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The Influence of Prior Knowledge and Repeated Questioning on Children's Long-Term Retention of the Details of a Pediatric Examination

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Children's recall of the details of pediatric examinations was examined over the course of a 6-month interval. Although the 83 4- to 7-year-old participants reported a substantial amount of information at each assessment, performance declined over time, dropping sharply over the course of 3 months but then remaining constant out to the final interview at 6 months. As expected, older children provided more total information than younger children did and reported a greater proportion of the event components in response to general rather than specific questions. However, comparable patterns of remembering and forgetting over time were observed at each age level. In addition, no effects of repeated questioning—in the form of an interview at 3 months for half of the children—were observed on performance at the 6-month assessment. Moreover, children's prior knowledge about routine doctor visits was assessed before the checkup for half of the participants at each age and was associated with initial but not delayed recall. Although knowledge increased with age as expected, it nonetheless affected recall over and above the influence of age.

Keywords: children, long-term memory, knowledge, repeated questioning

Children's autobiographical memory over long delays has been examined recently in a number of important investigations (see Fivush, 2002). For example, Peterson and her colleagues (Peterson, 1999; Peterson & Bell, 1996) found that preschoolers' reports of stressful experiences—injuries and subsequent emergency-room treatments—remained as detailed and accurate over a period of 2 years as they were shortly after the events. Moreover, 5 years after the event, the children retained many of the central components of the injury experience, although they were less successful in recalling the hospital episode (Peterson & Whalen, 2001). Similarly, Fivush and her collaborators (Fivush & Schwarzmueller, 1998; Fivush & Shukat, 1995) documented impressive long-term memory in young children. They observed that children initially interviewed at age 3 about personally selected positive experiences provided as much correct information 1 and even 5 years after the initial assessment as they did at the first report. Further work has documented children's excellent recall of a highly stressful event, a major hurricane that made landfall in their city, 6 years after it occurred (Fivush, Sales, Goldberg, Bahrick, & Parker, 2004). However, other research indicates that after extended delays, children's reports do not always remain as accurate and detailed as they were initially (Pipe, Gee, Wilson, & Egerton, 1999). Indeed, younger children can lose significant amounts of information over even a 3-month interval (Ornstein, Baker-Ward, Gordon, & Merritt, 1997). In some instances, key components of events may be lost over time, even among school-age children (Poole & White, 1993). It is thus apparent that children's long-term retention of personal experiences cannot be predicted simply on the basis of age or the length of the delay between memory assessments. As such, our purpose in this study was to examine the effects of two factors—knowledge and reinstatement through repeated questioning—that may affect children's memory for a salient personal experience over a 6-month interval.

Prior Knowledge

A great deal of evidence indicates that what an individual knows has a considerable impact on what he or she is able to remember (see Bjorklund, 1987; Chi & Ceci, 1987; Ornstein & Naus, 1985).

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Prior event-related knowledge facilitates the encoding, storage, retention, and retrieval of experiences over time (Nelson, 1986; Ornstein, Shapiro, Clubb, Follmer, & Baker-Ward, 1997) but can also lead to errors in delayed recall when events differ from expectations (e.g., Bartlett, 1932; Leichtman & Ceci, 1995; Myles-Worsley, Cromer, & Dodd, 1986; Ornstein et al., 1998). A body of work has established that prior knowledge enables an individual to attend effectively to the environment, to encode central aspects of an event that is being experienced, and to store information in an interconnected representational structure that can be accessed through multiple cues (for a review, see Baker-Ward, Ornstein, & Principe, 1997). Moreover, age-related differences in the contents and organization of the knowledge base have been linked to corresponding changes in children's memory performance (Bjorklund, 1987; Brown, 1975; Ornstein & Naus, 1985). In a now-classic demonstration of the effects of knowledge, Chi (1978) observed that the typical age-related increase in performance is reversed when memory is assessed within a domain in which children are experts and adults are novices, and much has been learned about linkages between knowledge and remembering on the basis of expert–novice comparisons (e.g., Schneider, Korkel, & Weinert, 1989).

Naturally occurring variations in knowledge are also associated with variability in children's memory for personally experienced events. For example, Goodman, Quas, Batterman-Faunce, Riddlesberger, and Kuhn (1997) explored the relation between children's prior knowledge regarding an invasive medical procedure and their subsequent reports of the experience and found that greater knowledge—indexed by parental reports of what their children believed would happen—was associated significantly with higher rates of correct responses to misleading questions. Moreover, other researchers have demonstrated connections between children's general knowledge of various types of events and their recall of specific instances of these event categories. To illustrate, in a study designed to establish norms of what 5-year-olds know about pediatric office visits, Clubb, Nida, Merritt, and Ornstein (1993) showed that generic knowledge of their normative sample was predictive of what other children could remember about a specific visit to the doctor for a well-child checkup. More specifically, Clubb and her colleagues constructed *knowledge scores* for each component of the office visit—defined in terms of the proportion of children who reported each feature in response to open-ended probes—and then related them to parallel *memory scores* for the individual features that were calculated from the data reported in an earlier study of children's memory for a well-child checkup (Baker-Ward, Gordon, Ornstein, Larus, & Clubb, 1993). In this feature-based analysis, Clubb et al. found that the two sets of scores were strongly correlated ($r = .74$, $p < .01$), such that the features for which children in the normative sample had more knowledge were better remembered than were those for which they had less knowledge.

