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When Delays Improve Memory: Stabilizing Memory in Children May Require Time

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Abstract

Memory is critical for learning, cognition and cognitive development. Recent work has suggested that preschool-aged children are vulnerable to catastrophic levels of memory interference, in which new learning dramatically attenuates memory for previously acquired knowledge. Work reported here investigates the effects of consolidation on children's memory by introducing a 48-hours-long delay between learning and testing. In Experiment 1, the delay improved children's memory and eliminated interference. Results of Experiment 2 suggest that this benefit of delays is limited to situations in which children are given enough information to form a complex memory structure. Results are discussed in relation to consolidation processes and memory development.

Memory is central to animal and human behavior as it enables organisms to deploy what was learned in the past in service of current and future goals. Memory is also related to new learning and these relations are often reciprocal: memory for past experiences affects current learning, and current learning affects past memories.

Although often these effects are facilitative (i.e., previous knowledge is useful or even necessary for acquiring new knowledge, Beier & Ackerman, 2005; Schlichting & Preston, 2014), there are many situations in which memory and learning interfere with each other. Sometimes memory for prior experience interferes with learning of new experiences (i.e., proactive interference). For example, after observing an object being repeatedly hidden in one location, infants may continue searching in this location even after watching an experimenter hide the object in a new location (Diamond, 1985).

Other times, new learning attenuates memory for past experiences (i.e., retroactive interference, or RI). Recent work has demonstrated severe RI in children, but not in adults (Darby & Sloutsky, 2015). Given that RI is a major cause of forgetting (Wixted, 2004), understanding reasons for such drastic RI in children and its decrease in development is important for understanding memory, and is the goal of the current research.

Why does RI Occur?

An extreme example of RI comes from the connectionist modeling literature. In some early connectionist networks memory for existing knowledge was quickly overwritten when new learning was introduced (McCloskey & Cohen, 1989; Ratcliff, 1990). This severe form of

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RI was called catastrophic interference (McCloskey & Cohen, 1989), as previously learned information was entirely forgotten. This result presented a challenge to the validity of some connectionist architectures, as RI effects are typically modest in human adults (French, 1999). In an attempt to address these challenges, an influential theory was proposed positing interactions between cortical and hippocampal memory systems (McClelland, McNaughton, & O'Reilly, 1995). These interactions explained relatively small RI effects in humans and led to reduced RI in computational models.

Although RI effects in human adults are typically modest, there is recent evidence that these effects may reach catastrophic levels in children (Darby & Sloutsky, 2015). Five-year-olds and adults were presented with a learning task, in which individual stimuli could not predict an outcome, but pairs of stimuli could. In Phase 1, participants learned AB $\rightarrow$ X (i.e., stimuli A and B were associated with outcome X) and CD $\rightarrow$ X. In Phase 2, they learned AC $\rightarrow$ Y and BD $\rightarrow$ Y. When presented in Phase 3 with the initial set of items presented in Phase 1, participants faced a conflict: A, B, C and D were equally likely to be associated with X and Y (see Figure 1A). Five-year-olds (but not adults) exhibited catastrophic-like interference in Phase 3, which pointed to important developmental differences in memory and interference effects.

In particular, catastrophic-like interference in Phase 3 suggests that children learned elementary associations (i.e., A $\rightarrow$ X and B $\rightarrow$ X in Phase 1, followed by A $\rightarrow$ Y and B $\rightarrow$ Y in Phase 2). In contrast, binding the items together and forming configural memories of object pairs (i.e., <A-B> $\rightarrow$ X and <C-D> $\rightarrow$ X in Phase 1, followed by <A-C> $\rightarrow$ Y and <B-D> $\rightarrow$ Y in Phase 2) should have resulted in little or no RI in Phase 3, as each pair uniquely predicted an outcome. Catastrophic interference could also be prevented by binding each item and a context, such as <A-Context $_1$> $\rightarrow$X and <A-Context $_2$> $\rightarrow$ Y. In general, binding individual elements into configural memory structures should reduce overlap between similar memories and as a result reduce vulnerability to interference compared to more simple structures (Darby & Sloutsky, 2015; Humphreys, Bain, & Pike, 1989; O'Reilly & Rudy, 2001; Yim, Dennis, & Sloutsky, 2013). The reported developmental differences in RI suggest that only adults, but not young children, encoded stimulus information configurally.

