The Credible Shrinking Room: Very Young Children's Performance With Symbolic and Nonsymbolic Relations

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Research Article

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Abstract—*Becoming a proficient symbol user is a universal developmental task in the first years of life, but detecting and mentally representing symbolic relations can be quite challenging for young children. To test the extent to which symbolic reasoning per se is problematic, we compared the performance of 2½-year-olds in symbolic and nonsymbolic versions of a search task. The children had to use their knowledge of the location of a toy hidden in a room to draw an inference about where to find a miniature toy in a scale model of the room (and vice versa). Children in the nonsymbolic condition believed a shrinking machine had caused the room to become the model. They were much more successful than children in the symbolic condition, for whom the model served as a symbol of the room. The results provide strong support for the role of dual representation in symbol understanding and use.*

Nothing so distinguishes humans from other species as the creative and flexible use of symbols. Abstract concepts, reasoning, scientific discovery, and other uniquely human endeavors are made possible by language and a panoply of symbolic tools, including numbers, alphabets, maps, models, and various notational systems. The universality and centrality of symbolic representation in human cognition make understanding its origins a key developmental issue.

How do children master the symbolic artifacts of their culture? They must start by recognizing that certain entities should be interpreted and responded to primarily in terms of what they stand for—their referents—rather than themselves. This is obviously a major challenge in the case of completely arbitrary symbol–referent relations. Nothing about the appearance of a numeral or a printed word suggests what it represents. Hence, it is not surprising that children have to be explicitly taught and only gradually learn the abstract relations between numerals and quantities and between printed and spoken words.

In contrast, it is generally taken for granted that highly iconic symbols (i.e., symbols that resemble their referents) are understood easily and early. Recent research, however, reveals that this assumption is unwarranted: A high degree of similarity between a symbol and its referent is no guarantee that young children will appreciate the symbol–referent relation. For example, several studies have established that very young children often fail to detect the relation between a realistic scale model and the room it represents (DeLoache, 1987, 1989, 1991; DeLoache, Kolstad, & Anderson, 1991; Dow & Pick, 1992; Marzolf & DeLoache, 1994; Uttal, Schreiber, & DeLoache, 1995). Most 2½-year-old children give no evidence of understanding that the model and room are related or that what they know about one space can be used to draw an inference about the other. Children just a few months older (3-year-olds) readily exploit this symbol–referent relation.

Why is a highly iconic relation that is so transparent to older children and adults so opaque to very young children? Many theorists have characterized symbols as possessing dual reality (Gibson, 1979; Gregory, 1970; Potter, 1979). According to the *dual representation* hypothesis (DeLoache, 1987, 1991, 1995a, 1995b), it is the double nature of symbols that poses particular difficulty for young children. To understand and use a symbol, one must mentally represent both the symbol itself and its relation to the referent. Thus, one must achieve dual representation, thinking about the concrete features of the symbol and the abstract relation between it and something else at the same time.

According to this hypothesis, the more salient the concrete aspects of a symbol are, the more difficult it is to appreciate its abstract, symbolic nature. Thus, young children's attention to a scale model as an interesting and attractive object makes it difficult for them to simultaneously think about its relation to something else. The philosopher Langer (1942) seemed to have something similar in mind when she noted that a peach would make a poor symbol because people care too much about the peach itself.

The research reported here constitutes an extremely stringent test of this hypothesis. We compared 2½-year-old children's performance in two tasks in which they had to detect and exploit the relation between a scale model and a room. In both tasks, children had to use their knowledge of where a toy was hidden in one space to infer where to find an analogous toy in the other space. In one task, there was a symbolic relation between the model and the room, whereas the other task involved a nonsymbolic relation between the same two entities. If achieving dual representation is a key obstacle in early symbolic reasoning, then performance should be superior in the nonsymbolic task, which does not require dual representation. We made this prediction even though the nonsymbolic task involved convincing children of an impossible scenario—that a machine could cause the room to shrink into the model.