In an extension of this normative approach to the knowledge–memory linkage, Ornstein, Shapiro, et al. (1997) used cluster-analytic techniques to identify four groups of medical features that exhibited contrasting retention functions over a period of 6 weeks after a physical examination. For example, the features in the first group (e.g., blood test, prizes, inoculation) were remembered well initially and were retained over the delay interval, whereas those in the fourth group (e.g., blood pressure, urinalysis, checks of feet and heels) were not recalled well at any assessment point. When Ornstein and his colleagues calculated the average knowledge scores for these four groups of features, they found that the high-knowledge features were associated with good long-term retention, whereas the low-knowledge features were less memorable over time. Additional analyses, based on Bender, Wallsten, and Ornstein's (1996) use of a multinomial model to characterize the data of Baker-Ward et al. (1993), suggested that children's knowledge of physical examinations impacts both encoding and retrieval processes but has an especially strong influence on encoding.

The present investigation was designed to extend in three major ways current understanding of the effects of knowledge on recall. First, in contrast to the normative work cited above, measures of both knowledge of a pediatric examination and recall of the experience were obtained from the same children. Moreover, with the inclusion of the necessary control for the effects of the knowledge interview, this procedure enabled a more sensitive examination of the knowledge–recall linkage than did earlier work and permitted a direct exploration of the effects of knowledge on forgetting across the retention interval. Second, knowledge and recall were examined among groups of children at each age level between 4 and 7 years, inclusive. This not only provided a more complete description of the effects of knowledge on recall but also enabled an examination of the independent contributions of age and knowledge on recall. Third, the knowledge–recall relation was studied over an extended period of 6 months, with each participant completing an initial and a delayed interview. With this design, it was possible to explore more precisely the relative impact of knowledge on both encoding and delayed recall.

Repeated Questioning

The effects of repeated questioning on children's retention after an extended delay were also examined in this investigation. It is well-known that misleading questions can result in increases in suggestibility among children and adults and that false reports become more likely when such questioning occurs on multiple occasions (see Bruck & Ceci, 1999). In addition, the repetition of closed questions within the context of an interview (Memon & Vartoukian, 1996; Poole & White, 1993) can result in a decrease in accuracy, even after long delays (Poole & White, 1993). However, the potentially reinstating effects of repeated verbal interviews in the absence of suggestive questioning remain somewhat unclear. A large body of evidence representing a variety of theoretical and methodological traditions indicates that additional presentations of aspects of a previous experience can serve to maintain memory over extended delay intervals (e.g., Campbell & Jaynes, 1966; Howe, Courage, & Bryant-Brown, 1993; Rovee-Collier & Hayne, 1987). To the extent that a verbal interview can be viewed as a reinstatement of an earlier experience, additional interviews would be expected to result in enhanced accuracy and decreased forgetting, although the effects seem to depend on the length of the delay and children's age.

The literature presents inconsistent effects of repeated interviews on children's event recall. With regard to the effects of an initial interview, Baker-Ward and her colleagues (1993) found that 3-, 5-, and 7-year-old children who were and were not interviewed immediately after a pediatric checkup did not differ in their memory performance after a 3-week delay. In contrast, Tizzard-Dover and Peterson (2004) observed that an initial interview had beneficial effects on memory as assessed 1 year later among 3–4 year olds but not among older children. Moreover, with regard to interviews conducted somewhat later during a retention interval, more extensive evidence for reinstatement can be found, although the effects are not consistent. Principe, Ornstein, Baker-Ward, and Gordon (2000) reported that both 3- and 5-year-old children who were interviewed immediately after a medical examination and again midway through a 12-week delay interval reported more components of their checkups at the final interview than did those who did not have the extra interview. The repeated interview benefited both open-ended and prompted recall and did not increase the children's false alarms to questions about typical or atypical examination components that did not occur. In addition, Gee and Pipe (1995) found that a verbal interview conducted 10 days after a staged event ameliorated forgetting after 10 weeks among 9-year-old but not 6-year-old children. However, in a follow-up study conducted after 1 year, no effects of the intervening interview were observed (Pipe et al., 1999).

By extending the interval between the pediatric checkup and the final assessment in this study to 6 months, it was possible to examine the potentially reinstating effects of an additional interview about the office visit after a delay of 3 months. In this regard, expectations about the effectiveness of this interview in maintaining memory over 6 months were mixed because reinstatement effects depend on the availability of information in memory (see Rovee-Collier & Hayne, 1987). On the one hand, it was felt that sufficient information about the physical examination would still be available at this point in time to serve as a foundation for reinstatement. Yet, on the other hand, because a considerable amount of information is lost after 3 months (Principe et al., 2000), with knowledge-based errors beginning to be observed in children's reports (Ornstein et al., 1998), it also seemed possible that an interview 3 months (as opposed to 6 or 8 weeks) after the checkup would not influence subsequent recall at 6 months.

Method

Participants

A total of 105 children between the ages of 4 and 7 years were recruited from two pediatric practices in the Piedmont region of North Carolina. These medical offices generated lists of children who had been scheduled for regular well-child checkups and whose families had agreed to be contacted about possible research participation. From these lists, families were randomly selected and contacted via telephone. During these conversations, the study was explained, verbal agreement to participate was obtained, and the time and date of the physical examination were confirmed. Of the families who agreed to participate, the data for 22 children (distributed evenly across the age range) were subsequently dropped for various reasons, including equipment failure, interviewer error, and difficulty in scheduling follow-up interviews. The resulting sample was thus composed of 83 children: 21 four-year-olds ($M = 51.86$ months, $SD = 3.76$); 22 five-year-olds ($M = 63.73$ months, $SD = 3.48$); 20 six-year-olds ($M = 74.15$ months, $SD = 3.53$), and 20 seven-year-olds ($M = 87.30$ months, $SD = 3.96$). The sample was composed of approximately equal numbers of girls (48%) and boys (52%), and the girl/boy ratio was comparable across the various cells in the design. Reflecting the characteristics of the suburban communities in which the pediatricians' offices were located, the sample consisted primarily of White children from middle- and upper-middle-class families. The parents indicated that approximately 90% of the children were of European American heritage and that both mothers and fathers completed approximately 16 years of education each.