Why did 5-year-olds fail to form configural memory traces? One possibility is that 5-year-olds cannot do so in principle, perhaps due to immaturity of the hippocampus. There is evidence that 4-year-olds have difficulty binding information in memory (Lloyd, Doydum, & Newcombe, 2009; Sluzenski, Newcombe, & Kovacs, 2006). However, there is also evidence that 4.5 year-olds succeeded in a configural memory task when training was presented over multiple days (Rudy, Keith, & Georgen, 1993).

Therefore, another possibility is that young children fail to form configual memory traces online, but are capable of forming such traces with passage of time. There is much evidence suggesting that in a variety of hippocampus-dependent tasks, passage of time (or perhaps a combination of passage of time and sleep) results in memory consolidation and subsequently in improved task performance (Bauer, Larkina, & Doydum, 2012; Stickgold, 2005; Wilhelm, Prehn-Kristensen, & Born, 2012; Wixted, 2004). For example, after learning individual premises (e.g., A>B, B>C) of transitive inference problems (A>B>C>D>E), adults were less likely to solve inference-based problems (e.g., B ? D) when tested almost immediately than when tested after 12 or 24 hour delays (Ellenbogen, Hu, Payne, Titone, & Walker, 2007; Werchan & Gómez, 2013).

Therefore, it is possible that whereas both children and adults can form configural memories preventing catastrophic interference, only adults can form such memories online. If this is the case, then introducing a delay between training and testing may give children an opportunity to form configural memories (i.e., <A-B> $\rightarrow$ X) and, as a result, reduce interference effects. The reported research tested this counterintuitive possibility.

Experiment 1. Catastrophic Interference in Children and Consolidation over Time

Across two conditions, 5-year-olds learned sets of contingencies between pairs of objects and an outcome (i.e., a cartoon character). There were three learning phases, with Phases 1 and 3 presenting identical contingencies and Phase 2 presenting different contingencies. Some of these contingencies had the same elements that were recombined across phases (*overlapping pairs*), whereas other contingencies had elements that were not repeated across phases (*unique pairs*; see Figure 1A). In the No Delay condition (which was similar to Darby & Sloutsky, 2015), participants received a short 1 min break between the phases. In the Delay condition, there was a short 1 min break between Phases 1 and 2, but a 48-hours-long delay between Phases 2 and 3 (see Figure 1C). If a delay results in consolidation of a configural memory trace, we should replicate catastrophic levels of interference in the No Delay condition and observe attenuation of interference (and perhaps even memory improvement) in the Delay condition.

Method

Participants

Forty preschool-aged children (*M* = 5.2 years; *SD* = 0.3; range = 4.6-5.8; 22 females) participated in the No Delay condition and 42 children (*M* = 5.2 years; *SD* = 0.3; range = 4.5-5.8; 20 females) participated in the Delay condition. Children were recruited from day cares in the Columbus, Ohio area on the basis of signed consent forms, and received a small reward for participating.

Stimuli

Experimental stimuli consisted of illustrations of twelve everyday objects (such as a turtle, airplane, and baseball cap) as well as two characters familiar to children (Winnie the Pooh and Mickey Mouse). Stimuli were presented throughout the task on a light grey background (see Figure 1B), using OpenSesame software (Mathôt, Schreij, & Theeuwes, 2012).

Procedure

The task consisted of three phases, in which objects were presented to participants in pairs and were linked to a character. Phases 1 and 3 consisted of the same set of contingencies, whereas a different set was introduced in Phase 2. Each set contained four pairs of objects, two of which were associated with each character. There were two types of pairs—

overlapping and unique. Overlapping pairs were composed of four objects, which were recombined across sets. Unique pairs were composed of the other eight objects, which were different across the two sets (see Figure 1A). Assignment of objects to set and pair type was randomized for each participant.

