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Development of Young Children's Understanding That the Recent Past Is Causally Bound to the Present

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The results of 6 studies (involving 304 children) suggested that 4- and 5-year-olds, but not 3-year-olds, understand that very recent past events determine the present. In Studies 1–3, 3- and 4-year-old children were introduced to 2 empty hiding locations. With children's backs to these locations, a camera recorded an experimenter secretly hiding a puppet in one of them. Children then viewed the videotape of what had just happened, along with another tape that depicted identical events except with a different child and with the puppet hidden in the other location. Only 4-year-olds were subsequently able to locate the puppet, even though 3-year-olds remembered the contents of the tapes and understood the equivalence between the video events and the real world. In Study 4, similar effects were obtained when a verbal analog of the test was presented to 3–5-year-olds. Studies 5 and 6 showed that when children observed 2 events in which they had just participated, only 5-year-olds understood that the most recent events were relevant.

Early research on the development of infants' and children's understanding of time focused on their initial appreciation of temporal distinctions implicit in their manual actions on the world (between 4 and 8 months of age) and the later development of their appreciation of the distinction between means and ends (between 9 and 18 months of age; Piaget, 1954). Such abilities were seen as reflecting the earliest forms of planning and thus seemed relevant to understanding time because they implied some understanding that future states can be achieved only through a series of intermediate steps intervening between now and then. More recent research has shown that young infants are sensitive to a wide range of temporal patterns in both the auditory and visual domains (e.g., Lewkowicz, 1985, 1989; Morrongiello, 1984; Morrongiello & Trehub, 1987). Other early studies by Piaget (1969) examined older children's abilities to appreciate the uniformity of time—that is, our folk-intuition notion that time is not relative. Although Piaget's research on this question suggested that it is not until about 8–9 years of age that children develop an understanding of the uniformity of time, later research showed that in simple circumstances even 5-year-olds can coordinate variables related to duration, speed, distance traveled, and the final resting location of objects (e.g., Levin, 1977).

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Preschool children also display some knowledge of time-related phenomena such as knowledge of the content of past events as well as their order. First, Friedman (1991, 1992) showed that by 4–5 years of age, children develop the ability to distinguish the relative recency of two past events and to retrieve specific events from specific past times (e.g., yesterday, their last birthday, various holidays), although it is not until much later that such events can be ordered sequentially relative to one another. In addition, other researchers have analyzed young children's spontaneous and elicited narratives about everyday events and have shown that by 3 years of age, children exhibit some knowledge of the typical ordering of major events that occur during common routines such as eating, sleeping, or taking a bath as well as specific knowledge from novel past events (e.g., Fivush, Gray, & Fromhoff, 1987; Nelson, 1986; Nelson & Ross, 1980).

Second, children as young as 1½ to 2 years of age may represent the temporal structure of events they witness. For example, after observing an adult carry out a series of actions with toy figurines, infants as young as 16 months have (a) displayed an ability to reproduce those actions in an order that retains some of the temporal order and (b) exhibited some degree of selective encoding of causally relevant versus causally arbitrary events (Bauer & Mandler, 1989, 1990; O'Connell & Gerard, 1985).

Third, when asked to make causal judgements, children as young as 3 years of age appear to believe that in order for an event to cause an outcome, it must happen prior to the outcome (e.g., Bullock, Gelman, & Baillargeon, 1982; Kun, 1978; Shultz, 1982). Finally, by about 2½ to 3 years of age children exhibit an ability to use and comprehend temporal terms such as *before* and *after,* as well as past, present, and future verb tenses, which suggests that they draw an ontological distinction between the past, the present, and the future (Harner, 1975, 1976, 1980, 1981; Weist, 1989; Weist, Wysocka, Witkowska-Stadnik, Buczowska, & Konieczna, 1984).

One underexplored aspect of the development of young children's notion of time concerns the development of their explicit understanding of time as a successive series of causally interdependent states of the world, as well as their own place in that unfolding time line. As we have seen, young preschoolers, and even toddlers, may be sensitive to causal relations among successive events. However, it is not clear whether such abilities unveil a genuine appreciation of the mediating notion of time as a series of causally linked events or merely the selective encoding of events that satisfy certain causal expectations. Figure 1 portrays three hypothetical stages in the emergence of a mature appreciation of this concept. Initially, children may appreciate past events as "islands in time" (see Figure 1a) that are relatively unconnected to one another (Friedman, 1990). Postulating such an early stage need not contradict proposals which argue that even infants' earliest representations of events necessarily contain order information (e.g., Mandler, 1984; Nelson, 1986) or that infants' early sensitivities to causal relations influence their representations of local events (Bauer & Mandler, 1989, 1990). For example, it is possible that young infants' direct perception of causal relations (e.g., Leslie, 1982, 1984; Leslie & Keeble, 1987) influences their initial representations of local event structure to some degree but that the conceptual ordering of major events relative to one another

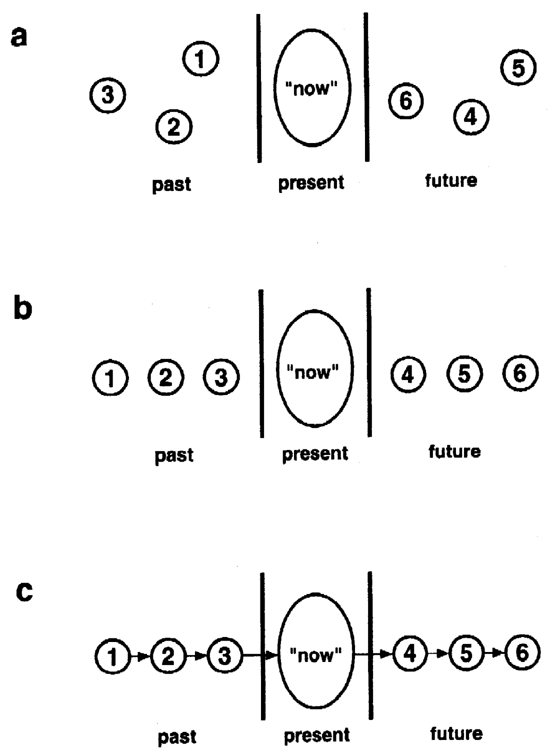

Figure 1. Three depictions of young children's representations of very recent past events (1, 2, and 3), the present, and projected future events (4, 5, and 6). In (a), children represent a clear ontological distinction between the past, the present, and the future, but major events are seen as "islands in time" (Friedman, 1990). However, the order of local sequences of actions within these major events may also be represented (e.g., Bauer & Mandler, 1989). In (b), events are chronologically ordered, but this ordering is not connected to an appreciation of the causal flow of time. In (c) children represent both the chronological ordering of successive major events as well as the causal structure that binds each successive state of the world to the next.

develops only later, and only after a construction of the concept of time as a mediating variable (see Friedman, 1992). An intermediate stage in the development of the notion of time as a causally ordered progression of events is depicted in Figure 1b. Here, events are ordered chronologically on a time line of sorts leading from the recent or distant past to the present and ultimately to a projected future. Finally, at some point, children develop an understanding not only that events are ordered chronologically but also that this ordering is the result of an inherent underlying causal arrow of time that binds each state of the world to each succeeding one (see Figure 1c).

The studies reported in this article were designed to probe the development of young children's appreciation of the causal arrow of time for events from their very recent past (see Figure 1c). Related studies in our laboratory have focused on the child's developing understanding of the self as an agent with multiple temporal (historical) states leading up to the present. Although it is generally accepted that the ability of 18–24-month-olds to pass tests of self-recognition is supported by the development of an objective self-concept, empirical and theoretical investigations from our laboratory have questioned whether infants of this age appreciate how their present selves are causally bound to previous states of the self (Povinelli, 1995; Povinelli, Perilloux, & Landau, 1996; Povinelli & Simon, 1998). Povinelli et al. (1996) explored the reactions of 2-, 3- and 4-year-old children to briefly delayed video images of themselves. The images depicted the children playing an unusual game and revealed that one of the experimenters had covertly placed large stickers on the children's heads in the context of praising them. Few 2- and 3-year-olds responded by reaching up to their heads to remove the stickers, whereas the majority of 4- and 5-year-old children did so immediately after the delayed tape revealed that the experimenter placed them there. Additional tests and controls indicated that the difficulties experienced by younger children were not the result of an inability to recognize their own images on video or of their failure to notice the stickers on the image. Finally, control tests involving their responses to live video and mirrors suggested that the younger children's difficulty stemmed from the temporal component of the feedback, not from the medium itself.

