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1. Young children's understanding of forgetting over time.

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LYON, THOMAS D., and FLAVELL, JOHN H. *Young Children's Understanding of Forgetting over Time.* CHILD DEVELOPMENT, 1993, **64,** 789–800. 2 studies investigated young children's understanding that as the retention interval increases, so do the chances that one will forget. In Study 1 (24 3-year-olds and 24 4-year-olds), 4-year-olds but not 3-year-olds understood that of 2 characters who simultaneously saw an object, the character who waited longer before attempting to find it would not remember where it was. In study 2 (24 3-year-olds and 24 4-year-olds), 4-year-olds but not 3-year-olds understood that of 2 objects seen by a character, the object that was seen a "long long time ago" would be forgotten and the object seen "a little while ago" would be remembered. The findings are discussed in relation to research on young children's understanding of the acquisition, retention, and retrieval of knowledge over time.

Research investigating young children's metamemorial development has emphasized their understanding of memorization and the acquisition of memorial strategies, with relatively little research exploring preschool children's fundamental understanding of remembering and forgetting (Schneider & Pressley, 1989). Since memory involves the retention and retrieval of knowledge, one would have expected researchers studying young children's early understanding of knowledge and belief to turn their attention toward early metamemory. However, the primary focus of such research has been children's understanding of knowledge acquisition: how beliefs are the product of informational access to the world and interpretive activity by the mind. In contrast, very little has been said about children's understanding of how those beliefs, once created, are stored and subsequently retrieved.

When researchers interested in children's developing awareness of knowledge have speculated about children's understanding of memory, their views have differed sharply. Wellman speculates that even very young children ought to understand "that forgetting occurs—for example, that as a delay continues, one's mental copy of reality can fade" (Wellman, 1990, p. 307). Wellman's reference to a "fading copy" is consistent with his view that by 3 years of age, children conceptualize knowledge as internal copies of reality, and the mind as a copy-container. Pillow agrees with Wellman that the 3-year-old's conceptualization of the mind is as a passive repository for knowledge, but suggests that young children "may not realize that information that has been perceived may later be forgotten" (Pillow, 1989b, p. 127).

Unfortunately, neither Wellman nor Pillow cites direct support for his speculations about young children's understanding of memory. Interested in both children's metamemory in particular and their understanding of knowledge in general, we scanned the literature for research on children's understanding of this very basic fact about memory: As the retention interval increases, so do the chances that one will forget. Our search uncovered only three studies addressing children's explicit understanding of this fact. Kreutzer, Leonard, and Flavell (1975) asked kindergartners (and several older groups of children) questions about their understanding of various aspects of memory. In response to a general question about things that are easy or hard to remember, some of the kindergartners suggested that it was especially difficult to remember things that had happened a long time ago. The researchers did not measure the frequency of this response, however, One question was specifically designed to tap the

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subjects' understanding that information in short-term memory is susceptible to rapid forgetting. The researchers told subjects to imagine that they had just heard a phone number and needed to make a phone call. They were asked whether it mattered if they called right away or had a drink of water first. Only 12 of the 20 kindergartners either responded that they should phone first or appeared aware of the potential for rapid forgetting.

Rogoff, Newcombe, and Kagan (1974) examined children's understanding that in order to remember materials for longer periods of time, they would have to lengthen their study time. Four-, 6-, and 8-year-old subjects were given pictures to remember for varying lengths of time. The researchers informed the subjects of the need to remember the pictures and the length of the retention interval. Pretraining ensured that children both understood the task and the amount of time they would be required to remember the pictures. Only the 8-year-olds devoted more study time to materials that had to be remembered for longer periods of time.

Given the relatively poor performance of younger children in these two studies, one might expect preschool children to have little awareness of the relation between retention interval and memory. However, both studies probably underestimated children's understanding. In Kreutzer et al.'s (1975) study, subjects may not have recognized the point of the question about remembering a phone number, because the risks of forgetting were not explicitly mentioned. Alternatively, children may have been well aware of the potential for memory failure, but felt confident that they could overcome any difficulty; the researchers note that some children's explanations support this possibility. That an exaggerated faith in effort may mask understanding of memory has similarly been offered to explain the common finding that young grade school children overestimate their memory spans (Wellman, Collins, & Glieberman, 1981). Finally, children may have little experience with the difficulty of maintaining information in short-term memory, but be familiar with the effects of longer delays on memory.