Each phase included five blocks with eight trials per block, four overlapping and four unique, such that the entire task included 120 trials. On each trial, participants saw a pair of objects near the bottom of the screen, and the two characters, one on each top corner (see Figure 1B). Participants were instructed before the task began that each pair of objects belonged to one of the characters, and that their task was to predict which character the pair belonged to. Once the participant made a prediction, the objects disappeared from the bottom of the screen and, regardless of the participant's response, immediately reappeared by the correct character (the incorrect character disappeared from the screen after a choice was made in order to highlight the correct contingency). In addition to this visual feedback, auditory feedback was given in the form of a high or low tone for correct or incorrect responses, respectively. Children also received verbal feedback from the experimenter on every trial (e.g. "Great job, that pair does belong to Mickey!" or "Uh oh, that pair actually belongs to Pooh Bear"). Each pair of objects was seen twice per block, with spatial position of each object (top or bottom) counterbalanced within each block. The spatial position of the two characters (left or right) was consistent across the task but was randomized for each participant. All phases were completed in one session in the No Delay condition, whereas a 48-hour-long delay was introduced between Phases 2 and 3 in the Delay condition (see Figure 1C).

Results

Three children in the No Delay condition were excluded from the analysis due to experimenter error (n = 2) or requesting to terminate the task (n = 1). Twelve children in the Delay condition were excluded from the analysis as a result of school absence on the day of the second session (n = 7), experimenter error (n = 4), or requesting to terminate the task (n = 1). We also implemented learning criteria: participants were required to achieve an overall accuracy of 70% or better, as well as 60% accuracy or higher for both overlapping and unique pairs, averaged across blocks 2-5 of Phase 1. The reason for these criteria was to ensure learning in Phase 1— without such learning, it is more difficult to interpret changes in accuracy in Phases 2 and 3. As a result of the learning criteria we excluded 5 children from the Delay condition and 12 children from the No Delay condition. The final sample included 25 children in the No Delay condition (M = 5.2 years; SD = 0.3; range = 4.5 – 5.8; 15 females), and 25 children in the Delay condition (M = 5.2 years; SD = 0.3, range = 4.8 – 5.8 years; 11 females). This sample size was identical to that in the study reporting catastrophic-like RI in young children (Darby & Sloutsky, 2015).

We define RI as a drop in accuracy between the final block of Phase 1 and the first block of Phase 3 (cf., Darby & Sloutsky, 2015). If no interference or memory decay occurs, accuracy should be the same for these blocks as both contain the same set of contingencies. We also examine savings effects, which we define as an increase in accuracy in the first block of Phase 3 compared to the first block of Phase 1: if participants benefit from having learned the same information previously, accuracy should be higher in the beginning of Phase 3 than in the beginning of Phase 1. We compare accuracy for overlapping and unique pairs to control for fatigue, memory decay, and other task effects, and expect interference to be greater for overlapping pairs, since these pairs consist of the same objects recombined across phases, whereas objects in unique pairs are different across phases.

No Delay condition—Accuracy information for all blocks and phases is presented in Table 1. Figure 1D presents difference scores of the magnitudes of RI and savings, which were calculated using accuracy in specified blocks presented in Figure 2. To reiterate, RI was calculated by comparing the attenuation of accuracy between the last block of Phase 1 and the first of Phase 3 for overlapping and unique pairs. Results in Figure 2 (left panel) point to substantial RI, which was confirmed by a 2 (Phase: 1 vs. 3) by 2 (Pair type: Overlapping vs. Unique) repeated-measures ANOVA, which revealed a significant interaction, $F(1,24) = 13.04$, $p = .001$, = .35. Planned comparisons indicated that accuracy significantly decreased for overlapping pairs, $t(24) = 6.82$, $p < .001$, Cohen's $d = 1.39$, but not for unique pairs, $p = .46$.