Our reasoning was that if a child believes that the model is the large room after having been shrunk, then there is no symbolic relation between the two spaces; to the credulous child, the model simply *is* the room (albeit dramatically different in size). Thus, if the room is shrunk after a large toy has been hidden in it, finding a miniature toy in the model is, from the child's perspective, primarily a memory task. Dual representation is not necessary. Note that in both tasks, children must use the correspondence between the hiding places in the two spaces; their memory representation of the toy hidden behind a full-sized chair in the room must lead them to search behind the miniature chair in the model. In the symbolic task, the child knows there are two chairs, so he or she must represent the relation between them. In the nonsymbolic task, however, the child thinks there is only one chair. Superior performance in the nonsymbolic, shrinking-room task would thus provide strong support for the dual representation hypothesis.

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METHOD

Subjects

The subjects included 15 children (29–32 months, $M = 30$ months) in the symbolic condition and 17 (29–33 months, $M = 31$ months) in the nonsymbolic condition. Names of potential subjects came from files of birth announcements in the local newspaper, and the majority of the children were middle class and white.

Materials

The same two spaces were used for both tasks. The larger space was a tentlike portable room (1.9 m × 2.5 m) constructed of plastic pipes supporting white fabric walls (1.9 m high) with a brown cardboard floor. The smaller space was a scale model (48.3 cm × 62.9 cm, with walls 38.1 cm high) of the portable room, constructed of the same materials. The room held several items of furniture (fabric-covered chair, dresser, set of shelves, basket, etc.); the model contained miniature versions of these items that were highly similar in appearance (e.g., same fabric on the chairs) to their larger counterparts. The relative size and spatial arrangement of the objects were the same in the two spaces, and the model was always in the same spatial orientation as the room. This model and room have been used in several previous studies (DeLoache et al., 1991; Marzolf & DeLoache, 1994). Figures 1a, 1b, and 1c show the arrangement of the room and model for the two tasks.

Procedure

Symbolic task

In this task (which was very similar to that used in the previously cited model studies), each child was given an orientation that began with the introduction of two troll dolls referred to as "Big Terry" (21 cm high) and "Little Terry" (5 cm). The correspondence between the room (described as "Big Terry's room") and the model ("Little Terry's room") and between all of the objects within them was fully and explicitly described and demonstrated by the experimenter.

On the first of four experimental trials, the child watched as the experimenter hid the larger doll somewhere in the room (e.g., behind the chair, in the basket). The child was told that the smaller toy would be hidden in the "same place" in the model. The child waited (10–15 s) as the miniature toy was hidden in the model in the adjoining area (Fig. 1a) and was then encouraged to retrieve it. The experimenter reminded the child of the corresponding locations of the two toys: "Can you find Little Terry? Remember, he's hiding in the same place in his little room where Big Terry's hiding in his big room." If the child failed to find the toy on his or her first search, increasingly direct prompts were given until the child retrieved the toy. On the second trial, the hiding event occurred in the model instead of the room. Thus, the child watched as the miniature toy was hidden in the model, and he or she was then asked to retrieve the larger toy from the room. The space in which the hiding event occurred again alternated for the third and fourth trials.[1]

To succeed, children in the symbolic task had to realize that the room and model were related. If they did, they could figure out where to search for the target toy, even though they had not actually seen it being hidden. If they failed to represent the model–room relation, they had no way of knowing where to search. Based on numerous previous studies with this basic task, we expected a low level of performance from our 2½-year-old subjects (DeLoache, 1987, 1989, 1991; DeLoache et al., 1991; Dow & Pick, 1992; Marzolf & DeLoache, 1994).

Nonsymbolic task

The initial arrangement for this task is shown in Figure 1b. In the orientation to the task, each child was introduced to "Terry" (the larger troll doll) and to "Terry's room" (the portable room). In the ensuing practice trial, the child watched as the experimenter hid the troll in the room and then waited for a count of 5 before searching. The children always succeeded in this simple memory-based retrieval (100% correct).

Next, the child was shown a "machine that can shrink toys" (actually an oscilloscope with flashing green lights—the solid rectangle in Fig. 1b). The troll doll was placed in front of it, a switch was turned on, and the child and experimenter retreated to an adjoining area and closed the door to the lab. During a delay of approximately 10 s, the child heard a tape of computer-generated tones, which were described as the "sounds the shrinking machine makes while it's working." When the sounds stopped, the child returned to the lab to find a miniature troll (5 cm high) in the place the larger one had previously occupied. Figures 1d and 1e depict the shrinking machine with the troll before and after the shrinking event.

