

Symbolic Insight and Inhibitory Control: Two Problems Facing Young Children on Symbolic Retrieval Tasks

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Many recent studies have explored young children's ability to use information from physical representations of space to guide search within the real world. In one commonly used procedure, children are asked to find a hidden toy in a room after observing a smaller toy being hidden in the analogous location in a scale model of the room. Three-year-old children readily find the hidden toy, although children at 2.5 years often have difficulty with the task. This experiment examined the causes of 2.5-year-olds' difficulty with this symbol system by incorporating testing procedures previously used with chimpanzees. Results indicate that young children's poor performance primarily stems from a difficulty achieving symbolic insight (i.e., recognizing the model–room representational relationship) but is also strongly affected by deficits in inhibitory control.

To navigate effectively within the environment, humans have created symbols to aid our memory of our surroundings and convey spatial information to others. For example, maps and scale models contain landmarks, and their spatial relations to each other, that are analogous to real space. Consequently, to understand and use a physical representation of space, one has to first recognize its representational relation to the real world. When and how children come to recognize this correspondence has been the focus of much research over the last 15 years (e.g., Blades & Cooke, 1994; DeLoache, 1987, 1991; Huttenlocher, Newcombe, & Vasilyeva, 1999; Liben & Downs, 1989).

In her innovative research program exploring children's ability to understand the representational nature of a scale model, DeLoache and her colleagues found

that 3-year-olds can locate a full-size item hidden in a room after witnessing a miniature item being hidden in a scale model of the room. In contrast, 2.5-year-old children perform poorly on the task (e.g., DeLoache, 1987, 1991; DeLoache, Kolstad, & Anderson, 1991), indicating that this age group has difficulty recognizing and utilizing the correspondence between the model and room.

However, there *are* situations in which 2.5-year-olds have been successful in scale model search tasks. When the model–room correspondence is made more perceptually obvious by increasing the size similarity (DeLoache et al., 1991), 2.5-year-olds reliably find the hidden toy. Young children are also able to solve the task when the importance of the symbol as a source of information is defined through prior experience with another representation such as photographs (DeLoache, 1991) or a similar-scale “model” (Marzolf & DeLoache, 1994). Additionally, if children are led to believe that the model and room are one in the same (i.e., a “shrinking machine” has transformed the room into the model) they will successfully find the hidden toy (DeLoache, Miller, & Rosengren, 1997). These studies have been cited as evidence that 2.5-year-olds’ difficulty in the original, standard model task stems from a failure to achieve “representational insight,” or the failure to understand the model–room symbolic relation (e.g., DeLoache, 1995). Search success is only observed when the model–room correspondence is made more obvious or when the recognition of the relation is not required at all (i.e., when the room has “shrunk”).

Recent research also explored the possibility that difficulty with the task is due to something other than a failure of representational insight. For example, O’Sullivan, Mitchell, and Daehler (2001) and Sharon and DeLoache (2003) have discussed the role of inhibitory control deficits, as manifested by perseveration (i.e., searching in the location where the toy object was found on the previous trial). Indeed, perseveration is commonly reported for 2.5-year-olds on this task; Sharon and DeLoache’s (2003) analysis of 13 scale model studies reports that perseverative searching occurred on 47% of the noninitial trials. O’Sullivan et al. (2001) and Sharon and DeLoache (2003) further examined the role of inhibitory control by testing young children in situations in which the opportunity to perseverate was reduced, by either altering the previous spot so as to make it an unlikely hiding location (i.e., turning a container on its side to reveal its empty interior; Sharon & DeLoache, 2003) or removing the previously used hiding spot altogether (O’Sullivan et al., 2001). If inhibitory control played a strong causal role in performance, children should have exhibited more successful searches in these conditions. Yet in both cases, although the level of perseverative searching decreased, overall performance did not improve. The authors concluded that in the standard task, perseverative responding is not causing the poor performance by masking an underlying ability to use the scale model—poor performance is more likely a consequence of a difficulty with representational insight.