Studies of self-recognition involving both live and delayed images of the self may be intimately linked with the child's developing appreciation of time as a causally ordered series of events. For example, Povinelli (1995) argued that in order for 18–24-month-olds to pass the mark test using live feedback (mirrors, live video), they must have developed the ability to explicitly represent the self's on-line actions (and possibly volitional states). However, although this explicit, on-line representation of the self can be thought of as the emergence of a self-concept, it is envisioned as still quite limited. Under the model offered by Povinelli (1995), the 18–24-month-old's semantic memories of his or her past states are not incorporated into this representation, and hence the child's self-concept does not contain an explicit temporal dimension. Following William James (1890/1950), Povinelli (1995) referred to this initial self-concept as the *present self.* This on-line or present self can be contrasted with the later emergence of the *proper self*—a meta-self-concept that includes both on-line states of the self as well as previous and future states. The ability to unite present, past, and future self-representations under a common conceptual umbrella is seen as allowing the child to construct the notion of a self that endures through time. Neisser (1991) labeled this the *extended self.* William James (1890/1950) held that this construct allows humans to understand that despite obvious changes in our physical appearances and mental activities through time, we remain the same selves we were in the past. Povinelli (1995) proposed that it is this temporal unification of the self's self-representations that allows children to pass tests of delayed self-recognition at about 4 years of age. The proper or extended self, then, refers to the self-representation that weaves together each past state of the self, as well as the present and each imagined future state, into a single, unduplicated self.

The purpose of the present research was to explore whether age-related changes may be found in preschoolers' ability to appreciate how events from their very recent past causally determine the present state of the world well beyond the self's physical appearance. In particular, we reasoned that if the general model proposed by Povinelli (1995) has merit, 4–5-year-old children ought to understand that, with respect to the present state of some specific aspect of the world, events from their very recent past that have affected that state have priority over comparable other events occurring at some unknown time point (see Figure 1c). In contrast, we expected younger children to possess other constructions of time that omit an appreciation of the causal arrow of time (see, e.g., Figures 1a and 1b). To this end, in Studies 1 through 4 we tested 3-, 4-, and 5-year-olds for their ability to appreciate the causal distinction between (a) a briefly delayed video playback (or a verbal script) that offered the children information about an event in which an object had been hidden in one of two locations behind them and (b) a comparable, previously recorded video playback (or verbal script) involving a different child and an object hidden in a different location. An understanding of the causal dimension of time ought to allow children to realize that only the events that occurred most recently (i.e., the ones involving themselves) were causally relevant to the current location of the object. The results upheld this prediction. Using similar procedures, we found in Studies 5 and 6 that older, but not younger, preschoolers could also appreciate that only the most recent of two events in which they themselves had participated was relevant for the current state of affairs.

Study 1

Method

Participants

The participants were 64 preschool children recruited from the Lafayette, Louisiana area, whose parents gave their informed, written consent for their participation in the study. The children were divided into four age groups (N = 16 per group): 36–42 months (M = 40 months; Mdn = 41 months; 14 girls and 2 boys); 43–48 months (M = 46.5 months; Mdn = 47 months; 7 girls and 9 boys); 49–54 months (M = 52 months; Mdn = 53 months; 8 girls and 8 boys); and 55–60 months (M = 59 months; Mdn = 59 months; 7 girls and 9 boys). Although no data were recorded on the children's backgrounds, they were primarily from working- and middle-class families of Caucasian, Black, Hispanic, and Asian descent. In addition to the final 64 participants, the data for 5 other children were not used because of their departure from the protocol (4 young 3-year-olds and 1 old 3-year-old). Two of these children did not cooperate during their visit. Three others were excluded because when they were asked to locate the Mickey Mouse puppet, they walked out of the testing room before searching in one of the boxes.

Procedure

Warm-up phase. Upon the child's arrival at the University of Southwestern Louisiana Center for Child Studies, the experimenters welcomed the family and entertained the child in a warm-up area. A variety of age-appropriate toys were made available, including books, blocks, and puzzles. During this play period, the experimenters introduced the child to a hand-held Mickey Mouse puppet and incorporated it into the play activities.

Once the child appeared comfortable with the surroundings, he or she was presented with a sticker page and invited to play another game. While the first experimenter led the child into an adjacent testing room, the second experimenter hid the Mickey Mouse puppet behind her back and followed them into the testing room.

Testing. As soon as the child entered the testing room, the first experimenter oriented the participant to two boxes located in opposite corners of the rear wall of the testing room. The boxes were of different colors and dimensions; a blue box was 15 × 15 × 33 cm and an orange box was 15 × 40 × 15 cm. Both boxes contained lids that could be easily lifted to reveal their contents. The first experimenter opened both of the boxes and showed the child that they were empty.

The child was then led to a novel game (which involved moving a frog figurine along a trail of sea creatures to a finish line) that was set up on a table against the opposite wall of the room. The child was seated in a chair facing the front wall of the testing room with his or her back to the boxes. The first experimenter sat across the table facing the child. Once the child was seated at the board game, the second experimenter seated herself midway between the two boxes along the back wall, facing the child's back. The second experimenter placed the Mickey Mouse puppet out of view behind her. A video camera was positioned so that it clearly captured the following information from over the shoulder of the first experimenter: (a) the child's face and upper torso, (b) the child's behavior as they played the game, and (c) the boxes and the second experimenter along the wall behind the child.

When the first experimenter felt that the child understood how to play the game, she activated the video camera and started a stopwatch. At 1 min into the board game, the first experimenter held up two fingers, which served as the cue for the second experimenter to reach behind her and grab the puppet, hold it up for a moment to emphasize its view in the camera, place it in the appropriate box, and then close the lid of that box. This procedure was extensively choreographed to ensure that a clear video record was obtained of the child playing the game as the second experimenter hid the puppet without the child's knowledge.

After the puppet was hidden, the child continued to play the game for an additional 2 min. Meanwhile, the second experimenter rolled a videocassette recorder unit and monitor (42 × 32 cm) against the back wall (centered between the two boxes) and cued two stimulus tapes that the child would observe shortly. This setup ensured that during the playback the left–right positions of the boxes on the video would match their left–right positions in real space.

After the child finished the game, the second experimenter invited the child to play another game to "watch ourselves on TV." The child's chair was turned around so that he or she was seated 60 cm directly in front of the television monitor, with the boxes clearly visible in their original positions to the left and right of the monitor. The first experimenter sat on the left side of the child and the second experimenter sat to the right of the child.

Two 20-s videotape segments (a *self tape* and an *other-child tape*) were then presented as the experimental conditions, both of which were shown to each participant. The self tape depicted the hiding event that had just happened (the participant playing the game while the second experimenter hid the puppet in one of the boxes). The self tape began 10 s before the second experimenter pulled the puppet out from behind her and ended after she hid the puppet and returned to her neutral position between the two boxes. The other-child tape was a previously recorded 20-s tape of a different child of the same gender and the same general age playing the board game. In the other-child tape, the puppet was hidden in the box opposite that shown in the self tape. Every effort was made to ensure that all aspects of the two videotapes were identical except for the child featured playing the game and the box in which the puppet was hidden. Thus, the experimenter who hid the puppet, her clothing, the board game, the testing room, and the video camera's view were all identical in the self and other-child tapes.

Five seconds into the viewing of each stimulus tape, the playback was paused and the first experimenter pointed to the child on the monitor and asked, "Who is that?" If the child did not respond verbally or gesturally (e.g., point to himself or herself or shrug his or her shoulders), the child was asked, "Can you tell me who that is?" The video presentation was then resumed. At the moment when the image depicted the second experimenter removing the puppet from behind her back and holding it up in the air, the first experimenter pointed to the image and said, "Hey look, she has Mickey!" The participant and experimenters then continued watching the tape as the puppet was hidden in the appropriate box. At the conclusion of the first tape, the second tape was inserted and the exact procedure described above was repeated.

The order of presentation of the self and other-child tapes was counterbalanced as follows. First, the 16 children within each age group were divided into two subgroups. One of these subgroups (n = 8) saw the self tape first, and the other subgroup (n = 8) saw the other-child tape first. Finally, these subgroups were further divided (n = 4 per group) so that for each of the presentation orders (self tape first and other-child tape first), equal numbers of children saw the puppet hidden in each box.