The child was then told that the machine could also make the troll get larger, and the process was repeated in reverse, ending with the large troll again standing in front of the machine. For the final part of the orientation, the same shrinking and enlarging demonstrations were performed with "Terry's room." The shrinking machine was aimed at the room, and the child and experimenter waited in the adjoining area, listening to a longer (38-s) tape of the same computer sounds. When the door to the lab was opened, the scale model was revealed sitting in the middle of the area previously occupied by the room (Fig. 1c). The sight of the small model in place of the large room was very dramatic. The process was then repeated in reverse, resulting in the room replacing the model.[2]

1. There were two major differences between the current symbolic task and the standard model task used in previous research: First, the hiding event alternated from trial to trial between model and room. In the standard task, it always occurs in one space or the other for a given child. In studies in which half the children see the hiding event in the room and the other half in the model, there has never been any difference in performance as a function of this variable. Second, in the standard task, children always perform two retrievals: For example, after seeing the toy being hidden in the model, they first search for the larger toy in the room and then return to the model to retrieve the toy they originally observed being hidden. However, the performance of the 2½-year-olds tested in the current study did not differ from that of a group tested in the standard model task using all the same materials.

2. An elaborate scenario supported the shrinking and enlarging events. When the child first saw the artificial room, it was surrounded on three sides by black curtains, which were visible only on the sides in front of the portable room (Fig. 1b). For each shrinking event, as soon as the child had left the lab, one assistant turned on a tape recorder to begin the shrinking-machine sounds (thereby concealing any noises made in the lab). Two other assistants pulled the artificial room behind the curtains, and the first placed the model, with the miniature troll in the appropriate position, in the center of the space formerly occupied by the room. In the enlarging events, the model was replaced by the room.