The findings of Rogoff et al. (1974) are complicated by the fact that in order to perform correctly on the task, subjects had to understand both that forgetting is more likely with longer retention intervals, and that studying longer could offset the detrimental effects of delay. Subjects might understand the former fact about memory but not the latter, or might be aware of the risks of forgetting but favor strategies for improving performance other than increased study time, such as increased effort at retrieval. Furthermore, Rogoff et al. (1974) used a between-subjects design, so that individual subjects were assigned to only one retention interval. A within-subjects design would have made more salient to the subjects the different demands of varying retention intervals, and might therefore have revealed greater understanding of the need for flexibility in study time.

Wellman (1978), in a study that focused on 5- and 10-year-olds' understanding of the interaction of memory variables in memory performance, found that 5-year-olds correctly evaluated the difficulty of remembering items on the basis of the amount of time that the items had to be remembered. Furthermore, in the tasks that varied more than one factor affecting memory, 5-year-olds gave more weight to the length of the retention interval than to either the amount of items to be remembered or whether one wrote down the items in order to remember them. Wellman's results might be confounded, however, by the fact that the judgment regarding retention intervals concerned characters who had to remember items while walking various distances; children might simply have based their judgments on the difficulty of walking longer distances rather than the difficulty of remembering for longer periods of time.

Because Kreutzer et al. (1975) and Rogoff et al. (1974) may have underestimated understanding, and Wellman (1978) may have overestimated understanding, we conducted two studies examining young children's explicit awareness of the fact that as the retention interval increases, the chances of forgetting also increase. In both studies, we used simple procedures involving dolls and miniature toys. In the first study, subjects attributed forgetting to one of two characters who waited for different periods of time to find an object they had perceived. A control task tested for subjects' ability to make judgments of relative duration. In the second study, subjects chose which of two objects a character would either remember or forget, an object seen recently or one seen a long time ago. Subjects were also told stories to test for their ability to equate "remember" with "know," and "forget" with

"not know." We chose 3- and 4-year-old children for our subjects in these studies, because pilot research suggested that an understanding of the effects of retention interval on knowledge emerges at about 4 years of age.

Study 1

Method

Subjects

The final sample consisted of 48 nursery school children, 22 boys and 26 girls, from a single nursery school serving largely upper-middle-class families. All subjects spoke English fluently; the race and ethnicity of the subjects was not recorded. Twenty-four children were in each age group. The 3-year-olds (10 boys and 14 girls) ranged from 3-6 to 3-11 (mean 3-9); the 4-year-olds (12 boys and 12 girls) ranged from 4-0 to 4-11 (mean 4-6).

Materials

Several types of materials were used, including four dolls, dollhouse furniture, six miniature objects, and a moon and sun made out of construction paper. The doll furniture, under which objects could be hidden, included a bed, a sofa, and a sink. Pieces of cloth were attached to the furniture so that an object underneath was visible only when the cloth was lifted. The dolls were realistic looking and included two painted dolls (one red boy and one blue boy), and two rubber dolls (one boy and one girl). The miniature objects were realistic-looking replicas of common items, such as a bucket, a brush, etc.

Procedure

Subjects were tested by one of two experimenters, one male and one female. Each experimenter tested equal numbers of subjects at each age. The child sat next to the experimenter at a table with the doll furniture. All subjects were told two types of stories: one "What's longer" story and six "Which one won't remember" stories.

"What's longer" story.—Previous research has demonstrated that the word "longer" can be understood as referring to relative duration by children as young as 34 months, as long as the tasks do not include potentially distracting cues such as distance or speed (Beauchamp, Feicht, & Weubbe, 1991; Levin, 1982; Richie & Bickhard, 1988). This story tested for the child's understanding that a "whole day" is "longer" than a "little while." The story utilized the two painted boy dolls. Placing one of the dolls on the bed, the experimenter told the child that "This boy is gonna play the whole day." The experimenter then propped up the paper sun and explained that the sun came up because it was morning. Moving the doll while he (or she) spoke, the experimenter described the doll getting up and playing. The experimenter then replaced the sun with the moon, commenting that the moon had come out because it was night, and noted that the doll "plays and plays and plays until it's time for bed. He plays the whole day." Putting the first doll to the side, and placing the other doll on the bed, the experimenter then told the child that "This boy is gonna play a little while." The experimenter propped up and mentioned the sun as before, and described the doll getting up and playing. However, after moving the doll briefly, the experimenter commented, "He plays a little while and then he stops." Placing the doll next to the first doll, the experimenter then said, "So he [pointing to the doll] played a whole day and he [pointing] played a little while. What's longer, a whole day or a little while?" The correct answer ("a whole day") was always mentioned first so as to avoid correct responding due to the common tendency among young children to choose the last-mentioned response in forced-choice questions (e.g., Mischel, Zeiss, & Zeiss, 1974).