REASSESSING THE ROLE OF INHIBITORY CONTROL
AND PERSEVERATION

Given numerous studies by DeLoache and colleagues, it does seem unlikely that 2.5-year-olds actually have an underlying ability to solve the standard scale model task. All evidence thus far suggests that young children have a difficulty recognizing that the model is representationally related to the real room. However, there are still reasons to believe that difficulty with inhibition is also an important factor underlying poor task performance.

First, although the studies detailed previously (O'Sullivan et al., 2001; Sharon & DeLoache, 2003) reported that performance remains low even when the opportunity for active, perseverative *responses* is not available, there is still reason to believe that deficits in inhibitory control are a factor in task performance. Deficits in inhibitory control can manifest themselves in two manners: inflexibility at the response level (difficulty inhibiting the motor act of searching the previous location) and inflexibility at the representational level (difficulty inhibiting the memory or representation of the previous location, leading to searching at that location). (e.g., Jacques, Zelazo, Kirkham, & Semscesen, 1999; O'Sullivan et al., 2001; Sharon & DeLoache, 2003; Zelazo & Frye, 1998; Zelazo, Reznick, & Pinon, 1995.) It is possible that the task manipulations did not actually affect this latter form of inhibition. Both studies report that children often perseveratively *looked* at the previously used location on first entering the room. Indeed, Sharon and DeLoache report that first looks directed at the previous site occurred on 44% of trials, a proportion similar to the 47% of active perseverative searches reported for the standard task. It is possible, then, that children did not inhibit the memory of the previous location, leading them to orient to the previous site, only to learn that it was either unavailable for searching or unable to hide the toy. Thus, these studies, though suggestive, have not definitely ruled out inhibitory control as a factor in overall performance (O'Sullivan et al., 2001).

Further evidence stems from the fact that in the scale model task, performance tends to be best during the first test trial, although not always significantly different from subsequent trials (Melzer & Daehler, 2003; Sharon & DeLoache, 2003). On the first trial, when the opportunity to persevere is not available (because no previous hiding sites have been experienced prior to Trial 1), some children may be more likely to respond based on information from the model. In later trials, inhibitory control is required and performance drops. A recent examination of 2-year-olds' difficulties with a search task employing photographs as a symbol system adds further support to this hypothesis. Suddendorf (2003) found high first trial performance and when children were tested in different rooms on every trial—arguably decreasing inhibitory demands—performance across all trials increased.

THIS EXPERIMENT

Thus, it is possible that inhibitory control may play an important role in the poor performance of 2.5-year-olds on the scale model search task. However, this does not mean that difficulty with representational insight is not *also* a factor. To accurately characterize the difficulties young children face when confronted with a physical symbol of space, this experiment systematically manipulated both of these potential factors through a series of five experimental conditions.

Two conditions (“standard”) tested 3- and 2.5-year-old children under the original procedures of the DeLoache scale model task (e.g., DeLoache, 1987) as a means of comparison with subsequent manipulations. The other three conditions tested 2.5-year-olds under modified task procedures that either encouraged representational insight, encouraged inhibitory control (i.e., discouraged perseverative responding), or simultaneously did both. To encourage representational insight, a “Point Model” procedure was used in which the experimenter indicated the hiding location within the model by pointing instead of hiding a miniature toy (DeLoache, 1991). This manipulation removes an additional mapping (small toy to big toy) that is extraneous to the understanding of the model–room relation. Indeed, children’s performance on tasks involving physical representations of space appears to be affected by the number and nature of the relational mappings required (Marzolf & DeLoache, 1997). Additionally, there is reason to believe that the pointing gesture illuminates the communicative intent of the experimenter. For example, Tomasello and colleagues found that children are more likely to use a pointing gesture as a cue indicating a hiding site than a replica of the hiding site (Tomasello, Call, & Gluckman, 1997). In turn, recent evidence suggests that “boosting” the experimenter’s communicative intent aids in representational insight during scale model tasks (Sharon, 2003).