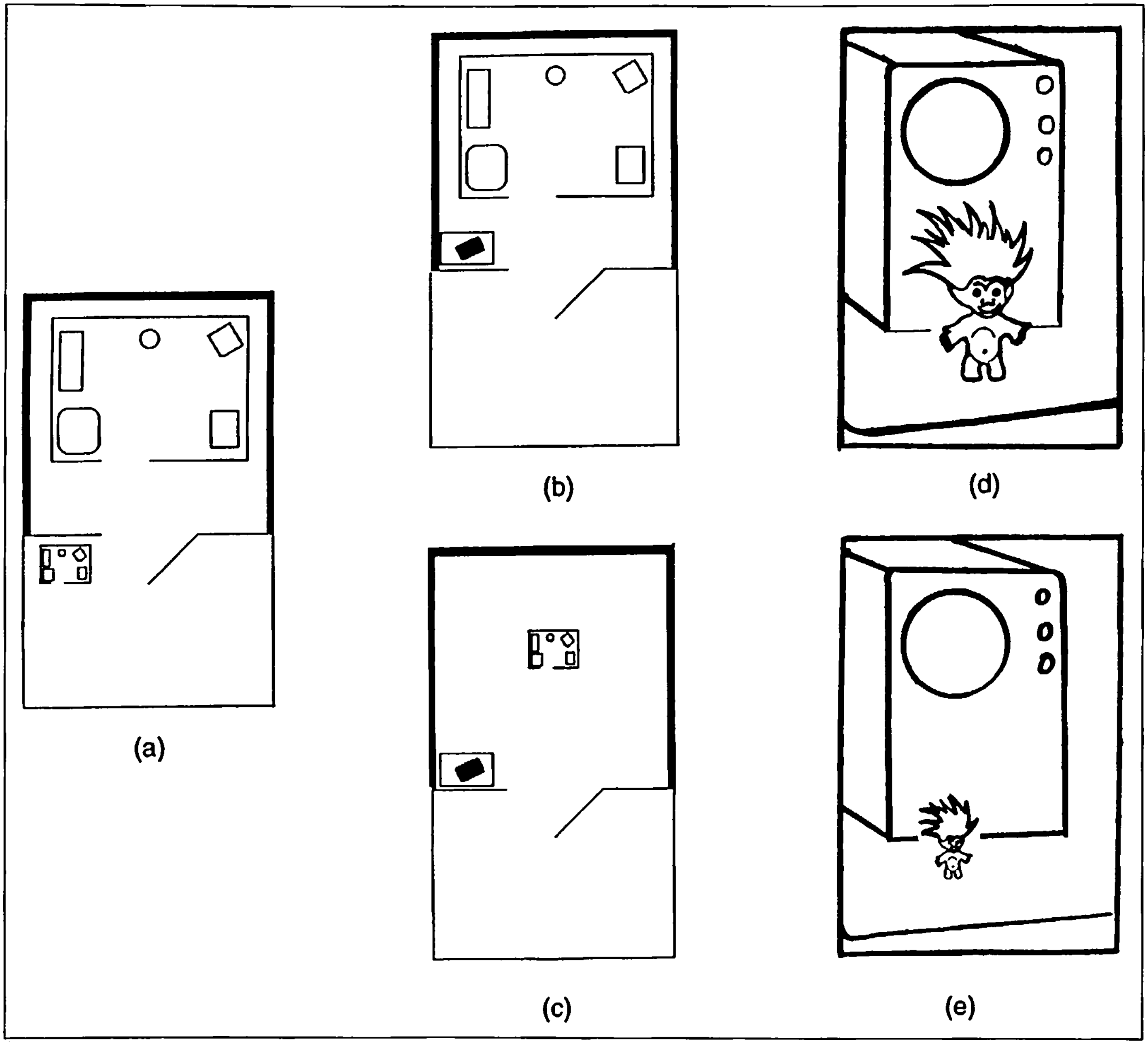

Fig. 1. Physical arrangements for the symbolic and nonsymbolic tasks. For the symbolic task (a), the portable room was located in a large lab, surrounded on three sides by opaque curtains (represented by heavy lines); the model was located in an adjoining area. The nonsymbolic task began with the arrangement shown in (b); before the first shrinking event, the portable room was located in the lab, partially surrounded by curtains, just as it was for the symbolic task. The only difference was the presence of the shrinking machine, represented by the dark rectangle, sitting on a table. In the aftermath of the shrinking event, depicted in (c), the model sat in the middle of the area previously occupied by the portable room. The sketches in (d) and (e) show Terry the Troll before and after the demonstration shrinking event.

On the first of four trials, the child watched as the larger doll was hidden in the room (the same hiding places were used as in the symbolic task), and the child was instructed to remember where it was hidden. After a 38-s delay, again spent waiting in the adjoining area listening to the sounds of the shrinking machine, the child entered the lab, where the model had replaced the portable room. The child was encouraged to find the doll: "Can you find Terry? Remember where we hid him? That's where he's hiding." The miniature troll was, of course, hidden in the model in the place that corresponded to where the child had seen the larger troll being hidden in the room. On two of the four trials, the room and large troll were shrunk, alternating with two trials in which the model and miniature troll were enlarged. A different hiding place was used on each trial.

To assess the extent to which the children accepted our shrinking-machine scenario, the experimenter and each child's accompanying parent independently rated the child on a 5-point scale, with 1 indicating that the child "firmly believed" that the machine really did shrink the objects and 5 indicating that the child "firmly did not believe" it. The average ratings were 1.1 and 1.5 for the experimenter and parents, respectively. There was only one child that the observing adults judged to be at all skeptical. The children generally reacted to the shrinking events with interest and pleasure, but not astonishment. Several children made revealing comments, such as "I want to make it big [little] again," and, while listening to the sounds of the shrinking machine, "It's working to make it big." In addition, when the children later told other family members about the session, they typically talked about the troll or the room "getting little." None ever described the situation as pretend or as a trick. We therefore feel confident that our subjects believed that the model and room were actually the same thing, which means that the shrinking-room task was, as intended, nonsymbolic (involving an identity rather than a symbolic relation).[3]

We wish to emphasize that it is unlikely that the a priori prediction of superior performance in the nonsymbolic task would be made on any basis other than the dual representation hypothesis. Indeed, various aspects of the procedures would lead to the opposite expectation. For example, getting and keeping toddlers motivated in experimental situations is always a challenge; and the shrinking-room task was more complicated, required more verbal communication, and took longer than the standard symbolic task. In addition, the delay between the hiding event and the opportunity to search for the toy was substantially longer in the shrinking-room task (ca. 50–60 s) than in the standard symbolic task (ca. 10–15 s). Delays between hiding and retrieval are known to cause the performance of even older children to deteriorate dramatically in the standard model task (Uttal et al., 1995).