Immediately after the child had finished watching the second videotape, the first experimenter turned to the child and said, "Hey, [child's name], I wonder which box Mickey is hiding in right now? I think he wants you to find him. Why don't you go find Mickey for me?" If the child did not respond, the child was prompted with "Okay, go get him for me." To maximize the likelihood that all participants understood at least the general equivalence between the scene on the video monitor and the room in front of them, the protocol of the study specified that participants who did not respond by looking in or pointing to one of the boxes would not be included in the final sample (see *Participants* section).

Data Analysis

A main rater was administered a set of written instructions for coding the video records of the children who participated in the study. A second rater was given an identical instruction set and was asked to code a sample of 20% of the children (n = 13) to measure the reliability of the coding system. The coding instructions required that the raters first record the child's verbal or nonverbal response (i.e., "me," proper name, pointing to self, or shrugging shoulders) to the question "Who is that?" that they were asked while viewing the self and other-child stimulus tapes. The reliability rater agreed with the main rater on 24 of 26 cases (Cohen's κ = .90). Instances of disagreement were resolved by discussion while the main rater examined the cases again. The instruction set also directed the raters to note the box the child selected when asked to locate the puppet. The reliability rater agreed with the main rater on 13 of 13 cases (κ = 1.00).

Results

The main rater's judgments were used to determine whether each child selected the appropriate box ("yes" or "no") when asked to locate the puppet. We analyzed these initial results to determine whether there was an effect of gender by placing them into a 2 (gender) × 2 (test result) contingency table. A Fisher's exact test revealed no significant association between the children's gender and their test results in this study (p = .42) or any of the subsequent studies. Thus, for the purpose of analyzing subsequent data, we collapsed the data for boys and girls in this and subsequent studies.

All of the children responded by either searching in or pointing to one of the boxes. Table 1 depicts the numbers and percentages of children in each of the four age groups who successfully located the puppet on their first try. As predicted by the autobiographical stance model, the number of young and old 3-year-old children who selected the correct box was at or near chance level (50% and 56%, respectively; see Table 1; binomial test, $p > .40$, in both cases). In contrast, the 4-year-olds performed at levels exceeding chance (69% of the young 4-year-olds and 94% of the old 4-year-olds located the puppet on their first try; binomial test, p = .10 and .0003, respectively). A chi-square test for trend revealed a highly significant age-related trend, $\chi^2(1, N = 64) = 7.499, p = .006$, so that as age increased so did success in locating the puppet.

Table 2 shows the numbers and percentages of responses of the children in each age group to the "Who is that?" question that was asked during the viewing of the self and other-child tapes. We collapsed these responses into three groups (correct, incorrect, or no-response/other). Responses to the self tape were considered correct if the children said "me," stated their proper name, or pointed to themselves; incorrect responses were "I don't know" and, in a few instances, "not me." Responses to the other-child tape that were considered correct were "I don't know" or "not me"; incorrect answers in the other-child tape were usually "me." Children who did not respond or responded with an unrelated or unintelligible answer were grouped into the third response type (no-response/other). Table 2 reveals that even the youngest children easily recognized their own images in the self tape (94% correct in both 3-year-old age groups and 88% and 81% in the young and old 4-year-olds, respectively). To examine whether there was a relation between the ability to accurately identify the child in each videotape and to subsequently locate the puppet, we classified all children (collapsed on age) as either providing a correct response to both "Who is that?" questions or providing at least one incorrect answer (or no response), and we then placed their data into a 2 (response type) × 2 (puppet task result) contingency table. A Fisher's exact test indicated no significant association between their ability to correctly identify the images and their success on the puppet location task (p = .589).

In an attempt to uncover potential strategies that the children might have used to determine the location of the puppet, we analyzed the participants' tendencies to choose the box in which the puppet was placed during the final tape they observed, regard-

Table 1
Numbers and Percentages of Children Who Successfully Located the Puppet in Each Age Group in Study 1

Age (in months)	n	%
36–42	8	50
43–48	9	56
49–54	11	69
55–60	15	94

Note. For each age group, n = 16.

Table 2
Numbers and Percentages of Responses to the "Who Is That?" Question During Playback of the Self and Other-Child Tapes in Study 1

		Correct		Incorrect		No response or other	
Age (in months)	Stimulus tape	*n*	%	*n*	%	*n*	%
36–42	Self	15	94	1	6	0	0
	Other-child	11	69	3	19	2	13
43–48	Self	15	94	1	6	0	0
	Other-child	12	75	3	19	1	6
49–54	Self	14	88	1	6	1	6
	Other-child	7	44	3	19	6	38
55–60	Self	13	81	1	6	2	13
	Other-child[a]	12	75	1	6	2	13

Note. For each age group, $n = 16$.
[a] One participant's responses to the other-child tape were not available for analyses by the raters because of a videotaping error.

less of whether it was the self or the other-child tape. Separate binomial tests for the four age groups indicated that the majority (75%) of the youngest children (36–42 months) chose the box depicted in the tape they viewed last ($p = .038$), whereas the remaining groups exhibited no such preference ($p = .77$, .96, and .40 for the old 3s, young 4s, and old 4s, respectively). Thus, the only group whose behavior was affected by the order of playback (independent of whether it was the self or other-child tape) was the youngest group. This finding allows for the possibility that the reason the youngest children performed randomly on the puppet location task was not because of an inability to use the information in the stimulus tapes, but rather because they failed to interpret the information in the self tape as having causal priority over the information in the other-child tape. Also, in no age group (nor across all age groups collapsed) did the children perform significantly better (or worse) with one viewing order of the tapes than with the other.

Study 2

Study 1 confirmed our age-related predictions, but it was possible that the younger children's failure to locate the puppet might have been due to a general problem in understanding that the video images referred to the real world. Although there was evidence from the young 3-year-olds (although not the older 3-year-olds) in Study 1 that they did use the information presented in the videotapes to guide their searches (they selected the box corresponding to the puppet's location in the last tape they viewed), in Study 2 we directly assessed whether young 3-year-olds could understand the general correspondence between the boxes in the videotape and the boxes in real space. (Note that such a direct assessment was not possible from Study 1 because each child saw both the self and the other-child tapes before responding.) We confronted one group of 3-year-olds with only the self version of the tape and a second group of children with only the other-child tape. If the 3-year-olds experienced difficulty with this task, it would cast doubt on our interpretation of the results of Study 1 by suggesting that 3-year-olds might have difficulty understanding a general equivalence between the video images and the real world. In contrast, the autobiographical stance model predicted that although 3-year-olds may not understand either the causal connections among successive events or that the images they witness are representations of previous events, they should easily appreciate the equivalence between the image and the scene in front of them and hence should search in the correct location for the puppet.

Method

Participants

The participants were two groups of 36–47-month-old children ($N = 24$). The *self* group ($n = 12$) consisted of 6 boys and 6 girls ($M = 41$ months; $Mdn = 41.5$ months). The *other-child* group ($n = 12$) consisted of 5 girls and 7 boys ($M = 41$ months; $Mdn = 41$ months). No child who participated in Study 1 participated in this study. In addition to the 24 final participants, 2 children were eliminated because of an experimenter error and 12 others were eliminated because they departed from the protocol (2 turned around during the hiding procedure or opened a box prematurely, and 10 others left the room either before or immediately after the script was delivered but before opening a box).

Procedure

The procedure was identical in all respects to that of Study 1 except that the children in each group were shown only one tape (either the self tape or the other-child tape) during the presentation period. They were then asked to locate the puppet in the same manner as in Study 1. The tapes were coded in the same manner as in Study 1. A main rater and a reliability rater agreed on 24 of 24 cases ($\kappa = 1.00$).

Results and Discussion

The results revealed that 24 of 24 children located the puppet on their first attempt ($p < .0001$, binomial test). Thus, when confronted with only a single tape (either the self tape or the other-child tape), the children had no difficulty understanding the general equivalence between where the puppet was shown to be hiding on the videotape and where the puppet was hiding in real space. These results support those of Troseth (1997, Experiment 1) and are considered further in the General Discussion.