To discourage perseverative searching, a “Contingency” procedure similar to one employed with chimpanzees (Kuhlmeier & Boysen, 2001) was used. Studies with chimpanzees have shown that some subjects are prone to using an alternative search strategy on the scale model task (Kuhlmeier & Boysen, 2001; Kuhlmeier, Boysen, & Mukobi, 1999). After witnessing the hiding event in the model, these chimpanzees simply searched the full-size space in a clockwise manner until ultimately finding the hidden item (a bottle of juice). Thus, overall performance was low and the chimpanzees gave no indication of the ability to recognize the model as a source of information as to the location of the juice bottle. When a cost was imposed on using this rigid search pattern (i.e., a juice reward was only obtained if a hidden object was found on the first search choice), performance very quickly improved, indicating that using the model was not beyond their cognitive ability.

For this experiment, a similar cost on incorrect searching was in place such that children received a reward if, and only if, they retrieved the hidden toy at the first location they searched. In the study of attention deficit-hyperactivity disorder (ADHD), it has been demonstrated that contingencies (rewards and response

costs) are effective in situations that demand inhibition and heightened vigilance (e.g., Barkely, 1989; Carlson & Tamm, 2000; Douglas, 1980, 1985). Thus, given the previous chimpanzee studies, and the ADHD literature, it seemed likely that the contingency procedure would encourage attention to the task and inhibition of the representation of the previous hiding site.

A fourth condition combined the “point model” and “contingency” procedures to examine performance under a condition in which representational insight was encouraged *and* perseverative responding was discouraged. If inhibitory control is a factor in the scale model task, certain performance patterns are predicted. For all conditions, performance would be high in the first trial when inhibitory demands are negligible, and performance would drop on subsequent trials when inhibitory control is required (Sharon & DeLoache, 2003). Perseverative searching would be observed on noninitial trials and, thus, overall correct performance across trials would be low. Additionally, if inhibitory control is the *sole* factor impeding performance, performance would improve for all trials under conditions in which the contingency is in place.

However, if a difficulty in achieving representational insight with the scale model is the sole factor impeding correct performance, a different pattern is predicted. Successful performance would be observed only under conditions in which insight is encouraged (point model condition) and this performance would remain consistent across trials. There is also the possibility that *both* factors play a role in young children’s poor performance. If this is the case, conditions that only manipulate one of these two factors would not result in consistently correct performance. That is, children tested under a condition that only encourages representational insight would be predicted to show high first trial performance, but low performance on subsequent trials when inhibitory demands are greater, and children tested under a condition that only discourages perseverative searching would not perform well on any trials. Consistently high performance would only be observed during a condition in which representational insight is encouraged and perseverative searching is discouraged.

METHOD

Participants

Twenty 3-year-old children (35–38 months, $M = 37$ months; 8 girls and 12 boys) and 80 2.5-year-old children (30–32 months, $M = 31$ months; 40 girls and 40 boys) participated. There were five between-subjects conditions and 20 children participated in each (the 3-year-olds were only tested in the standard condition).¹ Six ad-

¹ Although the conditions were not completed at the same time, one experimenter tested all children, the children were all recruited in the same manner, and the same room and model were used for all conditions. Thus, comparisons across conditions were deemed appropriate.

ditional 2.5-year-olds were not included in the study: 5 for refusing to participate and 1 for refusing to continue past the second trial. One additional 3-year-old was eliminated due to sibling interference.

Stimuli and Apparatus

Two adjoining rooms were used for all conditions. The larger of the two rooms (5.10 m × 3.00 m) was furnished like a living room, containing a red couch, a brown bookshelf, a large, green chair, and a small table covered with a blue tablecloth. The room also had a permanent, large pillar near one wall.