RESULTS

The critical question was whether performance in the nonsymbolic (shrinking-room) condition would be superior to performance in the symbolic (model) condition. Figure 2 shows the mean number of errorless retrievals (searching first at the correct location) achieved in the two tasks.

The children in the symbolic task achieved a mean of only 0.8 errorless retrievals over four trials ($SE = 0.2$), a rate not different from chance. (We conservatively estimated chance at 25%, based on our use of four hiding places; however, it is actually lower because there are additional possible hiding places.) Individual performance in this task was similarly poor: Six of the 15 children never found the toy, and 6 retrieved it only once. No child succeeded on more than two of the four trials. These children understood that they were supposed to search for a hidden toy on each trial, and they were happy to do so, but they apparently failed to realize that their knowledge of one space could be applied to the other.

The poor performance of the children in the symbolic task (19%) is exactly what would be expected from previous model studies. In

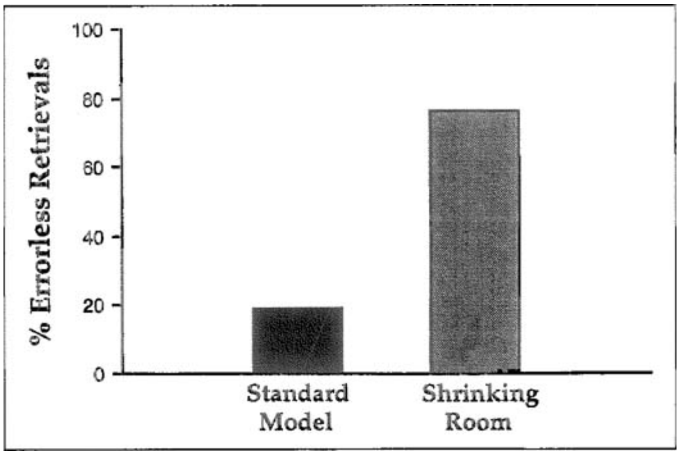

Fig. 2. Mean number of errorless retrievals (searching first in the correct location) in the symbolic and nonsymbolic tasks.

research in our own and other labs using a variety of different models and rooms, 2½-year-olds reliably average around 20% successful retrievals.

In contrast, children in the nonsymbolic task were very successful. Performance in the nonsymbolic (shrinking-room) condition was well above chance—3.1 errorless retrievals ($SE = 0.2$)—and significantly better than the performance of the children in the symbolic condition. Twelve of the 17 subjects achieved three or more errorless retrievals, and 7 of those had perfect scores. The difference between the two tasks was the only significant result in a 2 (task) × 2 (gender) analysis of variance, $F(1, 28) = 51.5, p < .0001$. Performance did not differ on trials in which the hiding event occurred in the room and the child searched in the model versus trials in which the hiding and search spaces were the reverse.

The main result of this study has been replicated, both in an additional study with 2½-year-olds and in two studies in which the same logic was applied to a different age group. Using two different, more difficult versions of the model task, we found the same pattern of results with 3-year-olds as occurred with the 2½-year-olds in the present study—significantly better performance in the nonsymbolic, shrinking-room version than in the symbolic model task (DeLoache, 1995a; Marzolf, 1994).

DISCUSSION

We conclude that a major challenge to detecting and using symbolic relations stems from their inherent dual reality and the necessity of achieving dual representation (DeLoache, 1987, 1995a, 1995b). The model task was more difficult than the shrinking-room task because the former required dual representation, whereas the latter eliminated the need for it. The research reported here provides strong support for a theoretical account of early symbol understanding and use in which young children's ability to use symbols is considered to be limited by several factors, a key one being the difficulty of achieving dual representation (DeLoache, 1995a, 1995b). Relatively limited information processing capacity makes it difficult for younger children to keep two representations active at the same time, and limited cognitive flexibility makes it especially difficult for them to mentally represent a single entity in two different ways.

