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REPORT

The role of perseveration in children's symbolic understanding and skill

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Abstract

In the first few years of life, children become increasingly sensitive to the significance of a variety of symbolic artifacts. An extensive body of research has explored very young children's ability to use symbol-based information as a guide to current reality. In one common task, for example, children watch as a miniature toy is hidden in a scale model, and are then asked to retrieve a larger version of the toy from the corresponding place in the room itself. Two-and-a-half-year-old children perform very poorly in most versions of this task. Their most common error is to perseverate; that is, they search again at the location where the toy was last hidden. Two studies examined the degree to which $2^1/_2$-year-olds' high rate of perseveration and poor performance stem from problems with inhibitory control. Results showed that problems with inhibitory control contribute very little to $2^1/_2$-year-old children's difficulty with the task. Instead, the results confirm young children's great difficulty appreciating and exploiting symbol–referent relations.

Introduction

The human environment is replete with symbols of every kind, from numbers and writing to pictures, models and maps. Acquiring the symbolic skills of one's culture is thus a critical component of development. For young children, however, recognizing symbolic meaning can present substantial challenges. In research in which symbolic artifacts such as scale models or pictures provide information relevant to solving a problem, young children often fail to use the information (see DeLoache, 1995; DeLoache, Miller & Pierroutsakos, 1998). In the standard model task, young children watch as a miniature toy is hidden in a small-scale model of a full-sized room. They are told that a larger version of the toy will be hidden in the corresponding location in the room itself.[1] They are then asked to retrieve the larger toy (the *symbol-based retrieval*). To succeed, they must use the model–room relation as the basis for searching for the larger toy. Finally, they are asked to retrieve the miniature toy that they originally observed being hidden in the model (the *memory-based retrieval*).

Three-year-old children are typically very successful in this task. They use their memory representation of the hiding event in the scale model both to infer where to search for the large toy in the room (around 75–85% correct), and to guide their search for the miniature toy in the model (85–95% correct). In contrast, $2^1/_2$-year-old children typically perform extremely poorly on the symbol-based retrievals (15–25% correct). Their poor performance is not due to memory problems, because their performance on the memory-based retrievals is equal to that of the older children. Nor is it attributable to lack of motivation or failure to understand the basic task of searching for hidden toys. They understand that a large toy is hidden in the room for them to find, and they search for it enthusiastically, if usually unsuccessfully.

DeLoache (1995) has argued that $2^1/_2$-year-olds' poor performance in the standard model task reflects a failure to achieve *representational insight*, that is, a failure to appreciate the significance of the model–room relation. They seem unaware of the relevance of the hiding event in the model for the location of the toy in the room. They pay attention to the model itself, and they encode and remember the location of the hiding event in it; but

[1] Some children experience the opposite order, watching the larger toy hidden in the room and searching for the miniature toy in the model. There is no effect on performance, so for ease of communication only the 'hide-model, search-room' case will be used in descriptions of the task.

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they fail to use their knowledge about the model to draw an inference about the room.

It is possible, however, that some of the poor performance of $2^1/_2$-year-old children in this task is due to something other than a failure to achieve representational insight. The goal of the two studies reported here is to examine the extent to which deficits in inhibitory control might be a contributing factor, as some have suggested (Solomon, 1999; O'Sullivan, Mitchell & Daehler, 2001). The development of inhibitory control has been identified by many researchers as a central component of overall cognitive development over the first several years of life (e.g. Dempster, 1993; Diamond & Taylor, 1996; Gerstadt, Hong & Diamond, 1994; Harnishfeger, 1995; Harnishfeger & Bjorklund, 1993). Deficits in inhibitory control can arise at two levels. At the behavioral or motoric level, children may fail to inhibit a prepotent response when that response is no longer appropriate. At the cognitive level, children may fail to inhibit attention to irrelevant or outdated information.

Children's difficulty in the model task is unlikely to stem from a simple problem with response inhibition. The response involved in the model task is not a simple motor act (such as a single reach); instead, children must walk from one room into another and then cross the second room to search a particular location. Further, the particular action varies depending on the hiding place (e.g. lifting a pillow, pulling a drawer). Hence, response repetition *per se* seems unlikely to be a major factor.

