Forgetting and Symbolic Insight:
Delay Improves Children's Use of a Novel Symbol

Kelly J. Sheehan^{a,1}, Brock Ferguson^{a,2}, Camille Msall^a, and David H. Uttal^a

^aDepartment of Psychology, Northwestern University, 2290 Campus Drive, Evanston, IL 60208,
USA

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¹ Age of Learning, Inc., 101 N. Brand Ave, Glendale, CA 91203, USA

² Strong Analytics, 330 N. Wabash Ave, 23rd floor, Chicago, IL 60611, USA

Abstract

To use a symbol, children must understand that the symbol stands for something in the world. This development has often been investigated in the model-room task (DeLoache, 1987, 2000) in which children use a scale model to try to find a toy that is hidden in the room that the model represents. To succeed, children must acquire dual representation: they must put aside their understanding of the model as an object and focus more on what the model represents (Hartstein & Berthier, 2017). Here we suggest that forgetting irrelevant details or misleading information may be an important part of acquiring and maintaining dual representation. Based on prior research showing that forgetting can promote insight in children and adults (e.g., Sio & Ormerod, 2009; Vlach et al., 2014) and that a small sample of 3-year-olds could improve on the model-room task with a delay (Marzolf & DeLoache, 1994), we hypothesized that taking a break during the model-room task would facilitate forgetting and hence symbolic insight. Eighty-eight 3-year-olds performed 8 trials of the model-room task. Half of the children received a 24-hour delay after trial 4 and half performed the 8 trials consecutively. Children who received a 24-hour delay had better symbolic performance on the last 4 trials compared to children whose testing sessions occurred consecutively on one day, even when statistically controlling for the effects of learning over trials and memory on children's performance. This study provides strong initial evidence that a delay can promote symbolic insight in 3-year-old children.

Key words: testing delay, insight, dual representation, forgetting, symbolic understanding

The use of symbols is an important hallmark of human cognition (e.g., Deacon, 1997). Children make remarkable gains in becoming “symbol-minded” from infancy to 4-years of age, as they learn how a variety of symbols (e.g., language, pictures, video, maps) relate to their corresponding referents (DeLoache, 2004, p.66; Winkler-Rhoades, Carey, & Spelke, 2013). A critical aspect of the development of symbolic understanding is obtaining *dual representation* (DeLoache, 2000). On this view, all symbols have a dual nature: They are simultaneously objects in their own right and intended representations of something else.

A classic example of the importance of dual representation comes from DeLoache's *model-room task* (DeLoache, 1987). An experimenter hides a toy in a room and shows the child where to search by hiding a replica toy in the corresponding location in a scale-model of the room. Typically, 2.5-year-olds fail this task, but 3-year-olds succeed in using the model as a representation of the room. These results have been interpreted in terms of the ability to achieve dual representation (e.g., DeLoache, 1989; Troseth, Bloom Pickard, & DeLoache, 2007). For example, DeLoache (2000) increased children's attention to the model as an object by having them play with the model before they attempted to use it as a symbol, which led to significant decreases in performance. Conversely, *distancing* (Sigel, 1981) children from the model by placing it behind glass decreased children's attention to the model as an object and thereby increased their symbolic performance. When the need to obtain dual representation was eliminated by convincing children that the room “shrunk” and became the model, even 2.5-year-olds could succeed (DeLoache, Miller, & Rosengren, 1997).

We extend the concepts of dual representation and distancing by linking them to another line of research: Taking a break while solving a challenging problem can promote insight, leading to enhanced performance (e.g., Baird et al., 2012; Dodds, Ward, & Smith, 2003; Sio &

Ormerod, 2009; Sio & Ormerod, 2015; Smith & Blankenship, 1989; Wallas, 1926). For example, adults who were given a break of 5 or 15 minutes were better at solving a picture-word puzzle than adults who did not receive a break (Smith & Blankenship, 1989).

Several explanations have been advanced to account for these *incubation effects* (Wallas, 1926). One explanation is that giving problem-solvers a break gives them an opportunity to forget inaccurate solutions or approaches on which they were focused before the break (Kohn & Smith, 2009; Smith & Blankenship, 1989, 1991; Vul & Pashler, 2007). Smith and Blankenship found that when a misleading cue was presented with the picture-word puzzle, participants who did not remember the cue showed the greatest incubation effects.

Researchers have explored the effects of delay on problem solving from a developmental perspective. Vlach and colleagues suggest that delays and forgetting may play a critical role in children's learning and cognitive development (See Vlach, 2014). Vlach showed that spacing learning over time (and therefore giving children multiple breaks) facilitates preschool-aged children's learning of novel words (Vlach, Sandhofer, & Kornell, 2008). Additionally, spacing learning over days facilitates elementary school children's learning of science concepts (Gluckman, Vlach, & Sandhofer, 2014; Vlach & Sandhofer, 2012). Vlach and colleagues suggest that spacing learning allows time to forget variable features, like the superficial properties of the novel object or science lesson, while giving children multiple opportunities to learn unchanging features.