Experimental Design

The participants were assigned randomly, within age, to one of four groups that were defined in terms of the number and types of interviews that were administered. Table 1 outlines the experimental design and the number of participants at each age level assigned to each group. As can be seen, all of the children received an immediate and a 6-month-delayed memory interview. However, only half of the participants were asked to recall the pediatric exam after 3 months. Moreover, for half of the sample, knowledge assessments were carried out prior to the regularly scheduled pediatric examination.

Physical Examinations

A total of six pediatricians and five nurses provided medical care to the participants. Prior to the investigation, discussion with the medical staff at each practice resulted in the identification of 19 component features of the physical examination. As can be seen in Table 2, these features represented procedures that are typically administered during routine well-child checkups.[1] Each examination consisted of two parts, with the child being seen first by a nurse and then by a doctor. Because physical examinations vary somewhat from child to child, each checkup was composed of a subset of the features listed in Table 2. On average, the 4-, 5-, 6-, and 7-year olds, respectively, experienced 14.43 ($SD = 1.78$), 15.86 ($SD = 0.99$), 15.25 ($SD = 1.07$), and 15.10 ($SD = 1.33$) medical features during their physical examinations. In addition, to differentiate this checkup from other routine office visits, the nurses were asked to take a Polaroid photograph of each child. During the pediatric examination, the doctors, nurses, and parents were asked to mark on checklists those procedures that were administered so as to have independent records of the specific elements of each child's physical examination.

General Procedure

If the child was assigned to a group that required the knowledge assessment, an interviewer traveled to the family's home at least 4 but no more than 31 days ($M = 7.36$, $SD = 4.78$) prior to the regularly scheduled physical examination. On arrival, the examiner obtained written consent from the participating parent and verbal assent from the child to participate in the study. The knowledge assessment interview usually lasted between 20 and 25 min and was videotaped. On the day of a well-child checkup, the interviewer met with the participating parent and child at the pediatric practice just before the scheduled time of the physical examination. If the family was meeting the interviewer for the first time (i.e., if the child was not in the knowledge assessment interview condition), written consent and verbal assent to participate in the study were requested from the parent and child, respectively. At this point, each parent was given a background questionnaire to obtain information about parental employment and education, a questionnaire concerning the child's previous experiences with

[1] Over the course of data collection, the frequency with which two of these medical components were included in the children's physical examinations varied considerably. More specifically, the medical personnel came to administer blood and TB tine tests less frequently, and, as such, these features were not included in the analysis of the children's reports. Hence, the maximum number of features examined in this analysis of knowledge and memory was 17.

Table 1
Experimental Design and Numbers of Participants Across the Age Groups

Group number and participant age	*n*	Interview timing			
		Knowledge	Immediate	3 month	6 month
1	23		X		X
4-year-olds	6				
5-year-olds	5				
6-year-olds	6				
7-year-olds	6				
2	19		X	X	X
4-year-olds	6				
5-year-olds	5				
6-year-olds	4				
7-year-olds	4				
3	19	X	X		X
4-year-olds	4				
5-year-olds	5				
6-year-olds	5				
7-year-olds	5				
4	22	X	X	X	X
4-year-olds	5				
5-year-olds	7				
6-year-olds	5				
7-year-olds	5				

doctors and nurses, and a checklist to mark the completion of medical procedures administered during the checkup.

The children's physical examinations proceeded without further intervention by the researchers. After the checkup, which typically lasted 15 to 20 min, each child was escorted to a separate interview room that did not contain any medical equipment. Prior to the interview, each participant was given a small canister of bubbles and asked to blow bubbles while the interviewer took a Polaroid photograph. These photographs were used subsequently during the 3- and 6-month memory assessments to remind the children of the specific physical examination to be reported. The delayed memory interviews took place at the children's homes no earlier than 2 days prior to the 3-month and/or 6-month anniversary dates of the physical examination and no later than 2 weeks after the anniversary date. These interviews were videotaped and typically lasted between 20 and 25 min. After the 6-month interview, the examiner administered the Peabody Picture Vocabulary Test—Revised (PPVT–R: Dunn & Dunn, 1981) to provide a standard measure of each child's receptive language skills.

Knowledge and Memory Interviews

Basic protocol. The knowledge assessment was administered to characterize what the children knew about doctor visits in general, whereas the memory assessment was carried out to determine what they could remember of one specific physical examination. The basic protocol was similar for both assessments in that in each one, the children were asked a series of open-ended probes and yes–no questions concerning a pediatric examination. Consistent with prior work (e.g., Baker-Ward et al., 1993), these questions were hierarchically ordered on the basis of specificity, ranging from open-ended to yes–no probes. The only substantive difference in the two assessments concerned the wording of the questions, such that the knowledge interview was conducted in present tense and the memory assessment used past tense. After a general open-ended inquiry (e.g., "Tell me what happens/happened during your checkup"), the children were asked more specific open-ended questions (e.g., "Tell me what the nurse/doctor does/did to check you"). For each of the medical features not nominated at an open-ended level, four additional questions were posed. First, a general yes–no question (e.g., "Does/Did the nurse find out if you can hear okay?") was asked, followed by a request for elaborative detail when a child responded affirmatively (e.g., "How does/did the nurse do that?"). Second, two leading questions were asked for each medical feature: (a) the correct description of the specific medical procedure (e.g., "Do/Did you put on earphones and listen to sounds?") and (b) an incorrect description of the medical event (e.g., "Does/Did the nurse whisper in your ear and ask you to say it back?"). Because the correct leading question contained the to-be-remembered information, responses to the yes–no questions can be considered to reflect recognition memory. Finally, additional open-ended probes (e.g., "Does/Did the doctor check any parts of your face?) were intermixed among the yes–no questions.