Study 3

Although the results of Study 2 indicate that in the right setting, 3-year-olds can easily appreciate the equivalence between video images and objects in the real world, their difficulty in Study 1 may have stemmed from a different source. In particular, they may have had difficulty remembering the distinct contents of the two tapes. For example, the younger 3-year-olds may have simply forgotten what they observed in the first tape, whereas the older 3-year-olds may have remembered what they saw in both tapes but experienced a conflict during their encoding of the first and last events they witnessed. In addition, the similarity between the two tapes may have caused the children to confuse the events even further. Although the majority of the children (even the youngest ones) had little difficulty providing correct answers when questioned about the identities of the children in the tapes, this was the only salient difference between the tapes, and hence the children may have been more attentive to those aspects of the tapes that were similar (e.g., the game, the second experimenter who hid the puppet). In Study 3, we exaggerated the differences between the stimulus tapes by contrasting the self tape with a tape in which a complete stranger hid the puppet with no other child or experimenter present. In addition, prior to asking the children to search for the puppet, we asked two memory questions about what they had just seen. We predicted that if 3-year-olds possess a temporal representation similar to that depicted in Figures 1a or 1b, but not Figure 1c, their memories of those events would be excellent but that because such memories are not contained within a temporal–causal framework, there would be no relationship between the children's ability to answer the questions correctly and their ability to successfully locate the puppet.

Method

Participants

Twenty-four 3-year-old children (age range = 36–47 months) participated in this study (M = 41.6 months; Mdn = 43 months; 10 boys and 14 girls). No children who participated in the previous studies were used in this study. In addition to the final 24 participants, there were 12 other participants whose data were discarded. The data for 8 of these other children were not used because they departed from protocol (3 children left the room immediately after being asked to find Mickey, and 5 children did not select a box after the second prompt to do so), and the data of 4 children could not be used because of experimenter error.

Procedure

The warm-up and testing procedures were the same as in Study 1, except as follows. First, the causally irrelevant videotape was further differentiated from the self tape. A *stranger tape* was constructed that depicted an adult male (whom the participants had never seen) hiding the Mickey Mouse puppet. In addition, this tape did not portray another child or the first experimenter playing the game, although the game and table were in the same location as in the self video.

Several other procedural changes were implemented in a general effort to increase the clarity of the procedure. First, to clarify that the puppet was in one of the boxes, and that the procedure of watching the TV was relevant to finding it, just prior to viewing the stimulus tapes, the first experimenter told the child, "Hey, [child's name], we can't look now but I think the Mickey Mouse puppet is hiding in one of those boxes," as she pointed to the two boxes from left to right. She then added, "Let's watch the TV and see if we can find out where he's hiding." In addition, 5 s into the playback of the self tape, the first experimenter pointed to the image on screen and said, "Hey look, that's [second experimenter's name]," and 5 s later pointed again and said, "Hey look, [second experimenter's name] has Mickey. She's putting him in the [appropriate color] box." In contrast, 5 s into the playback of the stranger tape, the first experimenter pointed and said, "Hey look, that's Mr. Jim," and 5 s later pointed and said, "Hey look, Mr. Jim has Mickey. He's putting him in the [appropriate color] box." Half of the children (n = 12) were shown the self tape first, and the other half watched the stranger tape first.

After viewing both video clips with the child, the first experimenter asked each child two memory questions: (a) "Hey, [child's name], which box did Mr. Jim put Mickey in?" and (b) "Which box did [second experimenter's name] put Mickey in?" The order of these two memory questions was counterbalanced so that half of the children who saw the self tape first (n = 6) were asked about Mr. Jim's actions first, whereas the other half were asked about the second experimenter's actions first. The same counterbalancing method was used with the children who watched the stranger tape first. All other procedures were the same as those used in Study 1, including the script used to prompt the children to find Mickey.

Data Analysis

A main rater was administered a set of written instructions requesting that she view the videotapes of the 24 participants and note the following information: (a) the children's responses to the "Who is that?" question, (b) the children's responses to the two memory questions, and (c) the first box in which the children searched for the puppet (or, in those cases where they only pointed to a box, the first box to which they pointed). To evaluate the reliability of the coding scheme, we administered an identical instruction set to a secondary rater, who coded the same information for 50% (n = 12) of the participants.

For the "Who is that?" question, the secondary rater agreed with the main rater in 12 of 13 cases (κ = .88, where n = 13 because 1 child supplied two answers, thus creating an additional agreement possibility). To resolve the single disagreement, the main rater viewed the testing session a second time and recorded her final decision. In addition to the responses to the two memory questions that each of the 12 children who were coded were asked, 3 of these children also pointed to the box they referenced, thus increasing the total number of agreement possibilities to 27. The reliability rater agreed with the main rater on 26 of the 27 children's responses (κ = .95). Again, the single disagreement was resolved by having the main rater code the data a second time. Finally, the secondary rater agreed with the main rater on the children's box choice in 12 of 12 cases (κ = 1.00).

We conducted a secondary set of codings to determine if the children made at least an implicit connection between what they had seen on the tape and the real environment before them. A main rater and a reliability rater were administered a set of standardized, written instructions that asked them to record whether the child glanced or pointed to a box immediately after each of the two memory questions that were asked. The reliability rater coded the responses of half of the children (n = 12) and agreed with the main rater for 38 of the 42 children's responses (κ = .88). All of these disagreements were omission–commission errors (meaning that the raters never came to opposite conclusions about where the child glanced or pointed).

Results and Discussion

To begin the analysis of the results, we summarized the primary rater's decisions to determine (a) whether each participant chose the appropriate box ("yes" or "no") when asked to locate the Mickey Mouse puppet and (b) the number of memory questions he or she answered correctly (0, 1, or 2). There was no relation between the order in which the children saw the tapes (self tape first vs. stranger tape first) and whether they chose the correct box, nor did the children significantly prefer either the box highlighted in the first tape they saw or the box in the second tape they saw.

The main results of the study concern whether the children were able to successfully locate the puppet and whether this was related to their ability to correctly answer the memory questions (i.e., their ability to recall what had occurred in the two video presentations). First, as a group the children performed quite well on the memory questions (71% answered both of the memory questions correctly, 25% answered one correctly, and 4% provided an incorrect answer to both). In contrast, only 42% of the children selected the correct box on their first try (where chance = 50%). More important, there was no relation between the children's ability to answer the memory questions correctly and whether they chose the correct box (see Table 3). An unpaired *t* test confirmed that there was no statistical difference between the mean numbers of memory questions answered correctly by children who chose the correct box ($M = 1.80$, $SD = 0.42$) and by children who did not ($M = 1.57$, $SD = 0.65$), $t(22) = 0.97$, $p = .339$. To examine whether this relationship was different for the children who answered both memory questions correctly, we divided the children into two performance groups: those who answered both of the questions correctly versus those who answered one or both questions incorrectly (see Table 3). A 2 (memory task performance) × 2 (puppet task performance) Fisher's exact test revealed that there was no significant association between the children's ability to answer both questions correctly and their ability to succeed on the puppet location task ($p = .386$). Considered together, these analyses strongly support the predictions that (a) the 3-year-old children would be very good at remembering the relevant information presented on the videotapes and (b) their performance on the puppet location task would be independent of their ability to answer the memory questions correctly.

Second, in response to the "Who is that?" question, 23 of 24 children (96%) correctly identified their images by saying "me," using their proper names, or pointing to themselves. Thus, the difficulty that our 3-year-olds experienced in choosing the correct box was not the result of an inability to recognize themselves (at least at a featural level) on delayed video.

Third, we examined the results of the codings for whether the children referenced the boxes in real space after they were asked the memory questions. There was strong evidence that the children made a connection between the questions they were being asked about what they had just seen on video and the real boxes: (a) 96% of the children (23/24) glanced and/or pointed to one of the boxes immediately after they were asked at least one memory question, and 67% (16/24) did so after both questions; (b) 83% of the children (20/24) glanced *and* pointed to a box immediately following at least one question, and 50% (12/24) did so after both questions. Thus, the children were highly likely to use gestures to reference the real boxes either in conjunction with their verbal responses or as their primary answer.