Here we integrate research on incubation effects with research on symbolic insight, as operationalized in the model-room task. We hypothesize that the forgetting that occurs during a delay may operate in part as a form of distancing. Children may forget during a delay potentially distracting information, such as the characteristics of the model or locations at which the toy was

hidden in the room on prior trials (e.g., Hartstein & Berthier, 2017). As is true in other problem-solving tasks, the forgetting that happens during a delay may also be instrumental to children gaining insight into the nature of a symbol.

There is anecdotal evidence to support this hypothesis. Marzolf and DeLoache (1994, Experiment 2), asked one group of 3-year-olds to perform a difficult version of the model-room task. They then returned on the subsequent day and performed the same task. Surprisingly, children performed significantly better on the second day ($M = 65\%$ correct searches) than on the first day ($M = 30\%$). No explanation was provided for this finding, however, we suggest that something about the 24-hour delay may have facilitated performance and therefore explore it more here.

We investigated whether a delay can promote children's symbolic insight. We gave 3-year-olds a delay between 2 sets of 4 trials of the model-room task as a conceptual replication of Marzolf and DeLoache, with children receiving a 24-hour delay between the two sets of trials. We also extend Marzolf and DeLoache by comparing children's performance to a condition that did not receive a delay. We hypothesized that children who were given a 24-hour delay would perform significantly better on the last 4 trials, after they experienced a delay, compared to children who did not experience a delay. If a delay does not improve performance, then there should be no difference between children's performance on the last 4 trials. Like Marzolf and DeLoache, we used a sufficiently challenging version of the task to allow for improvement; we made the model and room less similar than they are in the standard DeLoache model-room task (1987) in which 3-year-olds typically perform around 75% errorless retrievals. Here the room contained 8 pieces of furniture or decoration but the model only contained 4 of these pieces. We believed that the lack of complete perceptual similarity would lead to relatively low performance

and adequate room for improvement (e.g., Marzolf & DeLoache, 1994; Yuan, Uttal, & Gentner, 2017).

Method

Participants

Eighty-eight English-speaking 36-month-olds (46 female, $M_{\text{age}} = 35.83$ months, range = 35 to 37 months) were recruited from a database of families interested in participating in research studies. Children were generally from middle-to upper-middle-SES families. They were randomly assigned to the 24-hour delay condition or to the no delay condition. Two children were excluded, one due to fussiness and one due to parental interference.

Materials

Materials included a room and a scale model of that room. The room was approximately 4m x 3.6m x 2.2m. It was constructed from plastic (PVC) piping, and curtains were hung as walls. The scale model was approximately 1:10 in scale to the room and measured approximately 50cm x 50cm x 27cm. The model was constructed of the same materials.

The room contained 8 objects: 4 pieces of furniture, which were used as hiding locations, and 4 decorations, which were not used for hiding. The 4 pieces of furniture were a couch, chair, floor pillow, and pot. The 4 pieces of decoration were a painting, rug, wall clock, and hanging lanterns (See Figure 1a). The model included miniature version of the furniture but did not include the decorations (See Figure 1b). The search objects were a yellow plastic duck for the room and a small yellow duck made from clay for the model.

Figure 1. Pictures of the (a) room and corresponding objects and (b) model and corresponding miniature objects.

Procedure

All participants completed informed assent and their parents or guardians provided informed consent in accordance with the University's ethics committee. The procedure was a modified version of DeLoache's (1987) model-room experiment. All children performed 8 test trials. In the no delay condition, children performed all 8 test trials consecutively on one day. In the 24-hour delay condition, children performed 4 test trials then returned 24 hours later and performed the remaining 4 trials.

The experiment consisted of 3 phases: orientation, practice trial, and test trials. Children in the no delay condition completed these phases on the same day. Children in the 24-hour delay condition completed the orientation, practice trial, and 4 testing trials on Day 1. They then returned approximately 24 hours later and completed 4 more trials³.

Orientation. The experimenter introduced the child to the search objects, explaining that Little Ducky and Big Ducky liked to do the same things. The experimenter showed the child the large room and labeled the hiding locations. The child was then shown the model, which was placed 1 meter in front of Big Ducky's room. The experimenter explained that "Little Ducky's room is just like Big Ducky's room, it's just smaller." The experimenter labeled the miniature furniture and then brought them into the room to compare them. The experimenter held each furniture replica up to its corresponding larger version and highlighted the similarities (e.g., "Little Ducky's couch is just like Big Ducky's couch, it's just smaller"). The furniture items were then placed back in their corresponding locations in the model. The experimenter never mentioned the decorations.