A scale model, one-seventh the size of the room (73 cm × 43 cm), sat on a table in the adjacent room, aligned in the same spatial orientation of larger room. The model was constructed of foam-core and was open on the front and top sides. The model was furnished with 1:7 size replicas of the four furnishings (and pillar) in the large room (Figure 1). These replicas were perceptually very similar to their

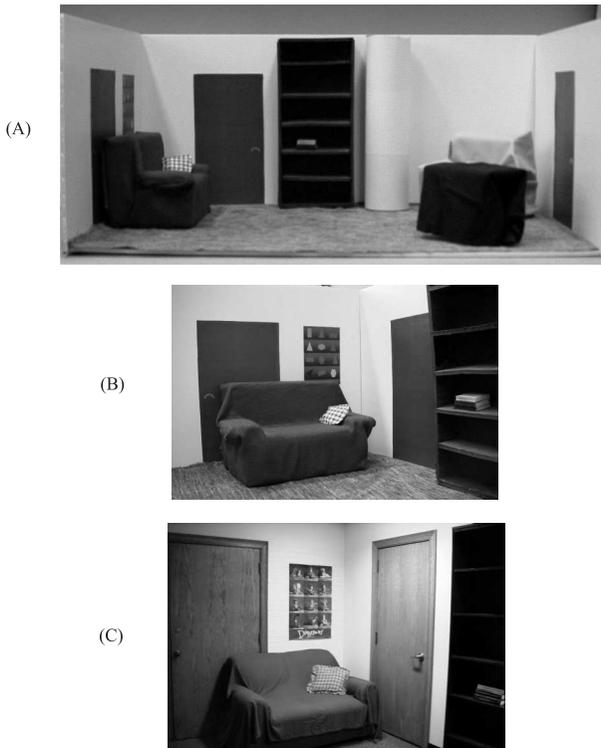


FIGURE 1 (A) Scale model used for all experiments. (B) Section of scale model. (C) Section of full size room.

full-sized counterparts. A *Sesame Street*TM “Elmo[©]” doll, and under some conditions, a smaller size (roughly 1:7) replica, were used as hiding items.

Procedure

The procedures for each condition are described next. Because the standard condition procedures for the 3-year-old and 2.5-year-old participants were identical, their descriptions will be combined.

Standard condition (3- and 2.5-year-olds). Procedures closely followed those of DeLoache’s original model–room task (DeLoache, 1987, 1991). Each child was given an extensive orientation phase. The child was first introduced to a toy named “Big Elmo[©]” and was told that the large room belonged to the toy. A smaller version of the toy, “Little Elmo[©],” was then introduced and the child was told that the model belonged to this toy. The experimenter then explicitly demonstrated the similarity between the model and the room by bringing each miniature item of furniture into the room and holding it next to the analogous full-size item while describing the correspondence. The last part of the orientation consisted of an imitation trial. While the child watched, the experimenter placed the miniature toy in front of the miniature pillar in the model. She then said to the child, “Now Big Elmo[©] wants to go into the big room and sit right here in the same place. Can you put him there?” If children were unsuccessful, the experimenter helped them to place the large toy in front of the full-size pillar. The pillar was not used as a hiding site in subsequent test trials.

Test trials began with the child observing the experimenter place the miniature toy in the model in one of four hiding sites (under the table, behind the chair, behind books on the bookshelf, or under a pillow on the couch). The experimenter called the child’s attention to the hiding event but never named the location: “Look, Little Elmo[©] is going to hide right here.” The child was then told that the larger toy, “Big Elmo[©],” was going to go hide “in the same place in the big room.” The experimenter then entered the large room and hid the toy while the child remained in the smaller room, near the model. On returning, the experimenter asked the child to find the larger toy (Retrieval 1). On every trial before the child began the search, the experimenter reminded the child that “Big Elmo[©] is hiding in the same place as Little Elmo[©].” If the toy was not found on the first search attempt, the reminder was repeated and the child was asked to continue searching. If the toy was not found after this attempt, the child was further encouraged to continue searching, and, if necessary, increasingly explicit hints were given until the child found the toy. Thus, the child’s last response on every trial was to the correct location.²

² In other experiments using this search task, a subset of children witness the hiding event in the full-size room and are asked to search in the model for the hidden miniature toy (e.g., DeLoache, 1987; DeLoache et al., 1991; O’Sullivan, et al. 2001). Results have not been found to differ between these two hiding orders and thus all trials in these experiments were conducted by completing the hiding event in the model.