"Which one won't remember" stories.—If the child correctly answered that a whole day is longer, the experimenter then proceeded to the six "Which one won't remember" stories. Before each story, the experimenter showed the child one of the miniature objects, and, while placing the object in its hiding place, said, "Let me show you that the [object] is under the [hiding place]." The stories all followed a similar structure, in which the experimenter both demonstrated the boy and girl rubber dolls looking in the hiding place and finding the object. The experimenter noted, "both this boy and this girl look under the [hiding place], and they find the [object], they see the [object], they know where the [object] is. The [object] is going to stay under the [hiding place]. And this boy and this girl are gonna wait and try to find the [object]."

The experimenter then noted that either the boy or the girl was "gonna wait a little while and then try and find the [object]," placing the doll on the table in front of the child. The experimenter then said that the other doll was "gonna wait longer, he's [or she's] gonna wait a whole day and then try

and find the [object]," placing the doll to the right of the first doll (from the child's perspective). The child then was asked who was "gonna wait a little while" and who was "gonna wait longer, a whole day." If the child answered one of the questions incorrectly, the experimenter repeated the information regarding how long each doll would wait. (Out of a total of 144 stories for each age group, information had to be repeated eight times to 3-year-olds, and zero times to 4-year-olds.) The experimenter then concluded, "Well, one of them won't remember where the [object] is. Which one won't remember?" Either a verbal response or a gesture was accepted. Following the child's response, the experimenter asked, "Why won't he [or she] remember?" and recorded the child's answer verbatim.

The set of six stories was counterbalanced within subjects so that each child received three stories in which the boy was the correct doll and three stories in which the girl was the correct doll. The identity of the correct doll alternated from story to story. The order in which the child was asked who was "gonna wait a little while" and who was "gonna wait longer, a whole day" alternated so that on three stories the "little while" question was asked first and on three stories the "longer, a whole day" question was asked first.

Results

Six 3-year-olds and six 4-year-olds answered the "What's longer" question incorrectly and were replaced; an additional three 3-year-olds had to be replaced because of repeated failure on the "Who's gonna wait a little while/longer" questions within the "Which one won't remember" stories or because of unwillingness to complete the procedure.

Preliminary analyses showed neither significant sex differences within each age group, nor any significant differences within subjects within age groups between questions in which the boy or girl was the correct choice or between questions in which "Who's gonna wait a little while" or "Who's gonna wait longer" was asked first. Therefore, further analyses were collapsed across sex of subject, sex of the correct doll, and order.

On the "Which one won't remember" questions, the 3-year-olds answered 61% correctly (M = 3.67, SD = 2.08), whereas the 4-year-olds answered 82% correctly (M = 4.92, SD = 1.64). The 3-year-olds' performance was not significantly different from chance (50% correct), $t(23) = 1.57$, N.S., whereas the 4-year-olds' performance was, $t(23) = 5.73$, $p < .001$. The 4-year-olds performed significantly better than the 3-year-olds, $t(43.6) = 2.31$, $p < .05$.

The distribution of individual subjects' performance within each age group is shown in Table 1. Six of the 3-year-olds answered six of the six questions correctly. By a binomial test, with the likelihood of a single child answering six of six questions correctly by chance at .016, the probability that 6 or more children out of 24 would answer six of six questions correctly by chance is less than .001. Fourteen of the 4-year-olds answered six of the six questions correctly, binomial test $p < .001$.

Based on our examination of the subjects' responses to the question "Why won't she remember?" we classified the explanations into one of six categories: (1) reference to time, either how long the child waited or when the child attempted to find the object; (2) reference to seeing or not seeing the object; (3) reference to finding or losing the object, or to the object's location; (4) reference to remembering, forgetting, knowing, or not knowing; (5) don't know or no answer; (6) unclassifiable. All explanations were independently coded by two coders blind to whether the subject had chosen the correct character on that question. The coders agreed on 88% of the explanations; disagreements were resolved by discussion. If an explanation could be categorized as referring to time, its content was not analyzed further. Explanations that did not refer to time, however, could fall into more than one category (this occurred only three times). The numbers of explanations (and percentages) within each category for each age group are shown in Table 2. Examination of the percentages reveals that references to time are more common among correct responses than

TABLE 1

Distribution of Individual Subjects' Performance within Each Age Group in Study 1

	Number Correct						
	0	1	2	3	4	5	6
3-year-olds	3	2	1	4	4	4	6
4-year-olds	0	2	1	1	3	3	14

TABLE 2

CATEGORIZATION OF EXPLANATIONS WITHIN EACH AGE GROUP IN STUDY 1, SUBDIVIDED BY AGE GROUP AND RESPONSE TO "WHICH ONE WON'T REMEMBER" QUESTION