³ Twenty-two children in the 24-hour delay condition were given the orientation again after the delay to model Marzolf & DeLoache (1994). There were no significant differences between the groups that received vs. did not receive the orientation after the delay ($F(42,1) = .02, p = .90$), so the groups were combined to increase power.

Practice trial. The child watched as the experimenter placed Little Ducky on his chair. Then the experimenter asked the child to put Big Ducky in the same place as Little Ducky but in his Big Room. If the child misplaced Big Ducky, the experimenter reminded the child that Big Ducky and Little Ducky like to do the same things. All children placed Big Ducky correctly on the chair within three attempts.

Test trials. Children completed 8 test trials. On each trial, the sequence was as follows: 1) child is shown the hiding location of the miniature toy in the model; 2) child searches for the larger toy in the room (*Retrieval 1*); and 3) child searches for the miniature toy in the model (*Retrieval 2*). Retrieval 1 was the symbolic search while retrieval 2 was a memory check, to ensure that the child remembered the location of the toy in the model (DeLoache, 1987). Throughout the 8 trials, the toy was hidden at each of the 4 hiding locations twice, but the toy was never hidden in the same location twice in a row. Children were assigned to 1 of 4 orders of hiding. Order of hiding was counterbalanced by sex and condition.

Retrieval 1. The child and second experimenter went outside the experimental room while the experimenter hid Big Ducky in one of the hiding locations (i.e., under the floor pillow, in the pot, under the couch pillow, or under the chair pillow). When the child returned, the experimenter ensured the child was looking and hid Little Ducky in his little room, saying “I’m going to hide Little Ducky here.” The experimenter then prompted the child, saying, “Remember, Little Ducky and Big Ducky like to do the same things, so Big Ducky is hiding in the same place as Little Ducky, but in his Big Room. Can you go find Big Ducky?” The child searched in the room. If the child searched in an incorrect location, the experimenter prompted the child to continue searching until they found Big Ducky.

Retrieval 2. The child returned to the model to find Little Ducky in its original location.

Again, the child was allowed to search until Little Ducky was found.

Results

We predicted that children in the 24-hour delay condition would perform better than the no delay condition on trials 4 through 8, which occurred after the delay for the 24-hour delay condition. We operationalized performance as the proportion of correct retrievals across the 8 trials (i.e., child's first search was at the correct location).

We analyzed the data using mixed-effects logistic regression models (Jaeger, 2008). We examined fixed effects of Memory (i.e., Retrieval 2), Trials (first 4 vs. last 4), and Delay (24-hour delay vs. no delay condition) while including random intercepts by subjects to account for individual differences. Specifically, we fitted a model predicting performance by Memory, Trials, and Delay, which revealed an effect of Memory ($B=.89$, $SE=.25$, $p < .001$) and an interaction between Trials and Delay ($B=.80$, $SE=.39$, $p < .05$). When children experienced a 24-hour delay between the first 4 and last 4 trials, their performance improved significantly more than children who did not experience a delay. Children who did not experience a delay performed an average of 57% correct retrievals on the first 4 trials and 60% correct retrievals on the last 4 trials. Children who experienced a delay performed an average of 56% correct retrievals on the first 4 trials and 73% correct retrievals on the last 4 trials (See Figure 2). There was no significant difference in children's performance on the first 4 trials, $t(86)=.23$, $p = .89$, $d = .05$. Interestingly, there was a trend in which children in both conditions searched more accurately on trial 1 ($M = 58\%$) than on trial 2 ($M = 47\%$), McNemar's $\chi^2(1) = 2.89$, $N = 88$, $p = .08$.

For retrieval 2, there was a significant interaction between delay and trials, with children in the 24-hour delay condition performing better after the delay ($M = 81\%$) than before ($M =$

71%), $F(1, 86) = 5.03, p = .03; \eta^2 = .05$). Children in the no delay group performed well on the first 4 ($M = 80\%$) and last 4 memory trials ($M = 76\%, p > .05$).

Figure 2. Performance of children in 24-hour delay and No delay condition across the 8 trials. Trials 5-8 occurred after a delay in the 24-hour delay condition. Dotted line indicates chance performance. Error bars in all graphs represent ± 1 standard error.

Discussion

The results strongly indicate that a delay can facilitate children's performance in the model-room task. Children who experienced a 24-hour delay performed better on the second set of trials than the no delay condition. The effect of delay remained significant after holding constant the effects of memory for the location of the toy in the model and performance across trials. Moreover, the results provide a replication of Marzolf and DeLoache's (1994) initial

observation that a delay can improve children's performance.