In addition, the children's referencing actions were not random. If we restrict our analysis to just those cases in which the children provided a verbal response (either correct or incorrect) to the memory questions and produced a referencing action (glancing and/or pointing), there were 14 relevant cases. Of these cases, 13 of the referencing actions were to the same box that children mentioned in their verbal answers ($p < .001$, binomial test). If we restrict our analysis to just those cases in which the children produced nonverbal gestures ($n = 40$), and if we use the correct box as the target, 33 of the 40 gestures were to the correct box ($p < .0001$, binomial test). Perhaps more significantly, if for both of the above analyses we examine just those cases in which the children provided a correct verbal answer to the memory questions (and produced a gesture), 13 of the 14 children's gestures referenced the box they mentioned in their answers and the correct location. These data provide clear support for the idea that the children's verbal answers to our questions about the events on the self and stranger tapes were grounded to the objects and locations in real space. Nonetheless, the children appeared not to appreciate the differing causal implications of the two tapes.

Table 3
Relationship Between Performance on the Puppet Location Task and Number of Memory Questions Answered Correctly by 3-Year-Olds in Study 3

		Number of correct answers		
Puppet location task	*n*	0	1	2
Successful	10	0	2	8
Unsuccessful	13	1	4	8

Note. The data of 1 participant are not presented because his response to one of the memory questions was inaudible.

Study 4

Despite our findings that even the youngest children in our studies appeared to appreciate the equivalence between the videotaped images and the objects in the testing room, we explored the idea that the video images confused rather than helped the younger children. Although our initial speculation was that video representations of the events would help the children integrate their own memories of playing the game with events that (unbeknownst to them) occurred behind them, another interpretation was possible. Younger children may have appreciated only a weak equivalence between the boxes and persons they saw on videotape, or perhaps they saw them as fictional (although various data from Studies 1, 2, and 3 all cast serious doubt on this interpretation). To test whether the video medium was at least partially responsible for the younger children's performance, we dispensed with it altogether and simply presented information concerning the crucial previous events verbally. Using appropriate pointing gestures, we explained to the children that while they were playing the game the puppet had been hidden in one box, whereas a long time ago, when another child had been playing the game, the puppet had been hidden in the other box.

Method

Participants

Ninety-six 3–5-year-old children participated in this study: 32 three-year-olds (36–47 months; $M = 41$ months; $Mdn = 40$ months), 32 four-year-olds (48–59 months; $M = 55$ months; $Mdn = 57$ months), and 32 five-year-olds (60–71 months; $M = 66$ months; $Mdn = 64$ months).

In addition to the 96 final participants, there were 17 children whose data were not used (8 three-year-olds, 7 four-year-olds, and 2 five-year-olds). Of these, 11 turned around and witnessed the puppet-hiding procedure or involved an experimenter error, 2 either did not participate or chose a bucket before hearing both scripts, and 4 left the testing room before choosing a bucket.

Procedure

Warm-up phase. Toward the end of the standard warm-up phase, the experimenters acquainted the child with a large Big Bird puppet. After this was accomplished, the second experimenter announced that he or she was "going to put Big Bird in the game room," at which point one of the experimenters pretended to bring the puppet into the testing room but actually placed it in an adjacent room. When the child was comfortable with the surroundings, he or she was presented with a sticker page and led to the testing room by the first experimenter.

Testing. The setup was similar to that in the previous studies except that instead of boxes, two 23-cm-tall opaque buckets (one was blue and the other was green) were used that were located 166 cm apart along the far wall. After letting the child look inside them and see that they were empty, the first experimenter played a simple zoo game with the child with the child's back to the buckets. At a point about midway through the zoo game, the second experimenter, unbeknownst to the child, hid the puppet in either the green or blue bucket and then joined the child and the other experimenter. After the game was finished, the second experimenter told the child about "another fun game" they could play, and the child's chair was turned around and positioned 122 cm in front of the two buckets so that the child was equidistant from each of them. The first experimenter then told the child, "Hey, [child's name], I have two fun secrets I want to tell you about Big Bird." Two scripts were then administered, a *self script* and an *other-child script.* The self script was as follows: "While you and I were playing the zoo game, Miss/Mr. [experimenter's name] hid Big Bird in the [appropriate color] bucket." The other-child script was as follows: "A long time ago, while my friend [Suzy or Michael, matching the child's own gender] was playing the zoo game, Miss/Mr. [experimenter's name] hid Big bird in the [appropriate color] bucket." The orders of these two statements were counterbalanced; the first was preceded by the question "You know what?" and the second was preceded by the question "You know what else?" Equal numbers of children heard each combination of experimenter/script and order/bucket-location. The experimenter completed the script by saying "Hey, [child's name], I think Big Bird wants you to get him out of the bucket he is hiding in. Why don't you go find Big Bird for me?" If needed, the experimenter further prompted the child by adding, "Okay, go get Big Bird for me." If the child still did not remove the lid from either of the buckets, the first experimenter asked, "Okay, I'll go get him for you. Can you point to the bucket Big Bird is hiding in?"

Data Analysis

A main rater was administered written instructions requesting that he view the videotapes of the 96 children who participated in this study and record which bucket each child selected. A secondary rater coded the performance of 20% (n = 19) of the children to evaluate the reliability of the rating procedures. The rating instructions required the coders to note the child's bucket selection (Bucket A or Bucket B) after the child was prompted to locate the puppet by the experimenter. The secondary rater agreed with the main rater on 19 of 19 cases ($\kappa = 1.00$).

Results and Discussion

The judgments of the main rater were used to determine whether the children in each age group selected the appropriate bucket on their first attempt when asked to locate the Big Bird puppet. The results indicated a strong age effect (see Table 4). Fifty-three percent of the 3-year-olds and 59% of the 4-year-olds located the puppet on their first attempts, whereas 88% of the 5-year-olds did so. A chi-square test for trend revealed a significant effect of age on the children's ability to locate the puppet, $\chi^2(1, N = 96) = 8.508$, $p = .0035$. The 4-year-olds' performance did not differ from chance (19/32 correct; binomial test, *ns*), although the 5-year-olds' did so strongly (28/32 correct; binomial test, $p < .0001$). There was no relation in any group between the order in which the children heard the scripts (self script first vs. other-child script first) and correct performance, although there was a marginally significant effect for the 4-year-olds in tending to select the box that was highlighted in the first tape they saw (21/32 cases; binomial test, $p < .06$).

In summary, the prediction that the 3-year-old children would choose randomly between the two buckets when asked to locate the puppet was strongly supported. Despite the fact that the crucial information was presented verbally, the task was no easier (and may have been more difficult) than the video versions of the task used in Studies 1 and 3. One possible explanation for this result is that the video playbacks provided rich contextual images of the events in which the children just participated, as well as of the hiding events, and perhaps made the relevant information more salient.

Study 5

The results of Studies 1 through 4 are consistent with the notion that between 3 and 5 years of age, young children construct a notion of time as a series of causally linked events. However, these studies involved a contrast between self- versus other-related events. Thus, the kind of understanding mediating the older children's successful performances may be open to question. For example, rather than updating their existing representations of the events in question, and then using these new representations to infer the current location of the puppet, 4–5-year-olds might simply have been more captivated by the information in the self tapes (or scripts) and thus have used a kind of "self-binding" heuristic to select the location depicted or mentioned in the self tape or the self script. To assess this explanation, we exposed 3- and 4–5-year-olds to video playbacks of two games in which they had just participated, and we assessed whether they could make the causal inference that the information in the second event (i.e., the most recent event) was diagnostic with respect to the puppet's current location.

Table 4
Numbers and Percentages of Children Who Successfully Located the Puppet in Each Age Group Using Verbal Information in Study 4

Age (in months)	n	%
36–47	17	53
48–59	19	59
60–71	28	88

Note. For each age group, n = 32.

Method

Participants

Thirty-two children participated: sixteen 36–47-month-old children (M = 41 months; Mdn = 38 months; 10 boys and 6 girls) and sixteen 54–66-month-old children (M = 60 months; Mdn = 61 months; 8 boys and 8 girls). Participants from previous studies were excluded. In addition to the final 32 participants, there were 7 children whose data were not used: 4 were excluded because they departed from the protocol, and 3 were excluded because of experimenter error.

Procedure

Warm-up phase. During warm-up, the second experimenter introduced a Mickey Mouse puppet to the child and incorporated it into the play activities. Once the child appeared comfortable with the experimenters, the child was invited into the testing room to "play some fun games."