	3-YEAR-OLDS RESPONSE		4-YEAR-OLDS RESPONSE	
	Correct	Incorrect	Correct	Incorrect
Time	34% (30)	17% (10)	48% (57)	31% (8)
Seeing/not seeing	4% (4)	6% (5)	0% (1)	0% (0)
Finding/losing	17% (15)	14% (8)	9% (11)	12% (3)
Remembering/forgetting	17% (15)	22% (13)	15% (18)	15% (4)
Don't know/no answer	18% (16)	28% (16)	8% (10)	23% (6)
Etc.	10% (9)	10% (6)	18% (21)	23% (6)
Total	(89)	(58)	(118)	(26)

NOTE.—A complete description of categories is in the text. Raw numbers are in parentheses.

incorrect responses for both age groups (though the data in this form are not amenable to statistical test).

In order to determine the likelihood that children both responded correctly and referred to time in their explanations, we categorized each explanation as either referring to time or not referring to time, and then computed the difference between the proportion of correct answers with reference to time and the proportion of incorrect answers with reference to time for each child. If a child's probability of referring to time when correct was higher than his or her probability of referring to time when incorrect (which included answering all questions correctly and sometimes referring to time), then that child received a positive score. If the reverse were true, the child received a negative score, and if the two proportions were equal (or if the child never referred to time), the child received a zero. Six of the 3-year-olds received positive scores, two negative scores, and 16 zero scores. The median difference for this age group is not significantly different from zero by a sign test, $p > .2$. Thirteen of the 4-year-olds received positive scores, one a negative score, and 10 zero scores. The median difference for this age group is significantly greater than zero, sign test $p < .005$. A significant number of 4-year-olds were therefore able to justify their correct responses by reference to time.

DISCUSSION

These results provide preliminary support for the proposition that children at close to 4 years of age acquire an understanding that lengthening the interval between initial perception and subsequent attempts at retrieval increases the chances of forgetting. Although a significant minority of 3-year-olds did well on the tasks, the mean performance of the 3-year-olds was not significantly different from chance, whereas the 4-year-olds both as a group and individually showed high rates of correct responding. Moreover, a significant number of 4-year-olds referred to time in justifying their correct answers. Given the verbal demands of explanation, we were impressed with the frequency with which subjects mentioned the length of the interval as a basis for their choice.

There are several reasons why these results might either underestimate or overestimate children's understanding, however. First, children might understand forgetting over time but not understand the term "won't remember." We asked the subjects to identify the character who "won't remember" because we believed that asking who "would remember" would (justifiably) lead many children to answer "both." On the other hand, we wished to avoid using the word "forget," given some indication in the literature that "remember" is better understood by young children (Wellman & Johnson, 1979). Subsequent findings have suggested that 3-year-olds are at least capable of associating "remember" and "forget" with knowledge and ignorance, respectively (Lyon & Flavell, 1992). We therefore used "remember" and "forget" in our second study, and added tests for children's understanding that "remember" is equated with knowledge and "forget" is equated with ignorance, in order to guard against the possi-

bility that failure on the tasks is due to a lack of familiarity with the words.

Second, we suspected that subjects might imagine that the two characters in each story were different in some way other than in the amount of time they waited to attempt retrieval. Stories in which one character sees different objects at different times might make the time interval more salient. We therefore used a single character for our stories in Study 2.

Third, we suspected that subjects might choose the correct character without a real understanding of the effects of waiting intervals on memory. Subjects might have assumed that the character who waited longer must not have liked or wanted the object as much as the character who waited a little while. Such an assumption would be a reasonable interpretation of the somewhat odd scenario portrayed by our stories, in which a character finds an object but then puts off retrieving it. If remembering connotes a positive association, then not wanting or not liking might suggest a failure to remember. Although we did not find references to liking or wanting the object among the explanations, this is only partially reassuring, because subjects could have such ideas without referring to them explicitly. Independently of an association of looking first with liking best, subjects could have performed well had they utilized an even simpler association of first is best and last is worst.

Subjects might also have come up with various nonmental reasons why the character who waited longer would not find the object. Several subjects gleefully explained that the first character to look would take the object, despite our insistence in the stories that the object would stay in its place (this occurred four times). Some subjects spoke of the second character looking "at night," possibly assuming it was therefore too dark to see the object (this occurred five times). A similar bias toward attributing changes over time to nonmental causes has been discovered by research examining young children's understanding of waning emotion. Younger children tend to attribute changes in emotion over time to changes in the situation (Harris, Guz, Lipian, & Man-Shu, 1985).