3. The parents of all the participants in this study were fully informed of the procedures to be followed, and a parent was present throughout each experimental session. The children's assent was always obtained before the sessions began. After the completion of their sessions, the children in the nonsymbolic (shrinking-room) condition were debriefed: They were shown the two dolls and the model and room together, and the experimenter explained that the machine did not really shrink or enlarge them.

The study reported here provides especially strong support against criticism of this theoretical account of early symbol use. It has been claimed that the use of a symbol such as a scale model requires nothing more than simply detecting some kind of correspondence between the symbol and referent (Blades & Spencer, 1994; Lillard, 1993; Perner, 1991). One claim is that the child succeeds on each trial by noticing that the current hiding place of the miniature toy corresponds to the full-sized hiding place of the larger toy, without ever appreciating the higher level relation between the two spaces.

The simple correspondence view cannot explain the current results. For one thing, it offers no account of how children's performance depends on the kind of relation that must be represented. In both tasks, corresponding items in the two spaces must be mentally linked; memory for the object concealing the original toy must support a search at the corresponding object. The challenge in the nonsymbolic task is simply to recognize that object in its new form. The challenge in the symbolic task is to represent the relation between that object and the other one it stands for.

Furthermore, simply detecting the correspondence between matching items does not support successful performance in the symbolic task. In a recent study (DeLoache, 1995a), 2½-year-old children readily matched the items in the room to the corresponding items in the model, yet still failed the subsequent standard model task. Establishing object correspondences is thus necessary but not sufficient for reasoning from one space to the other. Although the simple correspondence account has the appearance of parsimony, because it posits a lower level explanation than dual representation, it cannot account for results presented here and elsewhere in support of dual representation (DeLoache, 1991; Marzolf & DeLoache, 1994).

At the most general level, the research reported here indicates that it is the nature of a child's mental representation of the relation between two entities that governs the child's ability to reason from one to the other. Very young children can reason successfully based on an identity relation, even when it results from the complex and novel scenario of a shrinking machine. They fail to appreciate a symbolic relation between the same two entities, even though it is explained and demonstrated. Despite the importance and universality of symbolization, very young children are quite conservative when it comes to interpreting novel objects as symbols.

The dual representation hypothesis, which received strong support from the study reported here, has important practical implications. For example, it calls into question the assumption commonly made by educators that children will readily comprehend the meaning of manipulables—concrete objects used to instantiate abstract mathematical concepts (Uttal, Scudder, & DeLoache, 1997). One must take care to ensure that children appreciate the relation between, for example, the size of blocks and numerical quantities before using the blocks for teaching purposes. Similar doubt is cast on the widespread practice of using anatomically explicit dolls to interview young children in child-abuse investigations. Young children's difficulty with dual representation suggests that the relevant self–doll relation may not be clear to them; if so, using dolls may not be helpful and might even be counterproductive. Recent research has supported this conjecture: Several studies have reported no advantage to using dolls to interview 3-year-old children about events they have experienced (Bruck, Ceci, Francoeur, & Renick, 1995; DeLoache, Anderson, & Smith, 1995; DeLoache & Marzolf, 1995; Goodman & Aman, 1990; Gordon et al., 1993).

One other aspect of the results reported here merits attention. The 2½-year-old children had no difficulty dealing with the size transformations supposedly effected by the shrinking machine. This finding is consistent with research showing that very young children represent and rely on geometric features of a space (Hermer & Spelke, 1994). The children's ability to mentally scale the two spaces in the present research may have been assisted by the fact that the size transformations preserved the geometric properties of the original space, including its overall shape, the relative sizes and positions of the objects, and the distances among them.

Spatial representations other than scale models also pose problems for young children. Only with difficulty can 3-year-olds use a simple map to locate a hidden object, and their ability to do so is easily disrupted (Bluestein & Acredolo, 1979). Older preschool children often fail to interpret aerial photographs consistently (Liben & Downs, 1992); they may, for example, describe one feature of an aerial photo correctly as a river but another as a piece of cheese. Thus, figuring out the nature and use of spatial symbols is a persistent challenge for young children.

The current study, along with other research on the early understanding and use of symbols, makes it clear that one can never assume that young children will detect a given symbol–referent relation, no matter how transparent that relation seems to adults or older children. Young children may perceive and form a meaningful interpretation of both the symbol and the entity it stands for without representing the relation between them.

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