Extra-event questions. Eight yes–no questions were asked about medical procedures that are not typically included in well-child examinations but that may be administered in office visits prompted by an accident or illness. Examples of these activities include wrapping the leg in an Ace bandage, drinking medicine, and checking the head for ticks. When a child responded affirmatively to one of these extra-event probes, he or she was asked to describe the way in which the referenced procedure is or was administered ("How does/did the nurse/doctor do that?"). Four extra-event questions made explicit reference to suggested activities of the nurse, whereas the remaining four questions focused on actions of the doctor. These items were included to minimize the likelihood of response bias.

Administrative details. Each interview was conducted by 1 of 11 examiners, all of whom were advanced students in psychology who were trained and supervised by a child clinical psychologist. The majority of the participants were interviewed by a different examiner on each occasion. Half of the participants were questioned initially about the nurse's portion of the examination and then about the doctor's, whereas the other half were probed in the reverse order. Moreover, within each of these two sequences, two alternate orders of questioning were generated, and half of the participants were probed with each one.

Coding

Each interview was transcribed from the videotape and coded to specify the particular medical features reported by the child. Codes were assigned to the knowledge and memory protocols on the basis of the specificity of questioning necessary to elicit a verbal response (e.g., open-ended vs. yes–no questions) and the accuracy of the child's answer. This coding scheme was applied to those medical procedures that had and had not been included in each individual physical examination. In addition, a similar set of codes was used to characterize each child's response to questions about the extra-event questions. Consistent with earlier investigations (e.g., Clubb et al., 1993), the analysis of the knowledge data was based primarily on the children's responses to the open-ended questions, in an attempt to estimate the knowledge that could be generated spontaneously during the course of a physical examination. In contrast, the characterization of the memory reports focused on information generated in response to all levels of questioning. For this coding scheme, reliability was established among seven coders. The interrater agreement values ranged from 82% to 100%, with average reliability being 92%.

Results

Overview

The major questions of interest concern the children's recall of the various features (e.g., vision check, urine sample) of the physical examination over time as a function of age, specificity of the memory prompt, repeated questioning, and prior knowledge of medical routines. Because the number of features included in the children's checkups varied across individuals, the basic recall data are reported as percentages. For each child, the particular features

Table 2
List of Medical Procedures That Could Occur During a Well-Child Checkup

Name of feature	Description
Back	Doctor places a stethoscope on the child's back and listens to the lungs.
Blood pressure	Nurse wraps cuff around child's upper arm and measures the child's blood pressure.
Blood test	Nurse pricks the child's finger and collects blood.
Ears	Doctor visually examines the child's ear using an otoscope.
Elbow	Doctor taps the child's elbow with a reflex hammer.
Eyes	Doctor visually examines the child's eyes with an otoscope.
Foot	Doctor rubs the bottom of the child's foot to check reflexes.
Genitalia	Doctor visually examines the child's genitalia.
Hearing	Nurse places earphones on the child and asks the child to note the ear in which he or she hears the sound.
Heart	Doctor places stethoscope on the child's chest.
Height	Nurse asks the child to stand against the wall or on a scale and measures the child's height.
Knee	Doctor taps the child's knee with a reflex hammer.
Mouth and throat	Doctor visually examines the child's mouth and throat using a light and a tongue depressor.
Shot	Nurse uses a needle to give the child a shot in the upper arm.
Stomach	Doctor presses on the child's stomach.
TB tine	Nurse draws an outline of a bunny on the child's forearm and then adds the nose with the three-pronged tine.
Urinalysis	Nurse asks the child to collect a urine sample in a cup.
Vision	Nurse asks the child to read a vision chart.
Weight	Nurse asks the child to stand on a scale and measures the child's weight.

that were administered by the doctors and nurses were determined from the checklists described above, and the proportion of these features recalled in response to open-ended and more specific questions was calculated for each assessment point. To examine the linkage between prior knowledge and remembering, knowledge scores were determined for the children who received a knowledge assessment prior to the physical examination. Reflecting the children's understanding of the components of pediatric examinations, these knowledge scores were calculated as the number of features nominated in response to open-ended questions divided by the total number of features about which questions could be posed (i.e., the number of components present during each individual's checkup).

In the sections that follow, several aspects of the data are presented in detail. After a brief treatment of preliminary analyses, the formal assessment of the findings begins with inspection of the basic recall data, including treatments of the ways in which memory scores changed over the 6-month delay period, investigation of the influences of repeated questioning (the presence or absence of a 3-month interview), and examinations of age differences in memory performance. Next, analyses are conducted to explore linkages between knowledge and memory performance, including possible interactions with the effects of repeated questioning. Individual differences in remembering are correlated with individual differences in knowledge scores, and analyses are conducted to consider the ways in which these linkages change over time. After these analyses, rates of forgetting are examined as a function of age and knowledge. The extent to which individual differences in memory performance remained stable over time is also examined, and analyses are conducted to examine the children's abilities to correctly respond "no" to probes about features that had not been included in their checkups. Finally, in a subset of the analyses, raw PPVT–R scores were included to provide measures of the children's receptive language abilities.

Characteristics of Recall Performance

Preliminary analyses. A series of initial analyses indicated no differences in recall as a function of gender, participation in a knowledge interview, identity of the interviewer, assessment by the same versus different examiners across interview occasions, and order of interview questions. Accordingly, the data were pooled across these variables for subsequent analyses. In addition, at each age level, no differences at the initial interview were found among the four groups formed by the factorial combination of the knowledge assessment and 3-month interview variables, indicating that differences observed at the final assessment could not be due to group composition.