Playing the games. As soon as the child entered the testing room, the first experimenter oriented him or her to two boxes (red and blue and of different sizes) that were mounted on the wall 60 cm from the floor. The experimenter opened both of the boxes and let the child see that they were empty. The second experimenter entered the game room and, with the Mickey Mouse puppet clearly visible, told the child that he or she and Mickey would sit in a chair that was equidistant between the two boxes and would watch the first experimenter and the child play.

The first experimenter then led the child to a mat on the floor that was 90 cm in the front of the second experimenter and equidistant from the two boxes. The child was seated on the mat so he or she was turned away from the boxes and the second experimenter. The first experimenter and the child began a game of making airplanes. As in previous studies, a video camera clearly recorded the child and the first experimenter and, behind the child, the boxes and the second experimenter. As in the previous studies, the puppet was hidden while the child's attention was focused on playing the game (in this case, making the airplanes). After the puppet was hidden and the child had played the airplane-making game for 3–5 min, the child and the first experimenter picked up all props related to the game and handed them to the second experimenter (who removed them from the room).

Next, the first experimenter explained to the child that it was time to play a second game. The child was positioned with his or her back to the second experimenter and the two boxes. The first experimenter placed a large bucket 90 cm in front of the child and then showed the child how to fly the airplanes they had just made (plus several others) into the bucket. A video camera captured the scene in the same manner as in the first game. As the child was flying the planes and facing away from the boxes, the second experimenter removed the Mickey Mouse puppet from the box in which it was located and moved it to the other box. After transferring the puppet, the second experimenter prepared the videotapes and positioned a cabinet containing two video monitors (32 × 36 cm) stacked on top of each other. The cabinet was positioned equidistant from both boxes.

Viewing the games. After 3–5 min of the airplane-flying game had elapsed, the second experimenter told the child, "Hey, I have another fun game we can play. Let's watch ourselves with the airplanes on TV." The two experimenters encouraged the child to help pick up all of the props related to the game and remove them from the room. Next, the child and the experimenters faced the monitors (90 cm) and observed the two tapes that had been made. A video camera recorded the child's behavior.

At this point, the second experimenter said, "Hey, [child's name], we can't look now, but I think the Mickey Mouse puppet is hiding in one of those boxes [points to both boxes from left to right]. Let's watch the TVs and see if we can find out where he's hiding." Next, the child viewed the tapes, one at a time, beginning with the bottom monitor in all cases. One of the tapes showed 10 s of the child and the first experimenter making paper airplanes, followed by the second experimenter lifting the Mickey Mouse puppet and hiding it in one of the two boxes. The other tape depicted the analogous scene from the airplane-flying game. This segment ended with the second experimenter removing the Mickey Mouse puppet from one box and placing it in the other one. The viewing order of the two tapes was counterbalanced as follows. First, half of the children (n = 8) in each group viewed Game 1 followed by Game 2; the other half (n = 8) viewed Game 2 followed by Game 1. These groups were further divided into subgroups so that equal numbers of children (n = 4) saw the puppet hidden in the red box first and the blue box first.

As soon as each tape began, the first experimenter said, "Hey look! Boy, that was fun making/flying those airplanes!" and at the moment before the second experimenter either lifted the Mickey Mouse puppet from his or her lap or removed it from the first box, said, "Hey look! That's Mr./Miss [second experimenter's name]. Hey look! He/she's got Mickey. He/she's putting him in the [appropriate color] box." Immediately after each segment revealed the second experimenter hiding the puppet and closing the box lid, the image was paused. The paused image depicted the child either making or flying paper airplanes in the foreground and the second experimenter in the background leaning toward the box in which the puppet had just been placed. This image remained on the video monitor during the child's viewing of the second tape. (The purpose of pausing each tape was to assist the child in holding in mind the actual chronological ordering of the two events so as to more accurately distinguish between the models depicted in Figures 1b and 1c.)

The second tape was viewed in the same manner and was paused at the same juncture as the first. At the conclusion of both tapes, with both images paused on the monitors, the first experimenter asked the child two questions. Pointing in the general direction of the appropriate monitor (but not to either box), the experimenter asked, "Hey, [child's name], while you and I were making/flying the paper airplanes, which box did Mr./Miss [second experimenter's name] put Mickey in?" If the child did not respond, the experimenter asked, "Do you remember which box Mr./Miss [second experimenter's name] put Mickey in?" This procedure was repeated for the next monitor as well. The order of these two questions was counterbalanced so that half of the children were initially asked the question about the first game they played, and the other half of the children were initially asked about the second game they played. The purpose of these questions was to remind the children of where the puppet had been hidden and to assess a possible relation between their ability to verbally recall what they had just seen and their ability to locate the puppet. Finally, after the child was asked the two questions, the first experimenter faced the child and prompted him or her to find the puppet in the same manner as in the previous studies.

Data Analysis

A main rater was administered a set of written instructions for coding the video records of all 32 children in the study. A second rater was given an identical set of instructions and was asked to code a sample of 50% of the children (n = 16). The instructions requested the raters to record in which box each child first searched. The reliability rater agreed with the main rater on 16 of 16 cases (κ = 1.00). Next, the raters were asked to code the children's verbal and nonverbal responses to the two questions they were asked. For verbal responses, the raters agreed on 14 of 16 cases (both disagreements were omission–commission errors) for the first question and 16 of 16 cases for the second question (κs = .82 and 1.00, respectively). For nonverbal responses (e.g., pointing to a box), the raters agreed on 16 of 16 cases for both the first and second questions (κ = 1.00 in both cases). The main rater's data were used in all subsequent analyses.

Results and Discussion

The main rater's data were summarized to determine (a) whether each participant chose the appropriate box ("yes" or "no") when asked to locate the puppet and (b) the number of questions he or she answered correctly (0, 1, or 2).

The numbers and percentages of children who chose the correct box are displayed in Table 5 and show that the younger children responded as would be expected by chance. In contrast, the older children performed in the direction predicted by the model under study, with 69% responding correctly. However, this performance did not exceed levels that would be expected by chance (11/16 children correct; binomial test, $p = .11$). A closer inspection of the effect of the order in which the children viewed the games (Game 1 first vs. Game 2 first) revealed that although it had no effect on how the younger children performed (3 correct and 5 incorrect vs. 5 correct and 3 incorrect), it may have influenced the older children's performance (7 correct and 1 incorrect vs. 4 correct and 4 incorrect). Thus, when they saw the games played back in the order in which they had actually happened, the older children, unlike the younger children, had little trouble locating the puppet. This was not the result of the older children's simply choosing the location depicted in the last tape they observed, because (as just reported) they did not do so when the order was reversed. The younger children, in contrast, tended to select the box depicted in the last video they observed (in 10 of 16 cases).

Finally, we examined the children's responses to the two questions we asked about the events they had just observed. First, there was no statistically reliable age difference in the mean number of questions answered correctly, $t(30) = 1.481, p = 0.149$), although the older children tended to answer more questions correctly ($M = 1.5$, $SD = 0.82$) than the younger children ($M = 1.1$, $SD = 0.85$). More important, with age collapsed, there was no relation between the number of questions answered correctly (0–1 or 2) and whether the children selected the correct box (see Table 6; Fisher's exact test, $p = 1.00$). As can be seen from Table 6, even the children who answered both questions correctly responded at chance levels when asked to find the puppet.

Although the older children experienced more difficulty than predicted, in general the data provide some evidence that the older children had an ability to use the novel information in the tapes (the puppet being hidden) to update their reference time lines and thus successfully report the puppet's current location. Younger preschoolers displayed no evidence of such an ability. However, the data on this point are not definitive, and thus we considered several aspects of the current study that may have masked an even more mature understanding on the part of the older children or, for that matter, the younger children as well. In particular, two aspects of the current procedure seemed worthy of scrutiny. First, although we intentionally kept the two games causally dependent on one another (first making and then flying the airplanes), this resulted in a tight thematic relation between the two events that may have interfered with either the children's initial encoding of the events as distinct or their later retention of the events as distinct. In either event, this tight thematic association may have made it more difficult for the children to keep the order information distinct and thus may have interfered with an (existing) ability to update their reference time lines and then make the correct causal inference. Second, although the procedures of pausing both videos and asking the questions were intended to assist the children, they may, of course, have had the opposite effect of confusing them. Thus, in Study 6, we altered these aspects of the procedure and then compared the performance of 3-year-olds with that of 5-year-olds to assess whether under more favorable conditions only the older children's performance might improve or both the younger and older children's performances might improve equally.