In our second study, we attempted to control for these strategies. Rather than ask subjects to make judgments about a character's future attempts at retrieval, we told the subjects stories in which a character first sees one object, sees a second object much later, and at a third point in time attempts to remember both objects. In contrast to the situation in the first study, the first object seen is now the object most likely to be forgotten. Therefore, a first-is-best strategy would no longer lead to correct responding. Moreover, with this design, the various nonmental explanations mentioned above (missing object, looking at night) would not come into play.

Study 2

Method

Subjects

The final sample consisted of 48 nursery school children drawn from the same nursery school as in Study 1. All subjects spoke English fluently; the race and ethnicity of the subjects was not recorded. None of the children in Study 1 participated in this study. Twenty-four children were in each age group. The 3-year-olds (10 boys and 14 girls) ranged in age from 3-5 to 4-0 years (mean 3-8). The 4-year-olds (12 boys and 12 girls) ranged from 4-2 to 5-0 years (mean 4-8).

Materials

The materials included two paper cups, four painted dolls (two boys and two girls, one red and one blue of each sex), three rubber dolls (a boy, girl, and "mommy"), and 14 miniature objects. The cups had an opening in one side so that an object placed underneath was visible only when one faced the opening. The dolls and objects were similar to those used in Study 1.

Procedure

Subjects were tested by one of three experimenters, one male and two female. Each experimenter tested equal numbers of children at each age. Each subject was told two types of stories.

"Which one knows" stories.—Using one of the two cups, the experimenter placed a miniature bucket under one of the cups, positioning the cup so that the child could see the bucket, and then turned the cup so that the bucket was no longer visible to the child. The experimenter said, "The bucket is under this cup." The experimenter then placed the red painted boy doll in front of the cup, facing the child, and said, "The red boy remembers where the bucket is." Placing the blue painted boy doll to the right of the red doll (from the child's perspective), the experimenter said, "The blue boy forgot where

the bucket is." The experimenter then asked the child, "Which one knows where the bucket is?" Either a verbal response or a gesture was accepted. If the child answered incorrectly (i.e., "the blue boy"), the experimenter would say, "No, the red boy knows where the bucket is, because he remembers." The experimenter then asked, "Which one does not know where the bucket is?" and if the child answered incorrectly, the experimenter would correct the child. The child was then told a second story with a similar structure, except that a toy basket and two painted girl dolls were used, and the doll who forgot (the red girl) was mentioned first.

"Which toy remembered/forgotten" stories.—The child was first introduced to two of the rubber dolls, either a boy or a girl (matching the subject's sex), and the mommy doll. The two paper cups were put on the table across from the child, with the opening facing away from the child. The mommy doll was placed equidistant between the cups and toward the child. The child was told six stories, three in which the key question used the word "forget" and three using the word "remember." In each story, the experimenter first picked two toys at random from a bag and surreptitiously placed a toy under each cup. Then the experimenter held the doll to the left of the cups and said, "This girl walks home from school," moving the doll toward the first cup. (To simplify description, we are assuming the subject is a girl.) Turning the cup so that the child could see inside the opening, the experimenter said, "First she sees a . . . ," waited for the child to name the object, and then repeated the name. The experimenter then said, "She says, 'Oh, there's a [object].' " Moving the doll slowly to the second cup, the experimenter then said, "Then she walks and walks and walks and then she sees a . . . ," and turned the second cup around. Again, the experimenter waited for the child to name the object, repeated the name given by the child, and then said, "She says, 'Oh, there's a [object].' " Moving the doll to the mommy's position, the experimenter said, "Then, she's home, and her mommy says, 'Did you see anything on your way home?' And she wants to tell her what she saw." Whispering to the child, the experimenter reviewed the doll's experience, pointing to each cup in turn: "Well, she saw a [object] a little while ago. And she saw a [object] a long long time ago. But you know what? She remembers one of the toys. She forgets one of the toys." The experimenter then asked either "Which toy does she remember?" or "Which toy does she forget?" The child was then asked, "Why does she remember [or forget] the [object]?" and the child's response was recorded verbatim.

Stories using "remember" or "forget" in the test questions were blocked so that each child received one block of three of each type of question. Half of the subjects at each age received three "remember" stories first and half received three "forget" stories first. The review of the doll's experience (when the experimenter whispered to the child) alternated so that either the toy that was seen a little while ago or the toy seen a long time ago was mentioned first. For half of the subjects, the toy that was seen "a little while ago" was reviewed first in two of the three "forget" stories (and one of the three "remember" stories), and for the other half of the subjects, the toy that was seen "a long time ago" was reviewed first in two of the three "forget" stories (and one of the three "remember" stories). To reduce confusion, however, the doll always moved from left to right, the story was always told in correct temporal order, and remembering was always mentioned before forgetting.