Basic recall data. The basic recall data are presented in Table 3. At the immediate memory assessment, total recall increased with age, ranging from 65% of the features of the physical examination among the 4-year-olds to 88% among the 7-year-olds, $F(3, 79) = 14.22$, $p < .001$, $\eta^2 = .35$. This improvement with age in reporting the details of the physical examination reflects primarily the age-related changes that are clearly seen in the children's responses to open-ended questions at the initial interview, with mean recall scores of 38%, 43%, 55%, and 62% being observed among the 4-, 5-, 6-, and 7-year-olds, respectively, $F(3, 79) = 8.04$, $p < .001$, $\eta^2 = .23$. Repeated contrasts indicated that 4-year-olds did not differ from 5-year-olds, $p > .10$. Five-year-olds differed from 6-year-olds, $p < .05$. Six-year-olds did not differ from 7-year-olds, $p > .10$. Reflecting the hierarchical nature of the interview, with specific questions being posed only when additional information was not forthcoming in response to open-ended questions, there were no age differences in responses to the specific probes, $F(3, 79) = 1.85$, $p > .10$, $\eta^2 = .06$. Table 3 illustrates further that open-ended recall scores declined between the immediate and 3-month interviews, $F(1, 40) = 31.60$, $p < .001$, $\eta^2 = .44$, but not from 3 to 6 months, $F(1, 40) = 0.52$, $p >$

Table 3
Descriptive Statistics for Recall Data by Age, Interview Occasion, and Level of Questioning

	Immediate			3 months			6 months		
Age and question type	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*
4-year-olds									
Open-ended	.38	.20	21	.19	.22	11	.19	.14	21
Specific	.27	.17	21	.35	.24	11	.32	.21	21
Total	.65	.14	21	.55	.24	11	.51	.24	21
5-year-olds									
Open-ended	.43	.19	22	.26	.19	12	.31	.16	22
Specific	.36	.19	22	.29	.23	12	.33	.17	22
Total	.78	.12	22	.55	.35	12	.65	.23	22
6-year-olds									
Open-ended	.55	.15	20	.33	.18	9	.34	.21	20
Specific	.26	.11	20	.36	.12	9	.35	.19	20
Total	.81	.10	20	.70	.17	9	.69	.22	20
7-year-olds									
Open-ended	.62	.13	20	.41	.15	9	.41	.19	20
Specific	.26	.14	20	.33	.19	9	.29	.12	20
Total	.88	.08	20	.74	.12	9	.70	.14	20

Note. Scores are the proportions of component features of each child's checkup reported in response to open-ended and/or more specific questions.

.10, $\eta^2 = .01$, and that specific recall scores did not change over the 6-month assessment period, $F(2, 80) = 1.10$, $p > .10$, $\eta^2 = .03$. Overall, even 6 months after the physical examination, the children reported a considerable amount of information. Indeed, as shown in Table 3, overall recall ranged from 51% among the 4-year-olds to 70% among the 7-year-olds.

Because there was no Age × Delay interaction, $F(6, 74) = 0.26$, $p > .10$, $\eta^2 = .02$, for open-ended recall and to increase statistical power for subsequent analyses, the four age groups were merged into younger and older groups, composed of children at ages 4 and 5 and at ages 6 and 7, respectively. The recall of the children in these younger and older groups is illustrated in Figures 1A, 1B, and 1C, with performance at the initial and 6-month assessments being displayed separately for the children who did and did not receive an assessment at 3 months. Taking the data in Figure 1 as a starting point, in the sections that follow, attention is directed to an exploration of age, repeated questioning, and knowledge effects.

Age effects. Consistent with the data in Table 3, the data displayed in Figures 1A, 1B, and 1C indicate clear age differences in the children's recall in response to open-ended but not more specific questions at the initial, 3-month, and 6-month assessments. A series of one-way ANOVAs yielded significant age effects in open-ended recall at the initial, $F(1, 81) = 22.03$, $p < .001$, $\eta^2 = .21$; 3-month, $F(1, 39) = 5.50$, $p < .05$, $\eta^2 = .12$; and 6-month assessments, $F(1, 81) = 8.86$, $p < .01$, $\eta^2 = .10$. Additional insight into the linkages between age and remembering can be seen by inspecting the scatterplots displayed in Figures 2A, 2B, and 2C, in which age is treated as a continuous variable. These scatterplots display the performance of each participant and reveal age effects in open-ended recall but not in response to yes–no questions. These effects are reflected in the significant positive slopes of the regression lines for open-ended recall as a function of age (rs = .47, .44, .38, ps < .01, at the initial, 3-month, and 6-month interviews, respectively) and in the corresponding flat regression lines for specific recall (rs = −.09, −.07, −.06, ps > .10, at the initial, 3-month, and 6-month interviews, respectively). To illustrate, at the initial interview, age in months accounted for approximately 22% of the variance in open-ended recall scores but less than 1% of the variability in specific recall scores.

Long-term retention and the influence of repeated questioning. As seen in Table 3 and Figures 1A, 1B, and 1C, the children's recall in response to open-ended questions declined from the initial interview to the final assessment after 6 months, $F(1, 82) = 62.83$, $p < .001$, $\eta^2 = .44$. However, inspection of the data of the younger and older children who were interviewed at 3 months indicates a performance drop from the initial interview to the 3-month assessment, $F(1, 39) = 31.04$, $p < .001$, $\eta^2 = .44$, with no further reduction in open-ended recall out to the final interview at 6 months, $F(1, 39) = 0.59$, $p > .10$, $\eta^2 = .02$. Moreover, although the effect of age was significant, $F(1, 39) = 13.56$, $p < .01$, $\eta^2 = .26$, the course of retention over time was comparable for the younger and older groups, and, as such, the Age × Delay Interval interaction was not significant, $F(2, 78) = 0.13$, $p > .10$, $\eta^2 = .003$. In contrast, as is apparent in Table 3 and Figures 1A, 1B, and 1C, the children's recall in response to specific questions was not affected by age, $F(2, 78) = 0.33$, $p > .10$, $\eta^2 = .01$, or delay, $F(2, 78) = 1.26$, $p > .10$, $\eta^2 = .03$. In addition, as can also be seen in Figure 1C, recall at 6 months was not influenced by participation in a memory interview at 3 months, $F(1, 82) = 0.54$, $p > .10$, $\eta^2 = .01$.