To determine the extent of RI effects on children's memory we also measured savings effects by comparing accuracy in the first block of Phase 1 and the first block of Phase 3. Results presented in Figure 2 (left panel) point to savings for only unique, but not overlapping pairs: a 2 (Phase: 1 vs. 3) by 2 (Pair type: Overlapping vs. Unique) repeated-measures ANOVA revealed a significant interaction, $F(1,22) = 12.02$, $p = .002$, $\eta_p^2 = .33$, with savings transpiring for unique pairs, $t(24) = 5.82$, $p < .001$, $d = 1.19$, but not for overlapping pairs, $p = .56$. Substantial RI coupled with no savings for overlapping pairs point to catastrophic-like levels of RI, which replicates previous findings (Darby & Sloutsky, 2015).

Delay condition—As shown in Figure 2 (middle panel), in contrast to the No Delay condition, there was no RI after the 48-hour-long delay, with no Phase by Pair type interaction, $p = .20$. Also, as shown in the figure, there were substantial savings for both overlapping and unique pairs, with a significant main effect of Phase, $F(1,24) = 29.39$, $p < .001$, = .55, indicating significant savings for both unique pairs, $t(24) = 3.60$, $p = .001$, $d = 0.72$, and overlapping pairs, $t(24) = 4.24$, $p < .001$, $d = 0.85$. No other effects or interactions approached significance. This is a novel finding suggesting that a delay may reduce RI in children.

To directly compare RI effects in the Delay and No Delay conditions we performed a mixed ANOVA with Phase (1 vs. 3) and Pair type (Overlapping vs. Unique) as within-subject factors and condition (No Delay vs. Delay) as a between-subject factor. The three-way interaction was significant, $F(1,1,48) = 12.84$, $p = .001$, $\eta_p^2 = .21$, indicating that children in the Delay condition experienced significantly less RI than those in the No Delay condition.

We also compared children's performance in the Delay condition to adults' performance in Darby & Sloutsky (2015; Experiment 2), using a mixed ANOVA with Phase (1 vs. 3) and Pair type (overlapping vs. unique) as within-subject factors and age (children vs. adults) as a between-subject factor. Interestingly, the three-way interaction was significant, F(1, 57) = 6.11, p = .016, $\eta_p^2 = .10$, suggesting that children experienced less RI after a delay than adults did upon immediate testing. Although cross-experiment analyses must be treated with caution, this counter-intuitive finding points to an important role of consolidation in preserving memories.

Remarkably, when tested in Phase 3 after the delay, children exhibited better memory in the first block of Phase 3 ($M_{accuracy}$ = .84) than when tested immediately ($M_{accuracy}$ = .64), t(48) = 3.58, p = .001, d = 1.02. Therefore, a 48-hour delay resulted in substantially improved memory for overlapping information. This is another novel finding suggesting that, in the absence of any intervention between study and test, memory can *improve* over time (see Henderson, Devine, Weighall, & Gaskell, 2015, for findings of improved word learning following delays). This improvement of memory over time indicates that at the time of study, children encoded enough information to form a configural memory trace during the delay.

These results indicate that delaying testing for 48 hours both eliminated RI effects and improved memory for overlapping information in children. These remarkable findings point to a powerful role of consolidation on children's memory. We suspect that consolidation is able to eliminate interference by contributing to the formation of configural memory structures. Note that, in contrast to children, adults demonstrated small RI even when tested immediately (Darby & Sloutsky, 2015), which suggests that adults are able to form configural memories online.

Overall, Experiment 1 demonstrated that children's memory was improved and catastrophic-like RI effects eliminated following a 48-hour delay. We suggest that the delay facilitated consolidation of configural memory traces for overlapping elements. However, it is also possible that the passage of time affected performance in a non-specific way. For example, it is possible that delays facilitate configural traces for all memory traces, regardless of overlap. If this is the case, then including a delay prior to the introduction of overlapping material (i.e., Phase 2) should also eliminate interference and improve memory.

The goal of Experiment 2 was to address this possibility by introducing a 48-hour delay between Phases 1 and 2. In this case, no overlapping information was presented until after the delay. If the delay affected performance in a non-specific way, no RI and better memory than in the No Delay condition should again be observed. However, if observing stimulus overlap is necessary for forming a configural code and thus reducing interference, then RI should transpire in this condition.