Results

Preliminary analyses revealed no effects of sex or order within either age group; scores were therefore collapsed across sex and order. On the "Which one knows" stories, in which the child was tested for his or her understanding that one who remembers knows and one who forgets does not know, the 3-year-olds answered 85% of the questions correctly (M = 3.42, SD = 1.21), whereas the 4-year-olds made no errors. The difference is significant, $t(23) = -2.36$, $p < .05$. Eighteen of the 24 3-year-olds (and, of course, all of the 4-year-olds) answered all four questions correctly.

Regarding the "Which toy remembered/forgotten" stories, the 3-year olds were 58% correct (M = 1.73, SD = 1.2) on the "remember" stories, whereas the 4-year-olds were 89% correct (M = 2.67, SD = .48). The 18 3-year-olds who answered all four "which one knows" questions correctly were 55% correct on these stories (M = 1.64, SD = 1.3). On the "forget" stories, the 3-year-olds and 4-year-olds were 49% correct (M = 1.48, SD = 1.08) and 83% correct (M = 2.5, SD = .72), respectively. The 18 3-year-olds who answered all four "which one knows" ques-

tions were 55% correct on these stories (M = 1.64, SD = 1.11). The 3-year-olds' performance on the "remember" stories was not significantly different from chance (50% correct), $t(23) = .93$, N.S, in contrast to the 4-year-olds' performance, which was significantly above chance, $t(23) = 11.87$, $p < .001$. Similarly, the 3-year-olds' performance on the "forget" stories was not significantly different from chance, $t(23) = -.1$, N.S., unlike the 4-year-olds', $t(23) = 6.78$, $p < .001$. A two-way repeated-measures ANOVA, with age as the between-subjects factor and mental verb as the within-subjects factor, revealed neither a significant interaction between age and mental verb nor a significant main effect for mental verb. There was a significant main effect due to age, $F(1, 46) = 19.64$, $p < .001$. The 4-year-olds clearly performed better than the 3-year-olds.

To obtain a rough indication of whether performance varied depending on whether we used the term "won't remember" (Study 1) or the terms "remember" and "forget" (Study 2), we compared the scores across the two studies by means of a two-way ANOVA with age and verb (either "won't remember" or a pooled score for "remember" and "forget") as between-subject factors. Neither the interaction between age and verb, $F(1, 92) = 1.17$, N.S., nor the main effect for verb was significant, $F(1, 92) < 1$.

The distribution of individual subjects' performance within each age group is shown in Table 3. Nine of the 3-year-olds answered three of three "remember" stories correctly, binomial $p < .001$ (with the chances of a single subject answering three of three correctly by chance at .125); five of the 24 3-year-olds answered three of three "forget" stories correctly, binomial p = N.S. Of the 18 3-year-olds who answered all four "Which one knows" stories correctly, and therefore showed good understanding that "remember" means "know" and "forget" means "don't know," seven answered all three "remember" stories correctly, binomial $p < .001$, and five answered all three "forget" stories correctly, binomial $p < .05$. Sixteen of the twenty-four 4-year-olds answered three of three "remember" stories correctly, binomial $p < .001$; 15 of the 4-year-olds answered three of three "forget" stories correctly, binomial $p < .001$.

Examination of the children's explanations suggested the same categories as were used in Study 1, with the addition of reference to liking or wanting the object. The explanations were independently coded by two coders blind to whether the subject had chosen the correct toy. The coders agreed on 88% of the explanations; disagreements were resolved by discussion. The numbers of explanations (and percentages) falling within each category for each age group are shown in Table 4. Examination of the percentages again reveals that reference to time is more common among correct responses than incorrect responses, though this information is merely descriptive.

In order to determine the likelihood that children both responded correctly and referred to time in their explanations, we used the same coding procedure as in Study 1. Four of the 3-year-olds received positive scores, none received a negative score, and 20 received a zero score. The median difference for this age group is not significantly different from zero by a sign test, $p > .1$. Among the 4-year-olds, the corresponding numbers were 16, 1, and 7. The median difference for this age group is significantly

TABLE 3

DISTRIBUTION OF INDIVIDUAL SUBJECTS' PERFORMANCE WITHIN EACH AGE GROUP FOR EACH TYPE OF STORY IN STUDY 2

	Number Correct			
	0	1	2	3
"Which toy remembered":				
3-year-olds	6 (6)	3 (1)	6 (4)	9 (7)
4-year-olds	0	0	8	16
"Which toy forgotten":				
3-year-olds	5 (3)	7 (5)	7 (5)	5 (5)
4-year-olds	0	3	6	15

NOTE.—The performance of the 18 3-year-olds who answered all four "Which one knows" stories correctly is shown in parentheses.