Stability of individual differences over time. Although the recall performance of both the younger and the older groups declined over the 6-month delay interval, consistent with expectations, were the children consistent in their performance over time? That is, to what extent were individual differences in the children's recall maintained across the delay interval? To examine this issue, the open-ended recall scores at the initial and 6-month time points were converted to rank orderings, and Spearman's rho correlations were calculated. Overall, the rank orderings of children's scores held well over the 6-month delay, Spearman's $\rho = .39$ ($p < .001$). However, this stability in performance varied as a

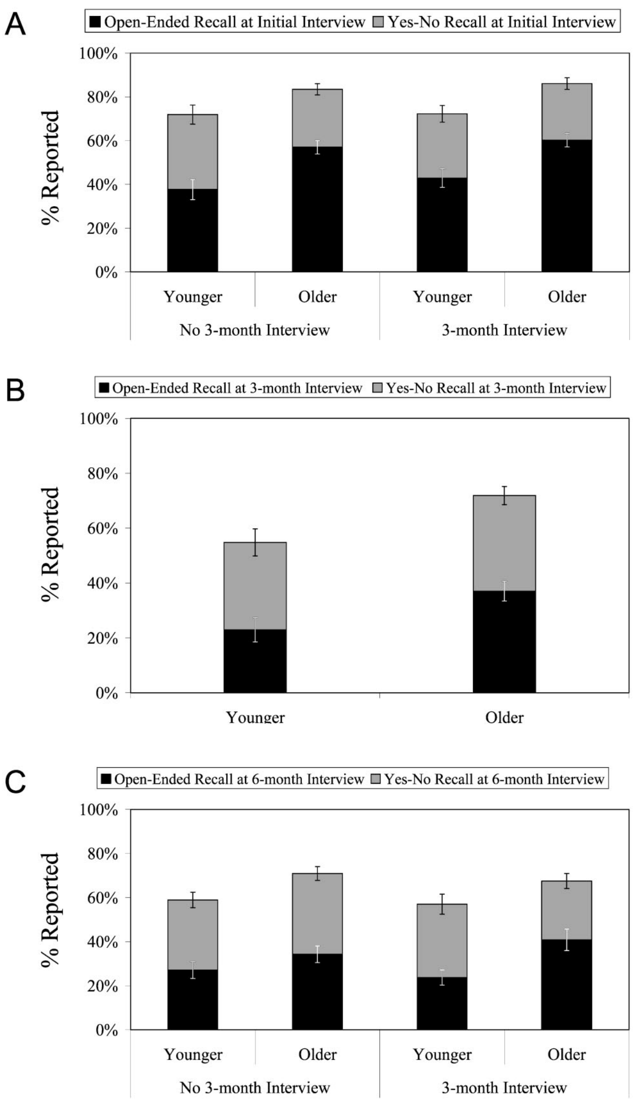

Figure 1. Recall of the features of the physical examination. A. Open-ended (black bars) and yes–no (gray bars) recall at initial interview by age group and interview condition. B. Open-ended and yes–no recall at the 3-month interview by age group. C. Open-ended and yes–no recall at 6-month interview by age group and interview condition.