Experiment 2: The Effect of Information Structure on Consolidation

Method

Participants

Forty preschool-aged children (M = 5.4 years; SD = 0.3; range = 4.8-6.0; 20 females) participated. As in Experiment 1, children were recruited from day cares in the Columbus, Ohio area on the basis of signed consent forms, and received a small reward for participating.

Stimuli and Procedure

The stimuli and procedure were identical to those of Experiment 1, except that in this experiment children performed Phase 1 in one session, and Phases 2 and 3 in a second session 48 hours later.

Results

Five children were excluded from the analysis after not completing the experiment due to a desire to stop the task (*n* = 2) or school absence on the day of the second session (*n* = 3). As in Experiment 1 we also excluded children who failed to meet a learning criterion of at least 60% accuracy for both overlapping and unique pair types and 70% accuracy overall, averaged across all but the initial block of Phase 1. Six children were excluded a result of this learning criterion. The final sample included 29 children (*M* = 5.4 years; *SD* = 0.3; range = 4.9 – 6.0; 19 females).

Results presented in Figure 2 (right panel) point to substantial RI, which was confirmed by a significant Phase by Pair type interaction, $F(1,28) = 4.24$, $p = .049$, $\eta_p^2 = .013$ (see also Table 2 for data from all blocks and phases). Planned comparisons indicated that accuracy attenuated significantly for overlapping pairs, $t(28) = 7.35$, $p < .001$, $d = 1.39$, as well as for unique pairs, $t(28) = 3.09$, $p = .005$, $d = 0.58$, although attenuation was greater for overlapping pairs ($M_{accuracy} = .28$) than for unique pairs ($M_{accuracy} = .16$), $t(28) = 2.06$, $p = .049$, $d = 0.39$.

Results presented in Figure 2 (right panel) also suggest no savings for overlapping pairs coupled with substantial savings for unique pairs, which was confirmed by a significant Phase by Pair type interaction, $F(1,28) = 6.21$, $p = .02$,, $\eta_p^2 = .018$. Paired samples t-tests indicated that savings were significant for unique pairs, $t(28) = 3.00$, $p = .006$, $d = 1.19$, but not for overlapping pairs, $p = .61$. These results point to marked RI coupled with no savings, which suggests catastrophic-like RI, which is similar to the No Delay condition of Experiment 1, but is in a sharp contrast to the Delay condition of Experiment 1 (i.e., when the delay was introduced after Phase 2). This finding suggests that children’s memory may benefit from time delays only when overlapping information is encoded prior to the delay.

To further examine the specificity of the effects of delays, we compared memory for overlapping and unique sources of information across experiments. Figure 3 presents accuracy in the first block of Phase 3 for both pair types across Experiments 1 and 2. We performed a mixed ANOVA on these data with pair type (overlapping vs. unique) as a within-subject factor and condition (Experiment 1 No Delay vs. Experiment 1 Delay vs. Experiment 2) as a between-subject factor. The interaction between these factors was significant, $F(2, 76) = 5.60$, $p = .005$, $\eta_p^2 = .013$, indicating changes across delays were not the same for overlapping and unique pairs. These analyses were followed up by one-way ANOVAs for each pair type. For the overlapping pairs, memory in the delay after Phase 2 condition was better than in the other two conditions as evidenced by a significant quadratic trend (p = .001). In contrast, for the unique pairs, delays resulted in (at least numerically) lower memory, and the linear trend approached significance, p = .078). This suggests that whereas accuracy for overlapping pairs was increased by a delay following Phase 2, perhaps due to the formation of a configural code, accuracy may have decreased following delays for unique pairs, due to non-specific sources of interference or memory decay. The finding that memory did not uniformly improve across delays indicates that forgetting does occur across delays in many situations (Hardt, Nader, & Nadel, 2013), and that benefits of consolidation may be specific to overlapping information. Therefore, a simple passage of time is not sufficient to eliminate catastrophic-like interference.

General Discussion

This study found that giving children a 48-hours-long delay between learning of overlapping information and testing improved their memory and eliminated effects of catastrophic interference. In contrast, when no delay was provided, children experienced catastrophic-like RI effects. Remarkably, children's memory after the 48 hours delay was better than memory without the delay.