Difficulty could, however, arise at the cognitive level, as success clearly requires cognitive inhibition. On every trial after the initial one, children must update their memory representation of the miniature toy's location in the model and use it to form a symbol-based representation of the large toy's location in the room. To base their search in the room on this newly formed symbol-based representation, they must inhibit searching on the basis of their most recent memory representation of finding the large toy in the room. Failure to inhibit their most recent memory representation, which is likely to be both salient and accessible, would lead to perseverative search.

There are three reasons to think that problems with inhibitory control may in fact play an important role in the model task. First, a large body of research on the development of inhibitory control shows that children's ability to control perseverative responses and inhibit attention to irrelevant stimuli is initially quite limited and develops slowly, well into middle childhood (e.g. Passler, Isaac & Hynd, 1985; Welsh & Pennington, 1991; Welsh, Pennington and Grossier, 1991).

Second, perseverative searching is very common, both in search tasks in general (e.g. DeLoache & Brown, 1983; Horn & Myers, 1978; Loughlin & Daehler, 1973; Perlmutter, Hazen, Mitchell, Grady, Cavanuagh & Flook, 1981) and in the model task. Across many studies and multiple labs, perseverative searching accounts for around half of all errors in retrieval tasks using symbolic media, including models, pictures and video (a rate that is well above chance) (e.g. DeLoache & Burns, 1994; O'Sullivan *et al.*, 2001; Sharon, 1999; Solomon, 1999; Troseth & DeLoache, 1998).

Third, in some previous studies using symbolic retrieval tasks, performance was notably better on the first trial than on subsequent ones (by as much as 60 percentage points) (Schmitt & Anderson, 2002; Sharon, 1999; Troseth & DeLoache, 1998). Perhaps children in these studies had sufficient insight into the relevant symbolic relation to successfully retrieve the toy on the first trial, when inhibitory control was not required, but insufficient control to inhibit perseverative searching thereafter.

On the other hand, there are also reasons to think that difficulties with inhibitory control are not a substantial factor in $2^1/_2$-year-old children's poor performance in the model task. For example, a variety of manipulations designed to make it easier for young children to detect a symbol–referent relation, without lessening the need for inhibitory control, have resulted in improved performance (e.g. DeLoache, 1991, 2000). In addition, performance is improved when children are led to believe there is a causal relation between room and model (i.e. that a machine has transformed the room into the model), thereby making it unnecessary to represent a symbolic relation between the two spaces (DeLoache, Miller & Rosengren, 1997). Although these and other results suggest that problems with inhibitory control are unlikely to play a major role in the model task, the claim that poor performance is due to a lack of representational insight does not adequately account for the superior first trial performance that has occasionally been reported (Chen, 2001; Schmitt & Anderson, 2002; Sharon, 1999; Troseth & DeLoache, 1998). An additional goal of the current research was to examine this 'first-trial effect' in more detail.

In the two studies reported here, we evaluated two explanations for the poor performance of $2^1/_2$-year-olds in the standard model task: (1) an *inhibitory-deficit* account, in which inadequate inhibitory control contributes to children searching perseveratively despite some understanding of the model–room relation; and (2) a *knowledge-deficit* account, in which perseveration is simply a consequence of not understanding the model–room relation – a fallback or 'best-guess' strategy in the absence of knowing where else to search (see also Chen, 2001). That is, without symbolic understanding to guide them, they fall back on something they do know, namely, where they most recently found the toy.

Table 1 *Groups included in Study 1*

Study	*N*	Age	Condition	% Correct	
				Symbol-based retrievals	Memory-based retrievals
DeLoache (2000)	12	30.3	Room and model 2	16	88
DeLoache (2000)	10	30.2	Room and model 1	15	88
Marzolf & DeLoache (1994)	12	30.4	Portable room and cloth model	27	73
DeLoache (1991)	8	30.7	Room and model 1	25	78
DeLoache (1991)	8	30.7	Room and model 1	16	94
DeLoache, Kolstad & Anderson (1991)	11	30.6	Portable room and cloth model	41	77
DeLoache, Kolstad & Anderson (1991)	8	30.6	Portable room and box model	28	78
DeLoache (1989)	8	30.4	Room and model 1	16	88
DeLoache (1989)	16	31.5	Room and model 1	15	83
unpublished data	10	30.1	Portable room and cloth model	30	93
unpublished data	10	30.7	Room and model 2	26	85
unpublished data	8	30.4	Room and model 2	16	75
unpublished data	8	30.0	Room and model 2	25	81

Study 1

The inhibitory-deficit and knowledge-deficit accounts make different predictions regarding two specific aspects of $2^1/_2$-year-olds' performance in the standard model task. First, if difficulties with inhibitory control contribute to children's overall poor performance, then they should perform significantly better on the initial trial, when inhibitory demands are minimal, than on subsequent trials, when inhibitory control is essential.