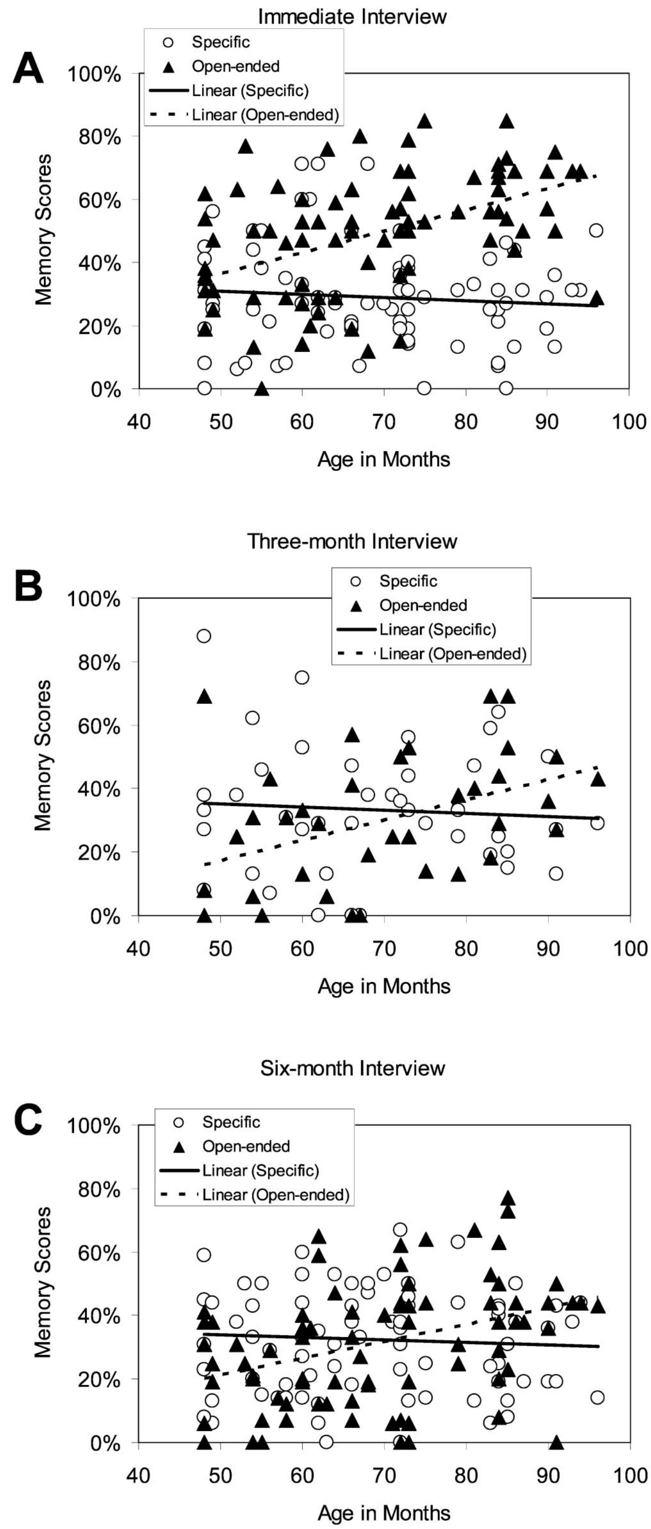

Figure 2. Scatterplots of open-ended (dark triangles) and specific (yes–no) recall (circles) memory performance by age in months at the immediate (A), 3-month (B), and 6-month (C) interviews. Note that when participants have identical scores, their data points overlap.

function of age, with the rank ordering of the younger children being less stable (and not statistically significant) over time, Spearman's $\rho = .25$ ($p > .10$), than that of the older children, Spearman's $\rho = .40$ ($p < .01$).

Children's errors. To explore issues of suggestibility and possible response bias, the children's answers to the absent-feature and extra-event questions were analyzed. On average, at each interview, the children were asked 1.86 ($SD = 1.39$) absent-feature questions about medical procedures that occur frequently during a routine physical examination but that were not included in their checkups. The particular questions posed varied from child to child, reflecting slight differences in the individual office visits. In addition, although the children were to have been asked about eight extra-event medical features (i.e., procedures that might be administered in a medical setting but not usually during a well-child checkup), administrative difficulties resulted in only 7.80 (SD = 0.47) extra-event questions being posed. Because of the relatively low number of absent-feature questions and the medically relevant nature of the extra-event questions, the two types of queries were combined for analyses of children's errors.

For each child, the proportion of correct denials (i.e., "no" responses) to these questions about activities not included in the physical examination was calculated. These data for the two age groups at each of the three assessment occasions are displayed in Table 4, where it can be seen that the children's overall response to these questions was quite good, with correct denial scores ranging between .75 and .96. As can be seen, at the immediate interview, the older children were more effective in saying "no" to the absent-feature and extra-event questions than were the younger children, $F(1, 82) = 7.78$, $p < .01$, $\eta^2 = .09$. However, reflecting the significant decrease in performance among the older children, $t(39) = 4.80$, $p < .01$, the groups did not differ at the 3-month, $F(1, 82) = 1.56$, $p > .10$, $\eta^2 = .02$, and 6-month, $F(1, 82) = 0.97$, $p > .10$, $\eta^2 = .03$, assessments. In addition, it should be noted that participation in the 3-month assessment did not influence correct denials at the final interview, $F(1, 82) = 0.73$, $p > .10$, $\eta^2 = .01$, and, as such, the 6-month data presented in Table 4 are averaged across the children who were and were not questioned at 3 months.

Role of Prior Knowledge

Age differences in knowledge of physical examinations. Half of the participants received a knowledge assessment prior to their physical examinations, and their resulting knowledge scores make it possible to explore linkages between prior understanding of medical routines and memory for a specific visit to the doctor. These proportion scores were based on the features that were generated in response to the interviewers' open-ended probes about what usually happens during a physical examination. For each child whose knowledge was probed, the number of features nominated was divided by the number of components later administered in his or her individualized physical examination. The knowledge scores are displayed in Table 5, where it can be seen that the older children reported more features than the younger children did, $F(1, 40) = 6.02$, $p < .05$, $\eta^2 = .13$, and that there was considerable variability in the children's production, especially in the younger group, where the knowledge scores ranged between .00 and .59. In addition, the correlation between age in months and knowledge score was .36, $p < .05$.

Table 4
Correct Denials to Absent Feature and Extra-Event Questions, by Age and Interview Occasion

	Immediate		3 months		6 months	
Age	*M*	*SD*	*M*	*SD*	*M*	*SD*
Younger children	.87	.16	.75	.24	.86	.18
Older children	.96	.11	.82	.15	.84	.13

Note. In calculating the above proportions, absent feature and extra-event questions were combined because of the low frequency of the absent feature questions and the conceptual similarity of the two categories.

Table 5
Descriptive Statistics of Knowledge Scores by Age Group

Age group	*M*	*SD*	Range	Min.	Max.
Young	.24	.16	.59	.00	.59
Old	.35	.13	.41	.18	.59
Total	.30	.15	.59	.00	.59

Note. Scores are the proportion of component features of each child's checkup reported in response to open-ended questions during the knowledge interview.

Linking knowledge and memory. The associations between knowledge and open-ended recall at the three assessment points are illustrated in the scatterplots presented in Figures 3A, 3B, and 3C. Knowledge and memory are clearly linked at each assessment, although the strength of the association decreases over time, dropping from $r = .53$, $p < .001$, at the initial interview, to $r = .32$, $p > .10$, at the 3-month interview, to $r = .30$, $p = .05$, at the 6-month interview. To explore these linkages more thoroughly, regression analyses were carried out to examine the extent to which children's levels of knowledge about physical examinations account for a significant proportion of the variance in open-ended recall beyond that accounted for by age in months alone. These models also included the raw PPVT–R scores as covariates. The results of these modeling efforts are displayed in the upper (initial assessment) and lower (6-month assessment) panels of Table 6. As can be seen, scores on the PPVT–R did not account for a significant proportion of variance at the initial or the 6-month interview. At both assessments, age accounted for a significant portion of the variance in open-ended recall above and beyond PPVT–R scores: .20 and .14 of the variance at the initial and 6-month interviews, respectively. In contrast, knowledge scores accounted for a significant proportion of additional variance in open-ended recall at the initial interview (.10) but not at the 6-month memory assessment (.03).