TABLE 4

CATEGORIZATION OF EXPLANATIONS WITHIN EACH AGE GROUP IN STUDY 2, SUBDIVIDED BY AGE GROUP AND RESPONSE TO "WHICH TOY REMEMBERED/FORGOTTEN" QUESTION

	3-YEAR-OLDS RESPONSE		4-YEAR-OLDS RESPONSE	
	Correct	Incorrect	Correct	Incorrect
Time	24% (19)	7% (5)	60% (76)	14% (3)
Liking/wanting	9% (7)	16% (11)	0% (0)	0% (0)
Seeing/not seeing	10% (8)	6% (4)	2% (2)	10% (2)
Finding/losing	4% (3)	3% (2)	5% (6)	5% (1)
Remembering/forgetting	14% (11)	12% (8)	10% (12)	29% (6)
Don't know/no answer	19% (15)	16% (11)	10% (12)	29% (6)
Etc.	19% (15)	34% (23)	15% (19)	29% (6)
Total	(78)	(68)	(126)	(21)

NOTE.—A complete description of categories is in the text. Raw numbers are in parentheses.

greater than zero, sign test $p < .001$. As in Study 1, a significant number of 4-year-olds justified their correct responses by referring to time.

General Discussion

Taken together, these two studies suggest that it is at about 4 years of age that children acquire the understanding that increasing the retention interval increases the likelihood of forgetting. Despite various changes in procedure, the results of the two studies were quite consistent: The overall performance of the 4-year-olds was near ceiling, whereas the 3-year-olds did not perform better than chance in either study. Inspection of individual responding suggests that a significant minority (about a fourth) of the 3-year-olds show good performance. Moreover, a number of 4-year-olds successfully explained their responses by reference to time. Understanding seems to be emerging among our 3-year-olds, and well in place among our 4-year-olds.

Various explanations for false-positive or false-negative responding in the first study were controlled for in the second study, with essentially the same results. It can be concluded that children were not merely responding correctly by relying on a "first-is-best" strategy, whereby what is first seen is best remembered. Although such a strategy would serve a subject well in the first study, it would guarantee failure in the second. Moreover, children who might have performed well on the first study by assuming that the situation facing the two characters differed (because the first looked when it was still light, or took the object) could not have used such a strategy in the second study, which involved one character who saw two objects equally clearly.

We attempted to control for difficulties in vocabulary by both varying the terms employed and testing the subjects for their understanding of potentially difficult terms. The first study ensured that subjects understood that "longer" referred to greater temporal intervals, an understanding previously demonstrated among children younger than those in our study (Beauchamp et al., 1991; Richie & Bickhard, 1988). The second study tested for subjects' understanding that "remember" signifies knowledge and "forget" signifies ignorance. Naturalistic observations have found that these words enter the child's vocabulary before the age of 3 (Bretherton & Beeghly, 1982; Limber, 1973; Shatz, Wellman, & Silber, 1983), and previous research has suggested that 3-year-olds associate "remember" with attending to and talking about objects, and "forget" with the failure to do those things (Lyon & Flavell, 1992). Similarly, the use of these words to indicate either knowledge or ignorance posed little difficulty for our subjects. Moreover, subjects' performance did not differ appreciably depending on whether the test questions referred to "remember," "forget," or "won't remember." It thus seems unlikely that unfamiliarity with the words in our studies explains the differences in performance among subjects of different ages.

The results of these studies are consistent with other findings documenting an emerging awareness among 4-year-old children that in order to "remember" or "forget" some fact, one must have known that fact at

a prior time (Lyon & Flavell, 1992). Such an awareness entails the appreciation that the mental verbs require consideration of two points in time: prior exposure and current performance. It is possible, however, that children could have some awareness of these two points in time without recognizing the relation between the two. In other words, they might not be aware that one's current performance depends upon one's prior exposure. The studies reported here offer some evidence that by 4 years of age, children are in fact aware of one important fact about the relation between prior exposure and current performance: the greater their distance in time, the greater the likelihood that forgetting occurs.

It is important to emphasize that the studies here were designed to test for the most rudimentary understanding that time affects memory. We maximized the salience of differences in duration, unconfounded by other factors that either could make judgments of relative duration difficult or that could be understood as affecting the chances of forgetting. It is therefore likely that children demonstrating competence in our studies still have much to learn about the way in which time and memory interact.