The purpose of these conditions was to replicate the findings of DeLoache and colleagues (e.g., 1987, 1991) with these materials and testing room and to attain performance measures to compare to subsequent manipulations. Given the previous findings, it was predicted that 3-year-olds, but not 2.5-year-olds, would show reliable performance across trials.

Point model condition (2.5-year-olds). This condition used a “point model” procedure as a means of exploring the effects of simplifying the representational demands of the search task. This procedure was previously tested with 2.5-year-olds by DeLoache (1991) and no effects were found; however, only eight children were tested and no error or Trial 1 data were given. This study re-examines this condition by testing 20 participants and including additional data analyses.

The procedure was similar to that of the standard condition, except that only the larger toy doll was used. Each child was first given the orientation phase but no imitation trial was completed. During the four test trials, to show the child where the toy was hidden in the room, the experimenter pointed to the correct hiding location in the model and explained that the toy was hidden “in the same place.”

Success under this condition—one that encourages representational insight—would indicate that 2.5-year-old children’s difficulty under the standard condition stems from a difficulty recognizing the symbolic relation between the model and the room.

Contingency condition (2.5-year-olds). The contingency condition was identical to the standard condition in that the experimenter indicated the hiding site by hiding the small toy in the model. However, to keep procedures similar to the point model condition, no imitation trial was completed during orientation. In addition, before each trial, the child was told the following: “If you find Elmo© at the very first place you look, you will get a sticker.” After trials in which Elmo© was found on the first search attempt, the child was given a small sticker, which was placed on a “sticker sheet” kept near the model. At the completion of all four trials, children received stickers regardless of performance.

Success under this condition, which discourages perseverative responding, would indicate that children are deterred by the inhibition demands inherent in the standard condition and, thus, are unable to demonstrate an underlying representational insight.

Contingency + point model condition (2.5-year-olds). This condition was similar to the contingency condition but no small Elmo© doll was used for hiding in the model. Instead, the “point model” procedure was used: to show the child where the toy was hidden in the room, the experimenter pointed to the correct hiding location in the model and explained that the toy was hidden “in the same place.” If both a difficulty with representational insight *and* a difficulty with inhib-

iting perseverative searches is the cause of young children's poor performance in the standard condition, children tested in this condition should search correctly across all test trials.

Scoring and Preliminary Data Analyses

For each condition, participants completed four randomly ordered trials, one at each of the four hiding sites. A correct trial was defined as finding the hidden toy at the first location searched. All other choices were scored as errors. *Perseverative errors* were defined as searching first at the location that was correct on the previous trial. Trials were videotaped and coded by the experimenter. For interobserver reliability measures, a second experimenter, naïve to the experimental condition, coded the videotape for 25% of the participants (for a total of 25 children). The two experimenters agreed strongly; all but one trial was coded identically. In this and all succeeding experiments reported, preliminary analyses indicated that gender had no significant effect on task performance and, thus, all analyses collapse data across these two groups.

RESULTS

For each condition, four major analyses were completed and are described in detail in the following. Data were analyzed for the first trial alone, using as a dependent measure the number of participants who searched correctly (Figure 2a). Mean percentage of correct performance across all four trials was also examined (Figure 2b), including analyses of performance change over trials (Table 1). Descriptive statistics for the percentage of perseveration during all noninitial trials, as well as among error trials, are also presented (Table 2).

Standard condition (3- and 2.5-year-olds)

Performance replicated that of DeLoache and colleagues (e.g., 1987; 1991). Three-year-old children performed above chance³ on the first test trial (17 out of 20 children, binomial test, $p < .001$) and analysis across all four trials indicated above chance performance, $t(19) = 5.09$, $p < .001$. The 2.5-year-olds, however, did not perform above chance on either the first trial or across all trials. The percentage of perseverative searches is consistent with these results: the 2.5-year-old children perseverated on almost half of the noninitial trials, although the 3-year-olds only

³ Chance level was set conservatively at 25%, due to the four hiding sites used. There are undoubtedly more than four possible hiding locations in the room, but because these are difficult to accurately quantify, the conservative approach was taken.