These results suggest that although children may fail to form a configural memory code online, they can do so over a protracted period of time. Therefore, early in development, consolidation may protect memory from interference effects.

Consolidation, as discussed above, is the process of memory stabilization (see McGaugh, 2000, for a review). This stabilization is the result of interactions between networks of information represented in the hippocampus and cortical areas (McClelland et al., 1995; Nadel & Hardt, 2011; Nadel et al., 2012). Many have provided evidence that much of this process takes place during sleep (see Stickgold, 2005, for a review), although little is known about the roles of sleep and wakefulness in reducing interference effects.

Why would consolidation reduce RI? One intriguing possibility is that consolidation creates more stable conjunctive memory traces in the hippocampus (Hardt et al., 2013). The finding that children experience much greater RI than adults immediately following learning (Darby & Sloutsky, 2015) suggests that the neural function subserving the creation of a conjunctive memory code online may be immature in children, such that consolidation is required form such a code.

Importantly, consolidation did not eliminate RI in all experiments: RI remained high when children were provided with a delay after learning only Phase 1 information, but not the entire set. We suggest, therefore, that knowledge of the overlapping stimulus structure (in conjunction with a delay) may be necessary to eliminate RI. Interestingly, although accuracy for overlapping pairs was increased by a delay following Phase 2, accuracy for unique pairs was somewhat decreased by delays. Unique pairs, then, may have been subject to general interference (Wixted, 2004) or decay (Hardt et al., 2013), whereas overlapping pairs may have been protected by the formation of a configural code. This difference between pair types in conjunction with results of Experiment 2 suggests that consolidation does not improve memory for all elements, but may have more selective effects that form a configural memory code for overlapping sources information (see Hardt et al., 2013, and

Nadel et al., 2012, for discussions of consolidation and decay processes as selective and only affefting memory for some information).

Implications for Memory Development

If RI is a major cause of forgetting (Wixted, 2004), understanding RI has important implications for memory development. Previous work suggests that children are highly vulnerable to RI effects from learning of overlapping information (Darby & Sloutsky, 2015), but results of the experiments presented here suggest that Phase 2 did not permanently erase children's memory for Phase 1: children encoded all the necessary information online, but binding of this information into a configuration required time.

Interestingly, consolidation may have a detrimental impact on children's ability to generalize learning to new instances. Werchan and Gómez (2014) recently found that 2.5 year-old children were able to generalize word learning following four hours of wakefulness, but not four hours of sleep. These authors suggested that consolidation processes during sleep may have helped children remember specific instances of word learning items, but that this may have actually made it more difficult to extract the relevant category information during generalization. In contrast, children in the wakefulness condition may have forgotten some irrelevant details of the learning task while retaining relevant commonalities, leading to better generalization. It is for future research to directly investigate the relationships between RI, generalization, and consolidation, but an intriguing hypothesis is that consolidation may help children form configural memory traces and thus avoid interference, although these more stable and precise memory traces may decrease their ability to generalize this learning to new instances. Future research would need to also examine precise developmental time course of these effects by including multiple age groups and identifying memory parameters accounting for developmental change (cf. Howe, Brainerd, & Kingma, 1985; Yim et al., 2013).

Conclusions

This study demonstrates remarkable effects of time delays on children's memory: providing children with a 48-hour-long delay following learning eliminated catastrophic-like RI effects and resulted in better memory than when no delay was provided. This suggests that during consolidation children are able to form configural memory structures that protect information from RI effects. Although additional research is needed, these results have implications for better understanding of the mechanism of memory and its development.