Second, children should frequently correct their errors. If children have some understanding of the model–room relation, but are unable to inhibit their previous memory representation when first searching in the room, they should often follow an incorrect search by spontaneously going to the correct location.

A different pattern of performance would be expected under the view that children who perform poorly in the model task lack insight into the model–room relation and search perseveratively simply as a 'best-guess' strategy. First, children should perform equally poorly across trials, as there would be no basis for doing better on the first trial versus later ones. Second, they should rarely correct their errors spontaneously as they would lack the requisite knowledge of the correct location.

In Study 1, data from several previous experiments were combined into one large data set, enabling a close examination of performance over trials and rates of error correction.

Method

Participants

From a large set of experiments conducted over many years, we selected all groups of $2^1/_2$-year-olds who had participated in the standard or slightly modified versions of the model task (see Table 1). The resulting set of 13 groups included a total of 129 participants (*M* age = 30.5 months, range = 28.5–32.5).

Table 2 *Size and approximate area ratios for the model and room arrangements used in Study 1*

	Room	Model	Ratio[a]
Room and model 1	$4.8 \times 3.9 \times 2.5$ m	$71 \times 65 \times 33$ cm	50:1
Room and model 2	$6.5 \times 5.5 \times 2.6$ m	$84 \times 74 \times 33$ cm	60:1
Portable room and model	$2.6 \times 1.9 \times 1.9$ m	$63 \times 43 \times 38$ cm	16:1

[a] Some reports of studies using the model task have provided the size ratio between model and room along one dimension only, rather than the area ratio (length multiplied by width). For consistency with previous reports of our studies, we provide the area ratio here. The approximate size ratios (measured on one dimension) are as follows: first room–model arrangement, 7:1; second room–model arrangement, 8:1; portable room and model, 4:1.

Stimuli and apparatus

Three different room–model arrangements were employed (see Table 2). Regular rooms served as the larger space in two of the arrangements, and in the third, the large space was a tent-like portable room. The regular rooms contained a large number of standard items of furniture and an even larger number of potential hiding places, as some locations afforded multiple hiding spots (e.g. a dresser with three drawers). The portable room contained fewer items and hence fewer potential hiding locations. The scale models included miniature versions of all items of furniture in the corresponding rooms, and the model items were generally highly similar to the real items in material and color. The scale model was always placed outside the room, and in the same orientation. The objects used for hiding and retrieving were a larger toy dog (15 cm) and a smaller one (2 cm).

Procedure

In all versions of the task, the child was first given an extensive orientation to the room and model, which included carrying all items from the model into the room and explicitly pointing out the correspondence between them and the larger items. The orientation was followed by a placement trial, in which the experimenter placed the small toy in the model and asked the child to put the larger toy in the corresponding location in the room.

Finally, the child participated in 4 test trials, each of which involved three parts:[2] (1) *hiding event*: the child watched as the experimenter hid the miniature toy in the model (with a different location used on each trial). The experimenter called attention to the hiding act, but without naming the location. She then told the child that she would hide the large toy 'in the same place in his big room'; (2) *symbol-based retrieval*: the child was led into the larger space and asked to find the larger toy; (3) *memory-based retrieval*: the child was asked to retrieve the miniature toy from the model. For both retrievals, if the first search was incorrect, the experimenter provided increasingly explicit prompts until the child found the object, but only the first, unprompted search was counted as correct.

Scoring

A correct search was scored for each trial in which the child searched first in the correct location without any prompts. A self-correction was scored if a child searched incorrectly, but then without prompting searched the correct location. A perseverative search was scored for any non-initial trial in which a child's first search was at the location that had been correct on the previous trial. Because children who searched incorrectly were always prompted to retrieve the toy, the children's last response on every trial was to the correct location. (For more details on the stimuli and procedures, see DeLoache, 1987; DeLoache *et al.*, 1991; DeLoache, 1991.)

Results and discussion

The overall success rate on the symbol-based retrievals was only 23%. After watching the experimenter hide the miniature toy in the model, the children usually failed to search the corresponding place in the room.[3] In contrast, 83% of their first memory-based searches were correct.