Further research can explore the ways in which children discover that forgetting occurs over time, and the means by which they believe it occurs. It is possible that young children first merely associate forgetting with longer temporal intervals, without considering the reasons why such an association exists. Learning could occur through experience, or through analogies to other domains with which children are more familiar. In order to learn from experience, children must be aware of the time elapsed since the occurrence of remembered and forgotten events. Though the children in Study 1 understood the distinction between "a whole day" and "a little while," other research has demonstrated that preschoolers only gradually acquire the ability to compare intervals between routine daily activities (Friedman, 1990), an ability that could foster discovery of the effects of time on forgetting. Through analogy, children's understanding of the effects of spatial distance on perception might influence their interpretation of the effects of temporal interval on knowledge. Children frequently confuse duration with distance in estimating time (Levin, 1982). It is at about 4 years of age that children first acquire the understanding that the distance between a perceiver and the object perceived affects how well the object is perceived (Flavell, Flavell, Green, & Wilcox, 1980). Children who understand that objects farther away are harder to see might thus appreciate that objects seen longer ago are less likely to be remembered.

It will also be interesting to discover to what extent children understand the mechanisms by which time leads to forgetting. If children draw analogies between memories and physical entities, they might believe that time leads to forgetting because memories, like objects in the world, decay and are lost over time (Wellman, 1990). Moreover, children might acquire an understanding of forgetting over time that is explicable in terms of interference or capacity limits. As lay adults, we understand that our memory for past events is limited by what and how much has occurred in the meantime. Understanding interference and capacity limits is no mean achievement, however (Flavell, Friedrichs, & Hoyt, 1970; Pillow, 1988, 1989a), leading us to suspect that an understanding of the effect of these variables on retention is a relatively late accomplishment.

Our results may also be understood in relation to research on young children's understanding of knowledge. In our studies, 4-year-olds appreciate that prior access does not guarantee current knowledge; rather, one must consider the temporal interval between access and subsequent attempts at retrieval. We view these results as consistent with a large body of research that suggests that by 4 to 5 years of age, children both understand that informational access is not always sufficient for knowledge to occur and critically evaluate the quality and quantity of that access in determining what knowledge is obtained thereby. Preschool children show some understanding that visual access may be incomplete or ambiguous and therefore fail to lead to knowledge (Perner & Davies, 1991; Ruffman, Olson, & Astington, 1991). Similarly, 4–5-year-olds understand that visual access does not inevitably afford reality, but often provides mere appearances (Flavell, Flavell, & Green, 1983), and that those appearances may be misleading (Perner, Leekam, & Wimmer, 1987). Furthermore, children of this age understand that when perceptual access to an object is limited to one sense modality, what one knows about that object may be limited as well (O'Neill, Astington, & Flavell, 1992). Hence, whereas previous research has suggested an increasing sophistication among preschool

children in their understanding of knowledge acquisition, the research reported here documents an analogous development in children's understanding of the retention (and loss) of knowledge over time.

We believe that our results contribute to the debate over whether young children understand the representational nature of knowledge and belief. In the context of children's theory of mind, representation refers both to the process by which knowledge and beliefs represent reality and to the products (or mental entities) formed by that process (Astington & Gopnik, 1991; Perner, 1991). Much of the debate over young children's understanding of the mind has emphasized their understanding of the process by which knowledge is acquired. Our research, and further research on the early understanding of metamemory, can help to determine when children first acquire a conception of knowledge and beliefs as mental entities, held in the mind over time.

Our findings contradict Wellman's assertion that even very young children ought to understand that "as a delay continues, one's mental copy of reality can fade" (Wellman, 1990, p. 307). Wellman's claim is founded in part on his characterization of 3-year-olds' understanding of the mind as a copy-container. Children with such a theory conceptualize beliefs and knowledge as copies of reality that are held in the mind. What children fail to understand at this age, however, is that knowledge is an interpretation of reality, leading them to fail tests for understanding ambiguity, inference, or false belief. Since memory merely involves holding information, rather than interpreting it, the copy-container theorist is capable of understanding how memories can be lost: copies either fade or fall out of the container over time (Wellman, 1990). Our results do not support Wellman's version of the copy-container theory of mind.

It is possible, however, that 3-year-olds conceive of the mind as a copy-container and yet do not understand forgetting over time. Children might believe that something once known is known forever (Flavell, 1988; Pillow, 1989b), and therefore fail on our tasks. If 3-year-olds have such a theory, they ought to understand remembering—the retention of knowledge over time—and there is little evidence that they do (Lyon & Flavell, 1992). Further work on metamemory can determine to what extent young children conceive of knowledge as an entity (whether as a copy or an interpretation) that is held in the mind over time.

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