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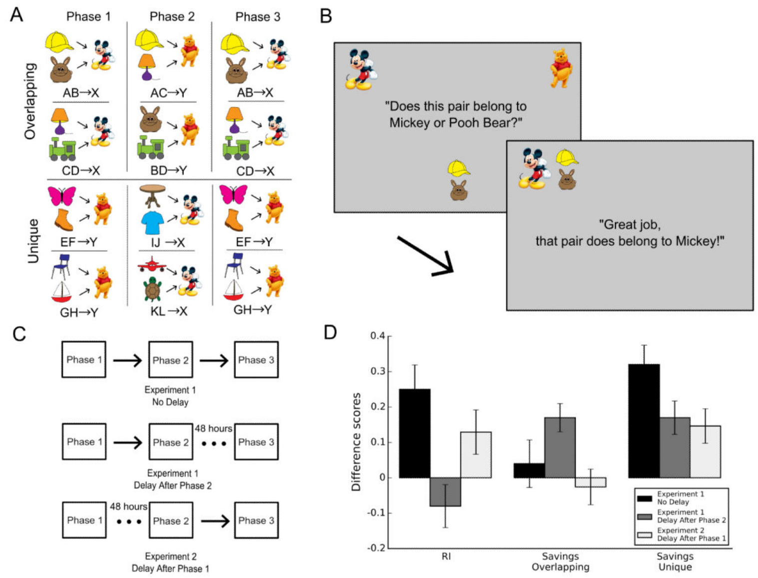

Figure 1.

Stimulus, task, and condition structure and results of Experiments 1 and 2. A. Stimulus Structure: Overlapping object pairs consisted of the same objects, re-combined and associated with different characters across phases, whereas unique object pairs consisted of different objects across phases. B. Task Structure: On each task trial children learned to associate pairs of objects with outcomes; C. Condition structure: Conditions differed only in the amount of time provided between phases. D. Results: Difference scores as measures of RI and savings for overlapping and unique pairs. Positive values indicate greater interference and savings. Difference scores are based on raw accuracy values for specified blocks as shown in Figure 2. RI was defined as the difference of differences in accuracies for Phase 1, Block 5 and Phase 3, Block 1 across Overlapping and Unique pairs, whereas savings was defined as the difference in accuracies for Phase 1, Block 1 and Phase 3, Block 1, separately for Overlapping and Unique pairs. Error bars represent SEMs.

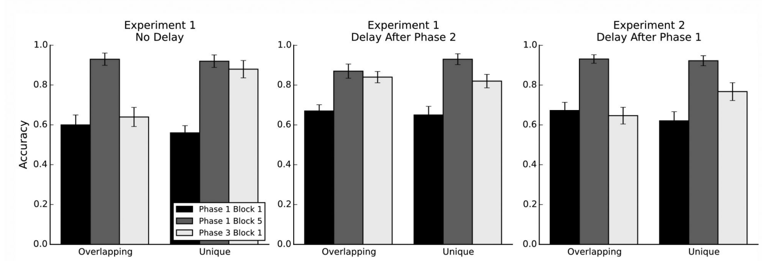

Figure 2.
Accuracy for overlapping and unique pairs in the first and last blocks of Phase 1, as well as the first block of Phase 3, for Experiments 1 and 2. These specified blocks were used to measure RI as well as savings effects (see Figure 1 for difference scores). Error bars represent SEMs.

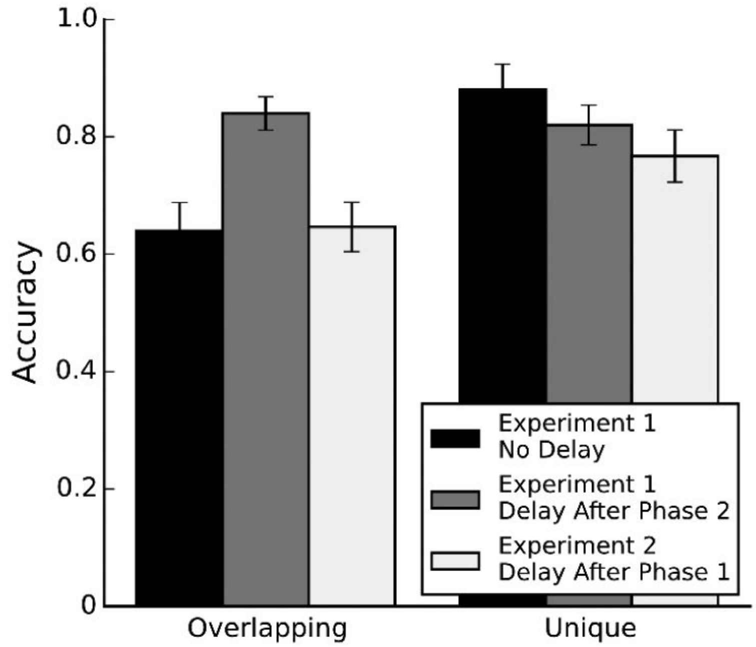

Figure 3.