Perseverative searching was common in the symbol-based retrievals, accounting for 47% of all first searches on the non-initial trials. This high level of perseverative searching is very similar to recent results from symbolic-retrieval tasks in other labs (e.g. O'Sullivan *et al.*, 1999; Solomon, 1999). In the memory-based retrievals, 14% of the children's searches were perseverative.

Perseverative responses thus clearly account for a large proportion of children's responses on the non-initial, symbol-based retrievals. The key question is whether these responses reflect a lack of symbolic understanding or instead reflect difficulties with inhibitory control despite symbolic understanding. To address this question, we assessed children's performance against the contrasting predictions made by the knowledge-deficit and inhibitory-deficit accounts.

Performance over trials

The first differential prediction concerned the pattern of correct performance across trials. If difficulties with inhibitory control contribute to children's poor performance on the task, they should do better on the initial trial than on all later trials. However, if children's main difficulty is achieving insight into the representational relation, there should be no systematic differences across trials; performance should be uniformly low across trials.

Figure 1 shows correct performance on the symbol-based retrievals across the 4 trials. To examine patterns of performance over trials, McNemar's test for the significance of changes was used.[4] An analysis of the change in performance between Trials 1 and 2 on the symbol-based retrievals showed that significantly more children went from correct to incorrect than vice versa, $\chi^2 = 12.60$, $p < .001$. However, after this initial decrease in performance, there was also a significant increase in performance between Trials 2 and 3, $\chi^2 = 3.9$, $p < .05$, as more children went from incorrect to correct than vice versa. Thus, this pattern might more accurately be characterized as a 'second-trial dip' than as a first-trial effect. It is not consistent with an inhibitory deficit account of

[2] In a few studies, 6 test trials were used. The extra trials were dropped in the current analyses.

[3] Calculating chance in the object-retrieval task is complicated by the fact that, although children are shown a specific number of hiding places, the hiding space actually contains additional potential locations (in the full-sized room, quite a number of them) and it is unclear how many of these children might notice or think to use. Study 1 has the additional complication that the number of items of furniture, and hence the number of potential hiding locations, was not the same for all groups.

[4] As the individual data for each trial are categorical (the child either succeeded or not), McNemar's statistic was the appropriate test. It is a nonparametric version of a *t*-test, and the preferred test for correlated, categorical-level data. It allows comparison of such data by determining whether the changes between datapoints are equal – for example, whether there is more change in one direction (from correct to incorrect) than in the reverse direction.

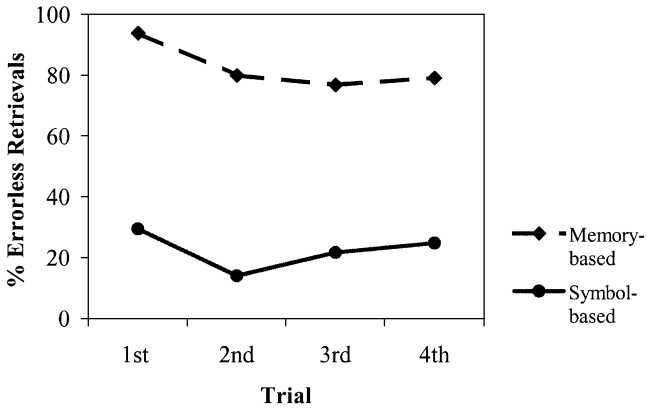

Figure 1 *Performance in Study 1 across trials.*

poor performance, according to which performance should be good on the initial trial but then equally poor across all non-initial trials. Furthermore, performance in Trial 1 was still only 29% correct, revealing that most children showed no evidence of understanding the model–room relation even on the first trial. Instead, the most common pattern by far – shown by nearly half (47%) of the children – was to err on every trial. These results are also contrary to the inhibitory account.

Another problem for the inhibitory account is the fact that the pattern of performance on the memory-based retrievals was similar to that for the symbol-based retrievals, in that performance declined between Trials 1 and 2, $\chi^2 = 8.76$, $p < .005$. The similar pattern of performance on the two different kinds of retrievals indicates that the first-trial effect is not specific to children's use of symbols, and hence is unlikely to be a major contributor to their poor performance on the symbol-based retrievals.

Self-correction

The second differential prediction concerned the frequency of self-correction. According to the inhibitory-deficit alternative, but not the knowledge-deficit view, children should spontaneously correct many of their errors. The results clearly support the latter view. Overall, the children spontaneously corrected themselves after only 8% of their errors in the symbol-based retrievals. In contrast, on the memory-based retrievals, children made relatively few errors, and spontaneously corrected their errors 43% of the time.