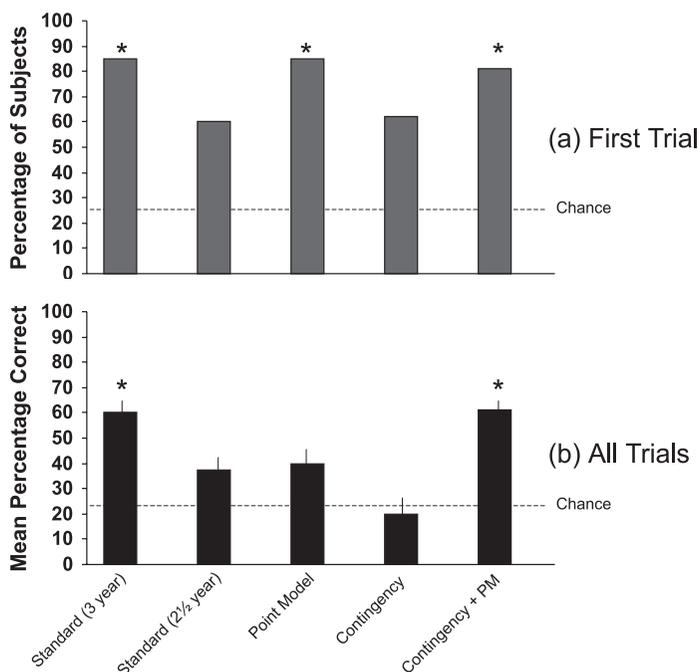


FIGURE 2 Performance for all conditions, first trial (Percentage of Subjects) and across all four trials (Mean Percentage Correct, with standard error bars). Asterisks denote statistically significant results at the $p < .05$ level. “Conting + PM” = Contingency + Point Model Condition.

TABLE 1
Number of Participants Searching Correctly Across Trials

<i>Condition</i>	<i>Trial 1</i>	<i>Trial 2</i>	<i>Trial 3</i>	<i>Trial 4</i>
Standard (3-year)	17	9	12	10
Standard (2.5-year)	12	5	6	6
Point Model (2.5-year)	17	3	4	8
Contingency (2.5-year)	13	1	1	1
Contingency + Point Model (2.5-year)	16	9	11	12

TABLE 2
Mean Percentage of Perseverative Searches on all Non-Initial Trials and on Errors Within Non-Initial Trials (+ SE)

<i>Condition</i>	<i>Non-Initial Trials</i>	<i>Errors on Non-Initial Trials</i>
Standard (3-year)	28.3 (5.6)	61.1 (8.4)
Standard (2.5-year)	48.3 (7.5)	66.7 (7.5)
Point Model (2.5-year)	46.7 (7.0)	69.4 (8.0)
Contingency (2.5-year)	58.3 (4.8)	64.1 (5.2)
Contingency + Point Model (2.5-year)	29.2 (5.6)	69.7 (11.2)

perseverated on a quarter of trials. For both age groups, however, over 60% of errors were due to perseveration. Both age groups also performed significantly better on the first trial than on the second (McNemar test using binomial distribution: 3-year-olds, $p = .008$; 2.5-year-olds, $p = .016$), followed by no other significant increases or decreases between adjacent trials.

Point Model Condition

Under this condition, 2.5-year-old children performed above chance on the first trial (17 out of 20 children, binomial test, $p < .001$), indicating representational insight. However, similar to 2.5-year-olds in the Standard condition, performance across trials was not statistically different from chance, with children engaging in perseverative searching on almost half the noninitial trials. Additionally, over two thirds of errors were due to perseveration. Children again performed significantly better on the first trial than on the second (McNemar test: $p < .001$), followed by no other significant increases or decreases between adjacent trials.