Table 5
Numbers and Percentages of Children Who Successfully Located the Puppet in Study 5

	Box selection			
	Correct		Incorrect	
Age (in months)	n	%	n	%
36–47	8	50	8	50
54–66	11	69	5	31

Note. For each age group, $n = 16$.

Table 6
Relation Between Number of Correct Answers to Memory Questions and Ability to Successfully Locate Puppet in Study 5

		Number of correct answers	
Child's selection	n	0–1	2
Correct box	19	9	10
Incorrect box	13	6	7

Study 6

In this study, we returned to the original procedure that involved only a single video monitor during playback (thus eliminating the problem of having both images visible as the child was asked to find the puppet). Also, for the reasons described above, we eliminated the questions following playback. In addition, we attempted to maximize the difference between each game by having experimenters wear costumes that were related to two very distinct games, by decorating the game room with posters related to the two games, and by having the child participate in the transformation of the room between games (taking down the game and posters before the next game was set up). Finally, we added strong temporal markers into the narration of the video playback to help the children remember which game occurred first and which occurred second.

Method

Participants

Sixty-four children participated in this study: thirty-two 36–47-month-old children ($M = 42$ months; $Mdn = 41$ months; 16 boys and 16 girls) and thirty-two 60–71-month-old children ($M = 66$ months; $Mdn = 66$ months; 16 boys and 16 girls). Children who participated in Study 5 were not eligible for this study. In addition to the final 64 participants, there were 18 other children (9 three-year-olds and 9 five-year-olds) whose data were not used because they departed from the protocol (1 child searched in one of the houses prematurely, 9 children saw the puppet being hidden, and 8 children were not used because of experimenter error).

Procedure

The temporal sequence about which the children were asked to reason was composed of two distinct games that were separated by a 5-min break in which the children returned to the warm-up area. The two games were a crawfish board game and an airplane-flying game. The order of the games was counterbalanced as described below. Each game took place in the testing room, which was decorated with large wall posters related to the theme of the current game. The two experimenters also wore distinctive attire (straw hats, pilot hats, goggles, jumpsuits) emphasizing the theme of each game.

Warm-up. During the initial warm-up period, the child was introduced to a Tigger puppet, and this puppet was then incorporated into the play activities. Once the child was comfortable, one of the experimenters retrieved the appropriate game attire from another room, and as the two experimenters donned the relevant apparel they invited the child into the game room to play the game in question. The order of the games was counterbalanced, but we illustrate the procedure here by describing the order in which the crawfish game came first.

Playing the games. Upon entering the test room, the first experimenter introduced the child to two empty animal houses—a bird's nest and a doghouse—that were positioned on the floor and separated by 120 cm. The bird's nest was a round wicker basket turned on its side (35 cm in diameter and 28 cm deep) with a burlap curtain that could be used to obscure the contents of the nest. The doghouse (21 × 50 × 48 cm) was made of cardboard and possessed a curtain hung in the doorway that could be opened or closed. A chair was positioned midway between the animal houses.

Next, the child and the first experimenter sat across from each other at a table so that the child's back was to the animal houses. The second experimenter then entered the testing room with the Tigger puppet and explained to the child that she and Tigger were going to sit in the chair that was midway between the animal houses and watch them play the game.

As the first experimenter and the child played the crawfish game, a videocamera captured the following on tape: (a) the crawfish game board, (b) the child playing the game, and (c) the two animal houses and the second experimenter who sat between them. Once the child was focused on the game, the second experimenter hid the Tigger puppet in the predetermined animal house and closed the curtains on both animal houses. Once the hiding event was over, the second experimenter cued the video as in the previous studies.

After the child had played the crawfish game for 3–5 min, the child assisted the experimenters in picking up the game and taking the posters off the walls. The first experimenter then took the child back into the warm-up area; meanwhile, the second experimenter prepared the testing room for the next game (in this case, the airplane game). Once the room was prepared, the second experimenter opened the curtains on both of the animal houses and joined the child and the first experimenter in the warm-up area. After interacting with them for a moment, the second experimenter told the child: "Oh, wow, I forgot Tigger in one of those animal houses. I put him in there while you guys were playing the crawfish game. I'll be right back." The second experimenter quickly retrieved the Tigger puppet from the game room and returned. After the child had been in the warm-up area for 4 min, the two experimenters explained that it was time to play the airplane game and began to dress in the relevant apparel.

Upon entering the game room, the first experimenter pointed out all the new airplane posters to the child. The animal houses were not explicitly reintroduced, but both were open and empty as at the start of the first game. The airplane game consisted of the child's standing on footprints (with his or her back to the animal houses) and flying premade paper airplanes into a bucket. Just before the child began, the second experimenter entered the room with the Tigger puppet and told the child that she and Tigger would sit between the animal houses and watch them play. As before, at the designated point, the second experimenter hid the Tigger puppet and placed it in the house opposite from the one she had placed it in during the crawfish game, and she then closed the curtains over both animal houses. The second experimenter then cued the second videotape and rolled the video monitor (30 × 40 cm) into a position midway between the animal houses.

Video playback. After 3–5 min, the airplane game ended and the second experimenter told the child, "Hey, [child's name], I have another fun game we can play. Let's watch ourselves with the fun games on TV." The child and the experimenters removed all Game 2 props and posters from the room. The child was seated facing the video monitor with the experimenters on either side, as before.

Before the child viewed the first tape, the second experimenter said to the child, "Hey, [child's name], we can't look now but Tigger is hiding in one of those animal houses [pointing to both animal houses from left to right]. Let's watch the TV and see if you can find out where he's hiding." The child viewed the tapes, one at a time, on the same video monitor (unlike in Study 5, there was only one monitor present). The first tape depicted 20 s of the child playing the crawfish game and ended with the second experimenter hiding the Tigger puppet in an animal house and then closing that house. The other tape depicted 20 s of the child playing the airplane game and ended with the second experimenter hiding the Tigger puppet in the opposite animal house and closing that house.

The second experimenter narrated each video segment. For the segment depicting the first game that the child had played, the experimenter said, "Hey look! It's the crawfish game! Remember? That was the *first* game you played. [pause] Remember? When you first got here you played that game!" At the moment before the video depicted Tigger being lifted, the experimenter said, "Hey look! That's me!" followed by "See, I've got Tigger, and look, I put him in the [name of appropriate animal house] while you guys were playing the crawfish game!" For the segment of the second game, the experimenter said, "Hey look! It's the airplane game! Remember? That was the *last* game you played. [pause] Remember? You just played that game." At the moment before the experimenter pulled the puppet from her lap, the second experimenter said, "Hey look! That's me!" followed by "See, I've got Tigger, and look, I put him in the [name of appropriate animal house] while you guys were playing the airplane game!" Finally, after both tapes had been viewed, the second experimenter prompted the child to get up and retrieve the puppet as in the previous studies.

Counterbalancing. The order in which the children played the particular games (crawfish game first vs. airplane game first), the order in which the children viewed the games during playback (Game 1 first vs. Game 2 first), and the animal house in which the puppet was hidden (doghouse or bird's nest) were counterbalanced according to the following scheme. First, the 32 children in each of the two age groups (3- and 5-year-olds) were assigned to two groups (matched to the nearest month within age group). One group (n = 16) saw the segment from Game 1 first, followed by the segment from Game 2. The second group (n = 16) saw the segments in the opposite order (i.e., Game 2 followed by Game 1). Second, these subgroups were further divided so that equal numbers of children (n = 8) played each type of game (crawfish and airplane) first. Finally, these subgroups were further divided so that for each of the games, the puppet was hidden equally between the bird's nest and the doghouse (n = 4 per group).

Data Analysis

A main rater was administered a set of written instructions for coding the video records of all 64 children in the study. A second rater was given an identical set of instructions and was asked to code a sample of 16 of the children (8 three-year-olds and 8 five-year-olds). The instructions requested the raters to record the animal house in which each child first searched. The reliability rater agreed with the main rater on 16 of 16 cases (κ = 1.00). The main rater's data were used in all subsequent analyses.