The results of Study 1 thus suggest that limited inhibitory control contributes very little to $2^1/_2$-year-olds' poor performance in the model task. Correct performance on the initial trial of the symbol-based retrievals was low, despite the lack of demands on inhibitory control, and spontaneous correction of errors was rare across all trials. However, given the general importance of inhibitory control in early cognitive development, we considered it desirable to have a direct experimental test.

Study 2

We modified the model task to reduce the need for inhibitory control. At the end of each retrieval trial in the room, the just-searched hiding location was altered to make clear that it was no longer a viable hiding place. For example, after the child had searched in the basket, either spontaneously or after prompting, it was turned on its side to reveal its empty interior. If young children do possess insight into the symbolic relation but have difficulty ignoring their memory representation of the previous hiding place, then making it clear that the previous location is no longer relevant should help them use their symbol-based representation of the current hiding place. However, if our analysis in Study 1 is correct, performance in Study 2 should be no better than that in Study 1.

Method

Participants

Eight $2^1/_2$-year-olds participated ($M = 30.1$ months, range = 29–32), with equal numbers of males and females. Two additional children were eliminated, one due to inattentiveness and one for refusing to continue past the second trial.

Procedure

The only modification to the standard model procedure was to alter each hiding location at the end of the trial in which it was used and leave it that way for the remainder of the session. For consistency, the same procedure was followed with the model furniture after the memory retrieval. The following changes were made to each hiding location in turn: the curtain was pulled back to show nothing behind it, the basket was turned over to reveal its empty interior, the tablecloth on the table was pulled up to show nothing beneath, the pillow was turned over and pulled away from the corner of the couch, the screen was laid flat on the floor, and the cloth on the chair was pulled up. For half the children the order of hiding locations was reversed.

In every trial, an assistant recorded the location to which the child first looked after entering the room. Because the hiding locations alternated between sides of

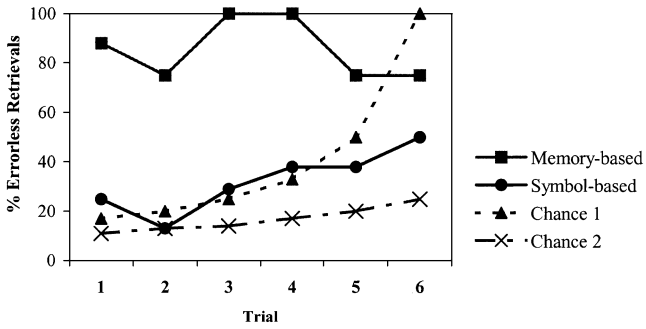

Figure 2 *Performance in Study 2 across trials. Two estimates of chance were calculated. The first was based on the number of hiding locations used in the test (6), the second on the number of hiding places judged viable by two adults (9). By neither estimate was children's performance better than chance, either overall or on any individual trial.*

the room, these first looks were usually unambiguous. In cases where children looked first to a parent or experimenter, the first look to an item of furniture was scored.

Results and discussion

Figure 2 shows the percent correct performance on the symbol-based and memory-based retrievals, plotted against the increasing probability of finding the toy by chance over trials as the number of potential hiding places decreased.[5] The children correctly retrieved the toy on only 31% of the symbol-based retrievals (M = 1.9), a rate similar to the 15–25% correct usually found in the standard model task. Only one child succeeded on 5 of the 6 trials. Two of the other children were correct on 3 trials, 2 were correct on 2 trials, and 3 never succeeded. Performance on Trial 1 was only 25% correct, very similar to the 29% figure from Study 1. Performance dipped in Trial 2, to 13%, but then increased over trials as the chance level increased. In contrast, performance on the memory-based retrievals was very good (85%) and comparable to the usual performance on this type of retrieval (75–85%).

Our efforts to make clear that the previous hiding place was not the current location of the toy did reduce the level of perseverative searching to only 25% (versus 48% in Study 1). The reduction in perseverative search did not, however, result in a corresponding increase in correct performance on the symbol-based retrievals. Perseverative search errors in this study consisted of, for example, the child picking up and examining a visibly empty wastebasket or looking under the table even though the pulled-back cloth showed nothing under it. Clearly, reducing the need for inhibitory control did not improve performance on the symbolic retrievals.