Contingency Condition

Performance on this condition was similar to the standard condition. The performance on the first trial was not significantly above chance and across trials performance was similarly low. Children perseverated on almost 60% of the noninitial trials and the majority of errors were due to perseveration. First trial performance, though not significantly above chance itself, was significantly different from the second trial (McNemar test: $p < .001$) but there were no other significant increases or decreases between adjacent trials.

Contingency + Point Model Condition

Under this condition, 2.5-year-olds performed above chance on the first trial (16 out of 20 children, binomial test, $p < .001$) and analysis across all four trials indicated above chance performance, $t(19) = 5.09$, $p < .001$. The percentage of perseverative searches is consistent with these results: Children perseverated on only 29.2% of noninitial trials. Of the error trials, however, over 60% were due to perseveration. Children performed significantly better on the first trial than on the second (McNemar test, $p = .039$) but there were no other significant increases or decreases between adjacent trials.

Analyses Across Conditions

A Kruskal–Wallis test (an omnibus nonparametric test for differences among independent samples) compared the five conditions in terms of first trial performance.

There was no significant difference among the groups, likely due to the fact that, though neither was significantly above chance, performance was high on the first trial in the standard (2.5-year-old) and contingency conditions. A one-way analysis of variance revealed a significant difference among the five conditions for performance across all trials, $F(4, 95) = 6.63$; $p < .001$. Post hoc analyses (LSD test) revealed that the contingency + point model condition differed from the 2.5-year-old standard condition ($p = .032$), the point model condition ($p = .03$), and the contingency condition ($p = .000$), but did not differ from the 3-year-old standard condition ($p = .816$).

DISCUSSION

The experiment reported here details the problems young children face when asked to use a scale model as a source of information for navigation in the real world. It was only under a condition in which representational insight was encouraged and perseverative searching was simultaneously discouraged (contingency + point model condition) that 2.5-year-olds reliably found the hidden toy. Conditions that only manipulated one of these factors did not lead to consistently correct performance. When representational insight was encouraged without discouraging perseveration (point model condition), children were able to find the hidden toy—but only for the first trial. On subsequent trials, children searched perseveratively, effectively masking an underlying ability to use the model and highlighting the importance of inhibitory control as a factor in performance. Conversely, when perseverative searching was discouraged but no manipulation to encourage representational insight was implemented (contingency condition), performance was low on the first trial and across all trials. It seems that perseverative searching could not be discouraged without first giving the children a means to solve the task by using the model. Taken together, these results suggest that 2.5-year-olds' difficulty in using a scale model as a source of information in a search task can be characterized as a problem achieving symbolic insight *and* a difficulty inhibiting perseverative responding.

The first of these, achieving symbolic insight, has been suggested by DeLoache and colleagues (e.g., 1991, 1995) to be a primary factor influencing performance on the scale model task and these results support this argument. When symbolic insight was encouraged, performance improved (e.g., in the first trials of the point model condition and in all trials of the contingency + point model condition). Yet these results also enrich this argument by demonstrating that symbolic insight regarding the model task can be brought about by making the communicative intent of the experimenter more obvious (see Sharon, 2003, for another demonstration). As has been argued elsewhere (e.g., Tomasello et al., 1997), the pointing gesture is a communicative signal that the children already knew on entering the task and,

compared to the standard use of a small replica of the hidden toy, has fewer dual representation and mapping demands (e.g., in the standard task, Little Elmo© is a toy *and* marker for Big Elmo©'s location). It is likely, then, that the children were more prepared to interpret this signal as a communicative act and, thus, recognized that the model was being used to convey information regarding the hiding location of the toy.

