasks. The map in our task was an aerial view of the room. Thus, the figures on the map were simple colored outline shapes. The map used by Bluestein and Acredolo depicted the room from an angular perspective, such that some three-dimensional information was evident. Like our map, the figures were colored to correspond to the proper objects in the room.

While the two maps differed in perspective, it is not likely that this accounts for the better performance of the 3-year-olds in our task. In fact, one might expect children to perform better with the angular perspective map since it is more iconic than the aerial perspective map. We believe that the major difference was in the kind of hiding places that were used. The hiding places used in our task were very distinctive (e.g., a dresser, a basket), whereas the hiding places used by Bluestein and Acredolo were identical green boxes. Thus, in our task, mapping was facilitated by perceptual similarity. The red circle on the map corresponded to the only red object in the room, the red basket. In contrast, in Bluestein and Acredolo's task, a green figure on the map corresponded perceptually to any of the four green boxes in the room. In order to be successful, children had to use relational information to determine which green box was the correct one. Young children tend to be perceptually bound and less sensitive to relational information (Gentner, 1988, 1989). Thus, a mapping task that is highly facilitated by perceptual similarity and not dependent on relations is likely to be easier.

If the success of the 3-year-olds during pilot testing is striking, then the success of the 2.5-year-olds in the transfer group is even more so. It is clear that their success on the map task is due at least in part to their experience with the model task. Thus, transfer appears to be a potentially powerful mechanism for symbolic development.

General Discussion

The goal of the research reported here was to investigate the construct of symbolic sensitivity by examining transfer in young children's symbolic functioning. There was evidence of transfer in all three studies, thus replicating and extending earlier research (DeLoache, 1991). To summarize the results to date, we have shown transfer in children of different ages, both 2.5- and 3.0-year-olds. Second, transfer has occurred in different tasks and symbolic media, including scale models, pictures, and a map. Finally, transfer has been demonstrated both within and across symbol types, from one model task to another, from a model to a map task, and from a picture to a model task. The fact that transfer is not limited to any particular age group or specific task and the fact that it occurs in a variety of situations supports the hypothesis that symbolic development may involve increased sensitivity to the existence of symbol-referent relations and hence increased facility at detecting them.

Although the results reported here support the idea of general symbolic sensitivity, there are several qualifications that must be made. First, we want to stress that this concept has to do with initial awareness of a symbol-referent relation, not mapping a relation of which one is fully aware. In terms of mapping and using symbols, one might not expect much transfer from one symbolic relation or system to another. Indeed, Wolf and Gardner (1981) have concluded that symbolic functioning in a given domain develops independently of symbolic functioning in other domains.

Second, our data are clearly limited in several ways, and hence the level of support for the existence of general symbolic sensitivity is similarly limited. All of our research has involved object retrieval tasks and spatial representations in a common context. We do not know to what extent transfer might occur with nonspatial or completely noniconic symbols. According to the most general view of symbolic sensitivity, insight

into the symbolic function of pictures might facilitate children's understanding of letters or numbers, which in turn might influence children's awareness of other types of symbols. Recent research by Acredolo and Goodwyn (1988) provides some support for this view. They reported that in infancy symbolic gestures tend to develop in tandem with verbal symbols, or words. They suggest that this synchrony in development may stem from infants' insight into the basic symbolic notion that things have names.

With respect to the results reported here, a question that needs to be addressed is, What is transferred? Our belief is that the transfer phenomena we have documented primarily involve representational insight (DeLoache & Marzolf, 1992). Insight into the existence of one (easier) symbolic relation helps children appreciate another (more difficult) one. In most of our tasks, there is a great deal of information to support mapping from the symbol to the represented space, given detection of the overall correspondence between the two. In all of the model tasks, for example, the corresponding objects are from the same category (e.g., chairs), and they are in the same relative spatial positions in the two spaces. In most of our tasks, they also have the same surface appearance. Thus, if a child notices the overall model-room correspondence, it is easy to get the individual object correspondences. In the absence of such knowledge, however, nothing leads the child to appreciate the significance of the object matches.

An alternative interpretation of the transfer effects must be considered. Perhaps the correct account is the other way around, that is, children might succeed in our task simply by noticing and using individual object correspondences without any insight into the overall symbol-referent relation. If so, then what transfers in the studies reported here would be an appreciation of these individual correspondences.

Certainly object-object relations are necessary for success, but they are not sufficient to account for the data as a whole. For instance, transfer across different media is difficult to account for by individual object correspondences. In the study in which transfer occurred from a picture task to a model task (DeLoache, 1991), a wide-angle photograph and line drawing were used as representations of the room. Thus, according to an object correspondence account of

transfer, children would have had to transfer their understanding of the relation between a depicted couch and a real couch to the relation between a miniature couch and a large couch. Transfer between tasks involving two different represented spaces is also difficult to explain in terms of individual object correspondences. Children would have to transfer appreciation of one set of object correspondences to an entirely different set of correspondences.

The individual object correspondence account becomes even less tenable for the model-map transfer study. In addition to requiring cross-media transfer and transfer between tasks involving different spaces, the level of physical similarity between a given feature on the map and the object it represented was very impoverished, more so than in any of our other tasks. Also, the features on the map were not given the same labels as the objects they depicted, nor did they share category membership with them. Thus, there was little to guide object correspondence in the absence of insight into the overall correspondence. It would seem that children must first recognize that the map corresponds to the room, and then figure out how it does so. Thus, the most parsimonious account of these data is that children transfer their awareness of the overall symbol-referent relation.

The final, and in many ways most important, issue about this research is what specific mechanisms might underlie the observed transfer. In other words, how might symbolic sensitivity operate? One possibility comes from Gentner's (1989; Gentner & Ratterman, 1991) process of re-representation. When confronted with similar situations, people try to align their mismatching representations. Re-representing the situations at a more abstract level leaves behind the mismatching elements, resulting in a common structure. Gentner and Ratterman (1991) conjecture that "re-representation induced by trying to align partially similar situations may be one way that children gradually come to an appreciation of abstract commonalities" (p. 265).

By this view, children who notice some part of the similarity between a model and a large space would then attempt to align their representation of one space with their representation of the other. Noticing, for example, that the miniature chair in the model looks like the larger chair in the room, ex-

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cept for the size, may lead our young subjects to look for similarity between other objects within the two spaces. This effort would lead them to abstract the common structure of the two spaces, thus facilitating the process of drawing inferences from one to the other. Their more abstract representation of the particular model-room relation would then facilitate detection of a structurally similar relation between a new symbol and referent, that is, it would facilitate transfer.

Karmiloff-Smith's (1991) theory of representation suggests a similar way in which prior symbolic experience could facilitate subsequent detection of a different symbolic relation. She distinguishes between knowledge representations at different levels. Knowledge can be implicit, embedded in procedures and not available to consciousness, or it can be explicitly represented and either consciously accessible or not. In our transfer tasks, it could be that the second experience with a symbolic task results in the children's knowledge being re-represented at a high level. Thus, a child might be successful in one task based on an explicit representation of the symbol-referent relation without having conscious access to that knowledge. Because the child is not fully aware of the relation, similarity would be crucial in supporting successful performance. The second task could promote conscious access to the symbol-referent relation. Such awareness would then lead the child to look for object correspondences, thus making surface similarity less important. Transfer would result.

In the long run, these processes could be very important in general symbolic development. With increased experience with symbols, children would become increasingly likely to look for symbolic relations and they would become increasingly less reliant on similarity or instructions to detect them. At the same time, they would have conscious access to an increasing number of explicit symbol-referent representations.

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