Although eliminating previous locations as possible current locations for the toy did reduce perseverative searching, it could be that the children may have inhibited their representation of the previous location only after entering the room and seeing the visibly empty hiding place. That is, they may have entered the room with their representation of the previous location activated, but failed to search there only because they could see the toy was not present. To test this possibility, the children's first looks upon entering the room were examined. The overall proportion of first looks directed at the preceding location was 44%. The rate was initially very high (88% on Trial 2), but declined to only 13% by the last trial. This result suggests that the children came to recognize the irrelevance of the previous (and now visibly empty) hiding places and altered their approach accordingly. However, they still did not search based on the symbolically conveyed information. Thus, the experimental manipulation reduced both perseverative searching (relative to previous studies) and perseverative looking (over trials), but performance was not improved.

As in Study 1, self-corrections were rare on the symbol-based retrievals; the children spontaneously corrected only 6% (2 out of 33) of these search errors. On the memory-based retrievals, the rate of self-corrections (14%) was lower than expected based on Study 1, but there were only 7 errors altogether (1 of which was corrected).

The results of Study 2 thus agree with those of Study 1 in suggesting that difficulties with inhibitory control contribute minimally to $2^1/_2$-year-olds' poor performance in the standard model task. Although making it clear that the previous location was no longer the correct one did substantially reduce perseverative searching, it did not increase correct performance.

General discussion

The research reported here clarifies the nature of very young children's difficulty using symbolic artifacts, specifically their poor performance when asked to use a scale model as a source of information about a larger space. The results provided little support for the idea that difficulties in inhibitory control contribute to poor performance in children who nevertheless have some understanding of the symbolic relation. In Study 1, nearly three-quarters of the children failed to find the toy on their own in the first trial, when inhibitory demands were minimal. Only a very small minority showed the specific pattern of performance across trials (success

[5] The difficulty of calculating chance in the model task has already been noted (see Figure 2).

followed by perseveration) that would most strongly suggest that some level of symbolic understanding was being masked by an inhibitory deficit. Further, in Study 2 performance was still extremely poor when the demand for inhibitory control was removed. Even when the irrelevance of the previous location was made clear, so most children searched elsewhere, they still failed to search in the current location.

Our conclusion in no way denies that the children had a strong inclination to search perseveratively. It was by far the most common category of error, in keeping with previous reports of young children's performance in both symbolic retrieval tasks (e.g. DeLoache & Burns, 1994; O'Sullivan *et al.*, 2001; Sharon, 1999; Solomon, 1999) and standard location memory tasks (e.g. DeLoache & Brown, 1983; Horn & Myers, 1978; Loughlin & Daehler, 1973; Perlmutter *et al.*, 1981). Indeed, such responses occasionally occurred even when overall performance was high (i.e. in the memory-based retrievals). However, the results make clear that children's tendency for perseverative searching is not a major contributor to their poor performance in the symbol-based retrievals.

The results do suggest that there may be a small subset of $2^1/_2$-year-old children who achieve some initial, inchoate understanding of the model–room relation that they are unable to maintain throughout the set of retrieval trials. Their representation of the symbolic relation may be adequate to support successful retrieval on the first trial, when there is no competing information. On the second and subsequent trials, however, interference from previous trials may override a fragile symbol-based representation.

This possibility is consistent with previous research with the model task indicating that young children's representation of the symbolic relation is fragile and easily disrupted, even for 3-year-olds who are typically successful in the standard task. For example, when a 5-minute delay was introduced between watching the smaller toy being hidden and searching for the larger toy, performance was impaired (Uttal, Schreiber & DeLoache, 1995). Presumably, children had a representation of the model–room relation at the end of the hiding event (and follow-up studies support this conclusion), but they failed to maintain it over the long delay.

In the current studies, however, children who might possess a fragile level of insight into the model–room relation comprise at most only a small minority of the participants. The most common response pattern in Study 1 was total failure: nearly half of the children *never* exploited the hiding event in the model to find the toy in the room. Another third found the toy only once. In addition, spontaneous self-corrections were very rare in the symbolic retrievals. When children did not know where to find the toy on their first search, they rarely knew where to look for it on their second search.

The results of the research presented here thus indicate that the typically poor performance of $2^1/_2$-year-olds in the model task is best explained as the result of a deficit in symbolic understanding. The primary reason these children rarely find the toy on symbolic retrieval trials is that they fail to appreciate the relation between the model and room. More generally, the results of the current studies testify to the major difficulty that young children have appreciating the significance of symbolic artifacts.

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