Accuracy for overlapping and unique pairs in the first block of Phase 3 for each experiment.

Table 1

Accuracy means (and *SD*s) across each phase and block of Experiment 1.

	Pair Type	Block 1	Block 2	Block 3	Block 4	Block 5	Phase Average
No Delay							
Phase 1							
	Overlapping	.60 (*.25*)	.91 (*.14*)	.91 (*.14*)	.92 (*.17*)	.93 (*.15*)	.85 (*.09*)
	Unique	.56 (*.18*)	.88 (*.19*)	.88 (*.16*)	.93 (*.14*)	.92 (*.16*)	.83 (*.09*)
Phase 2							
	Overlapping	.48 (*.22*)	.78 (*.26*)	.91 (*.12*)	.88 (*.16*)	.91 (*.16*)	.79 (*.11*)
	Unique	.70 (*.22*)	.93 (*.14*)	.93 (*.14*)	.97 (*.11*)	.97 (*.08*)	.90 (*.07*)
Phase 3							
	Overlapping	.64 (*.24*)	.85 (*.20*)	.89 (*.19*)	.93 (*.14*)	.95 (*.13*)	.85 (*.11*)
	Unique	.88 (*.22*)	.93 (*.15*)	.96 (*.09*)	.92 (*.14*)	.94 (*.11*)	.93 (*.08*)
Delay							
Phase 1							
	Overlapping	.67 (*.16*)	.91 (*.12*)	.89 (*.16*)	.94 (*.11*)	.87 (*.18*)	.86 (*.08*)
	Unique	.65 (*.22*)	.83 (*.16*)	.88 (*.15*)	.89 (*.19*)	.93 (*.14*)	.84 (*.10*)
Phase 2							
	Overlapping	.47 (*.20*)	.67 (*.21*)	.78 (*.24*)	.86 (*.22*)	.79 (*.30*)	.72 (*.17*)
	Unique	.65 (*.24*)	.85 (*.20*)	.87 (*.19*)	.88 (*.19*)	.86 (*.23*)	.82 (*.14*)
Phase 3							
	Overlapping	.84 (*.14*)	.90 (*.16*)	.83 (*.25*)	.95 (*.10*)	.92 (*.17*)	.89 (*.10*)
	Unique	.82 (*.17*)	.89 (*.15*)	.85 (*.25*)	.85 (*.19*)	.9 (*.20*)	.86 (*.13*)

Table 2

Accuracy means (and *SD*s) across each phase and block of Experiment 2.

	Pair Type	Block 1	Block 2	Block 3	Block 4	Block 5	Phase Average
Phase 1							
	Overlapping	.67 (*.22*)	.85 (*.13*)	.86 (*.18*)	.89 (*.16*)	.93 (*.11*)	.84 (*.10*)
	Unique	.62 (*.25*)	.81 (*.21*)	.85 (*.18*)	.96 (*.10*)	.92 (*.14*)	.83 (*.11*)
Phase 2							
	Overlapping	.55 (*.23*)	.73 (*.24*)	.80 (*.24*)	.84 (*.20*)	.87 (*.18*)	.76 (*.13*)
	Unique	.69 (*.22*)	.86 (*.18*)	.86 (*.18*)	.92 (*.17*)	.92 (*.14*)	.85 (*.10*)
Phase 3							
	Overlapping	.65 (*.23*)	.82 (*.21*)	.87 (*.18*)	.87 (*.18*)	.89 (*.17*)	.82 (*.14*)
	Unique	.77 (*.24*)	.87 (*.24*)	.95 (*.15*)	.93 (*.11*)	.94 (*.20*)	.89 (*.14*)