Forgetting and Symbolic Insight

Why did the delay facilitate children's performance? We hypothesized that giving children a delay could promote "distancing" or forgetting, akin to incubation effects found in other insight studies (e.g., Kohn & Smith, 2009; Smith & Blankenship, 1991; Vul & Pashler, 2007). Our results support the hypothesis that the delay promoted children's insight by promoting the forgetting of 1) information about where the toy had been hidden previously in the room, and/or 2) information about the model as an object in its own right.

Forgetting about where the toy had been hidden on previous trials. One explanation for our results is that children have some representation of the model-room relationship but struggle to maintain that representation over trials. There was a trend in which children were more likely to search incorrectly on trial 2 compared to trial 1. This second-trial dip has been observed in several studies (e.g., Hartstein & Berthier, 2017; Sharon & DeLoache, 2003) and indicates that initially many children could exploit the model-room relation. However, the performance dip on the second trial suggests their memory of the toy's location in the room may compete with their understanding of the location of the toy in the model, leading children to commit – and continue to commit – perseverative errors (Hartstein & Berthier, 2017; Suddendorf, 2003). A delay may have provided the opportunity to forget where they had seen the toy before, thus reducing competition from previous locations. This explanation is consistent with Hartstein and Berthier (2017), who found that children with high levels of working memory were able to overcome the second-trial dip and perform well. The delay in our study may have given children who initially did not overcome the second-trial dip a chance to forget where the toy was previously hidden, which helped them use the model as a symbol.

Forgetting about the salience of the model as an object. The delay may have helped children forget or become less dependent on their representation of the model as an object in its own right. Appreciating the model as both an interesting object and as a symbol is challenging for children (DeLoache, 2000). Our model may have been particularly interesting because of the added decorations compared to the classic model-room task. Anecdotally, a few children treated the model like a toy and tried to climb into the model to play with it. The delay may have provided temporal distancing that helped children's initial salient representation of the model as an interesting toy become less salient (e.g., Sigel, 1981). This explanation is consistent with previous research that indicates that taking a break works in part by allowing people to depend less on irrelevant details and focus more on relevant details (e.g., Smith & Blankenship, 1989; Vlach, Sandhofer, & Kornell, 2008). Here, a delay may have helped children become less dependent on irrelevant, albeit interesting, aspects of the model (like the miniature decorations) which helped children appreciate the overall relation between the model and the room.

Sleep and Symbolic Insight

Because children in the delay condition most likely slept in between testing sessions, memory consolidation that occurs during sleep could account for our results. Research shows that sleep is necessary for insight into certain types of problems for adults (Wagner, Gais, Haider, Verleger, & Born, 2004), enhances memory in infants (Kurdziel, Kent, & Spencer, 2018), and promotes executive functioning in preschool-aged children (Cremone, McDermott, & Spencer, 2017). Given this is the first research to link sleep with symbolic insight in children, it is important for future research to investigate whether memory consolidation during sleep is necessary to promote children's symbolic insight or whether a shorter break is sufficient, as has been shown in other studies (e.g., Vlach, Sandhofer, & Kornell, 2008). Giving children a short

break could be a powerful mechanism to help them gain insight into particularly difficult symbols.

Implications and Future Directions

The results have important implications for symbolic development. Notably, the results suggest that previous studies may have underestimated children's symbolic understanding; if a delay promotes insight, then perhaps children in previous studies would have succeeded in using a symbol if given a delay. While a delay may be a powerful means of promoting symbolic insight, a delay may have been particularly effective in this study because most children were on the cusp of grasping the symbolic nature of the model (i.e., performed well on trial 1). Future research can investigate whether a delay helps children exploit other symbol-referent relationships at slightly earlier ages than have been previously identified, when they might be at the verge of gaining symbolic insight.

There are limitations to this study. Participants were largely from affluent families and likely have different experiences with symbols, like television and books, compared to less affluent families, which can affect their symbolic performance (Troseth, Casey, Lawvery, Walker, & Cole, 2007). We also did not investigate the position of the delay. If a delay helps children forget where they last found the toy in the room, giving children a delay after the first trial may reduce perseverative errors and safeguard subsequent performance.

In conclusion, this paper integrates research on the development of symbolic insight and incubation effects in problem solving. It adds to the research showing that a delay, and the forgetting that occurs during a delay, can be critical to children's learning of important information. The results reveal that a delay can facilitate children's use of a symbol, adding evidence for the role of forgetting in a variety of cognitive tasks. For children who are on the

culmination of understanding a particular symbol, a delay may be enough to help them gain symbolic insight.

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