But why would children who have achieved symbolic insight still perseverate (e.g., point model condition)? In other words, what is the nature of the deficit in inhibitory control? The procedure for the contingency condition was originally developed as a means of discouraging the perseverative searching of chimpanzees on a scale model task (Kuhlmeier & Boysen, 2001). This is not to say that the causes of this alternative form of searching are the same for child and chimpanzee. The behavior of the chimpanzees has been described as a *search strategy*. Chimpanzees used a strategy of searching their enclosure in a ritualized, clockwise manner until finding the hidden item, a bottle of juice. When this behavior was discouraged via a contingency procedure, chimpanzees quickly switched to a strategy that used information from the model. Such a voluntary strategy seems an unlikely description of young children's perseverative searching. For example, even when a cost was imposed on incorrect searching (contingency condition), children did not switch from perseverative searching to try another search method; instead, they continued to perseverate.

As suggested by O'Sullivan et al. (2001), the perseverative errors of young children are likely due to inflexibility in conceptualizing the present location of the toy given the knowledge of the previous location. That is, remembering the toy's prior location may have interfering effects such that new information from the model is discounted. This account of inhibition is likely more appropriate than one based on a lack of inhibition of motoric responses. The latter has been previously shown to not be a factor in scale model task performance (O'Sullivan et al., 2001; Sharon & DeLoache, 2003) and the actual motoric response required in the model task varies from trial to trial (e.g., moving a pillow, looking under a table; Sharon & DeLoache, 2003). The inhibitory account based on memory or representational inflexibility suggested here predicts that there may be other methods of reducing perseveration on the symbolic object-retrieval task. For example, because young children often have trouble remembering the locations of hidden objects in search tasks if their attention is diverted from the hiding sites for a period of time after the hiding event (e.g., DeLoache & Brown, 1983; Loughlin & Daehler, 1973), a time delay between trials in the scale model task may sufficiently decay the memory of the toy's previous location so as not to affect future searches.

Yet, another question remains: Why would the children have so much difficulty with interfering representations? One possible answer is that scale models are particularly difficult symbol systems for young children. First, as three-dimensional

symbols, they have a “dual nature”—they are simultaneously a toy-like object and a symbol. The ability to represent both characteristics of the model may pose a particular challenge for children (DeLoache, 1987, 1991). Second, DeLoache and colleagues proposed that children have less experience with scale models in their daily lives as compared to other symbol systems (e.g., photographs, with which young children solve a similar search task; DeLoache, 1987, 1991) and this lack of experience may impede their ability to recognize the model–room relation (DeLoache, 1995; DeLoache et al., 1991). Thus, if representational insight is particularly difficult with this type of symbol system, young children in these tasks may only have a fragile understanding of the relationship. Such a nascent understanding may easily fall prey to interference from other sources, in particular, the uninhibited memory of the previous location. Indeed, even those children who demonstrated reliable performance in this study (3-year-olds in the standard condition, 2.5-year-olds in the contingency + point model condition) still showed a first trial effect and primarily perseverated when they erred. Thus, even when inhibitory control is encouraged, children will occasionally (though infrequently) fall prey to representational interference because of the overall difficulty of the task.

It is interesting to note that other task manipulations have resulted in improved and consistent performance for 2.5-year-olds, yet these conditions do not simultaneously discourage perseverative responding. For example, decreasing the size disparity between the model and the room (DeLoache et al., 1991) and giving prior experience with an easier model task can both lead to improved performance. It is possible that these conditions highlight the representational nature of the model to such an extent (and to a greater extent than the present point model condition) as to overcome interference from previous trials.

In sum, this study characterizes the poor performance repeatedly observed for 2.5-year-old children in scale model search tasks as an outcome of two factors. When developing representational insight with a symbol system such as a scale model, children are sensitive to the means in which the experimenter conveys symbolic, communicative intent. Furthermore, young children must inhibit competing information from previous search experiences that can discount information presently available from the model. More generally, these results demonstrate the challenge that symbolic artifacts pose for young children, and the need to consider the effects of inhibition deficits and experimental design when we test for symbolic understanding using multiple-trial search tasks.

ACKNOWLEDGMENT

The author wishes to thank Cindy DeCoste, Kristy vanMarle, Tanya Sharon, Karen Wynn, and Paul Bloom for valuable assistance and comments throughout

this project. The project was completed while the author was at Yale University and was funded by NIH F32-MH64269-01A1.

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