Results and Discussion

The main results of this study are presented in Table 7. First, as predicted by the model of children's understanding that is depicted in Figures 1a and 1b, the 3-year-old children's performance did not exceed that expected by chance (19 correct and 13 incorrect; binomial test, $p = .19$, *ns*). In contrast, the 5-year-olds performed at levels strongly exceeding chance (25 correct and 7 incorrect; binomial test, $p = .001$). Finally, there was no significant relation between the order in which the events were played back to the children and their task performance (Fisher's exact test, two-tailed, $p = .42$, *ns*), and in particular, unlike the results obtained in Study 5, the older children performed equally well when the order of playback matched the actual order in which the events had occurred and when it did not (Fisher's exact test, two-tailed, $p = 1.00$, *ns*). These results provide strong confirmation for the idea that 5-year-olds are capable of appreciating that occurrences during the most recent of two events in which they have just participated are most relevant for the present state of the world. In this sense, the results show that whatever the reasons for the older children's success in Studies 1 through 4, 5-year-olds are capable of using more than a self-binding heuristic to interpret the playback of briefly delayed images of the self. In short, they appear to understand the causal structure of time and their own place in it.

General Discussion

The results of these studies provide support for the idea that at some point between 3 and 5 years of age, children come to understand that the events from their recent past are part of a causal arrow of time—a flow of events leading up to and causally determining the present. Studies 1, 3, and 4 suggest that 4–5-year-olds, but not younger children, understand the differing implications of (a) events in which they have recently taken part and (b) nearly identical events that occurred to some other child at some other, unspecified time point: namely, that the events in which they participated are causally relevant to the present state of affairs in their world. Significantly, the results of Studies 1 through 4 show that the 3-year-olds in our tests clearly perceived and reported important aspects of the difference between the self and other-child video playbacks (as evidenced by their ability to correctly answer questions about who they were seeing on the video playbacks; see also Povinelli et al., 1996; Povinelli & Simon, 1998). Curiously, however, they did not seem to use a simple self-binding heuristic to locate the puppet when asked to do so. That is, it might be expected that even without explicitly understanding the differing implications of events depicted in the videos, younger children might simply find the events in the self tape more associated with themselves and their current experience than the events depicted in the other-child tape. However, the results of Studies 1 and 3 (and, with respect to the verbal analog of this idea, Study 4) clearly show that 3-year-olds do not use such a heuristic. Conversely, the performances of the 4–5-year-olds in Study 5 and especially of the 5-year-olds in Study 6 demonstrate that the correct performance of the older preschoolers in Studies 1–4 need not be viewed as dependent on such a simple association between the self's image and the hiding location. Thus, when both tapes involved events in which they themselves participated (as in Studies 5 and 6), older preschoolers were able to appreciate that the events that occurred most recently were most causally relevant to the here and now.

Table 7
Numbers and Percentages of Children Who Successfully Located the Puppet in Study 6

	Box selection			
	Correct		Incorrect	
Age (in months)	*n*	%	*n*	%
36–47	19	59	13	41
60–71	25	78	7	22

Note. For each age group, $n = 32$.

The construction of this kind of temporal understanding may be intimately involved with the development of autobiographical memory, which may not emerge until about 3–4 years of age. Indeed, both Nelson (1992, 1993) and Perner (1990, 1991) proposed that the fact that most people do not have genuine memories of events that occurred prior to about 3½ years of age indicates that a specific kind of memory—autobiographical memory—develops at about this time. This proposal should not be confused with the (erroneous) claim that young children do not have memories of events from the distant past. Even infants as young as 2 years of age can report events that happened in the relatively distant past (e.g., Nelson, 1989). However, these early memories are not retained into adulthood. A number of researchers have attempted to relate the emergence of autobiographical memory to factors such as children's developing understanding of mental representation, the construction of personal narratives with their mothers, and differing styles of maternal language in conversations about the past (Fivush & Hamond, 1990; Hudson, 1990; Nelson, 1992; Perner, 1991; Welch-Ross, 1997). Part of this process clearly involves the developing understanding of the temporal extension of the self—a representational system that allows the child to connect specific past events with specific instances of the self (and vice versa). On the basis of previous research from our laboratory examining 2–5-year-olds' reactions to delayed video images of themselves, we have proposed that until a temporally unified self emerges, the child may not be able to adopt an autobiographical stance toward previous events (Povinelli & Simon, 1998).

One important methodological issue for the present studies, as well as for our previous studies involving delayed video feedback of the self, concerns whether younger children may have some specific trouble understanding that the events depicted on video refer to objects in the real world. Several of our findings mitigate against this view. First, Study 2 revealed that 3-year-olds have no difficulty appreciating the equivalence between what they see on video and what they see in the real world. Second, Study 3 revealed that 3-year-olds spontaneously and appropriately reference the real-world counterparts of objects seen on delayed video. Third, Study 4 revealed that younger children experienced the same (or greater) difficulty when we dispensed with the video medium altogether and presented the relevant information verbally. Fourth, children perform better on tests involving live video feedback than tests involving delayed feedback (Povinelli et al., 1996, Experiment 3), and this better performance holds true even if the delay is only 2 s (Povinelli, 1998). Finally, Troseth (1997, Experiment 1) showed that in a simple video search task, even children as young as 30 months (6 months younger than the youngest 3-year-olds from Study 1) were able to witness an object being hidden on video and then successfully locate it. Thus, the simple claim that the younger children's difficulty in understanding the equivalence between delayed video images and the real world accounts for their performance on our tests may be difficult to reconcile with a host of other empirical facts.

In summary, the results of these studies suggest that by around 4–5 years of age, children understand that events from their recent past causally determine the present state of the world. To some extent, these results provide support for certain aspects of the autobiographical stance model of the development of young children's ability to reason about delayed self-images offered by Povinelli (1995; see also Povinelli & Simon, 1998). This model argues that the development of young children's ability to pass tests of delayed self-recognition (e.g., Povinelli et al., 1996) is based on broad cognitive changes not specifically related to the self's physical appearance. The current studies bolster this view by showing that the development of children's ability to reason about the causal connections between current states of affairs and events from their very recent past includes an ability to reason about transformations of the world not directly involving the self's physical appearance. This finding, of course, should not be confused with a related but different question concerning whether domain-general or domain-specific cognitive changes are responsible for the emergence of an autobiographical conception of the self (which in turn allows older children to understand the nature of previous events differently; e.g., Povinelli, 1995). For now, we merely note that the present data allow for either possibility.

In any event, the development of the proper self would seem to have cascading consequences for young children's ability to reason about events from an autobiographical standpoint. Indeed, nothing could highlight this point better than the fact that the younger children in Studies 1 through 4 failed to use a simple strategy of associating their own image with a particular puppet location, coupled with the fact (demonstrated in Studies 5 and 6) that the older children's performance did not depend on such a simple strategy. Finally, it is important to note that the present results leave open the question of whether the understanding of the causal arrow of time displayed by older preschoolers (see, especially, Study 6) is narrowly restricted to their interpretation of very recent past events in which they actively participated or is more abstract.

As a final consideration, we note that neither the results presented here nor those reported previously by Povinelli et al. (1996) and Povinelli and Simon (1998) clearly distinguish between two alternative ways in which 3-year-olds may understand previous events. First, it is possible that 3-year-olds conceive of past events as part of a genuine "past"—a time prior to the present. Our data are consistent with the possibility that 3-year-olds are ontologically committed to a distinction between past events on the one hand and present and future events on the other, but 3-year-olds do not necessarily understand how or why past states are causally bound to the present. So, for example, in the studies reported here, the younger children may have extracted genuinely new information about previous events from the video images they observed or the verbal scripts they heard but simply not have understood why one piece of information about the past (e.g., where the puppet was hidden in the self tape) was more relevant for the current state of affairs than the other piece of information (e.g., where the puppet was hidden in the other-child or stranger tape). Although such an explanation is possible, it is equally important to note that we know of no data that directly exclude the possibility that 3-year-olds' excellent memories of past events are not conceived of as "past" events at all. If this explanation is true, 3-year-olds may well conceive of an experiencing "now" on the one hand and of memories and imaginations on the other (see Nelson, 1989, for a similar proposal). Indeed, although it is a somewhat radical proposal, it is possible that for 3-year-olds, the only clear distinction between memories and imagination is the vividness of the mental imagery associated with the mental act of remembering versus the mental act of imagining. Current research in our laboratory is addressing this question. In either event, the results presented here continue to support the idea that it is not until 4–5 years of age that the young child comes to conceive of the self as unique and unduplicated—a self determined by the historical–causal interactions that lead from past to present and ultimately into an unknown future.

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