Linking knowledge and forgetting. As indicated above in Table 3 and Figures 1A, 1B, and 1C, recall of the features of the physical examination declined over the course of the delay interval. On average, the children forgot 18% (SD = 20%) of the features, and this loss of information was comparable for the younger and older groups of children, $F(1, 82) = 1.72$, $p > .10$, $\eta^2 = .02$. Consistent with this null finding, the correlation between forgetting (as defined by the amount recalled at the initial interview minus the amount recalled at the 6-month interview) and age in months was not significant, $r = .09$. In addition and contrary to expectation, the correlation between knowledge and forgetting was not significant, $r = .19$, $p > .10$.

Discussion

In this investigation, 4- to 7-year-old children's retention of the details of well-child pediatric examinations was charted over an interval of 6 months. Although the children reported a substantial amount of information at each interview, performance declined over time. Recall dropped considerably in the first 3 months after the checkup but then remained constant across the second half of the retention interval. Consistent with prior reports, older in comparison to younger children provided more total information and reported a greater proportion of the features of the physical exam-

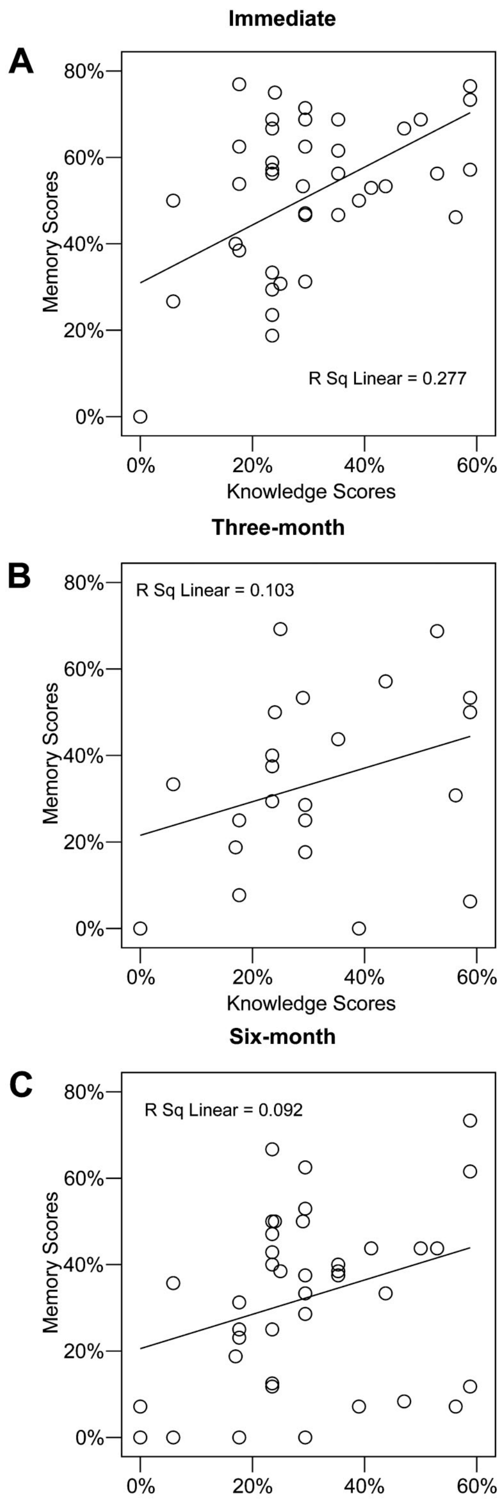

Figure 3. Scatterplots illustrating the associations between knowledge and open-ended recall at the immediate (A), 3-month (B), and 6-month (C) interviews. Note that when participants have identical scores, their data points overlap.

ination in response to general probes rather than specific questions. However, comparable patterns of remembering and forgetting over time were observed at each age level. Moreover, children's prior knowledge regarding the pediatric examination—as assessed before the checkup for half of the participants at each age—was associated with initial recall. Although knowledge increased with age as expected, it nonetheless affected recall over and above the influence of age. In addition, repeated questioning—in the form of an interview at 3 months for half of the children—did not influence performance at the end of the 6-month delay interval. The findings have implications for understanding long-term retention, the effects of repeated questioning, the role of knowledge in memory performance, and developmental changes in memory.

Long-Term Retention

Over the course of the 6-month retention interval, the children lost approximately 18% of the features they initially reported in response to open-ended questions. To some extent, this decline in performance over time contrasts with the findings of some other investigations of long-term retention. For example, Fivush and her colleagues (Fivush & Shukat, 1995; Fivush & Schwarzmueller, 1998; Hudson & Fivush, 1991) have observed that children's reports of salient positive experiences are as extensive after several years as they were shortly after the events occurred. It should be noted, however, that methodological differences between the studies might account for these divergent findings. For example, in the present investigation, there was an emphasis on the retention of the specific components of the physical examination across the delay interval, whereas Fivush and her associates focused on overall recall and noted that new information came to be included in the children's reports over time. As such, the findings of Fivush and her colleagues are not necessarily inconsistent with the present observation of forgetting over time. In contrast, however, Peterson's (1999) results do appear to be at odds with the observation of forgetting over a 6-month interval. Indeed, tracking children's reports of details of their injuries and resulting emergency room treatments over periods of up to 2 years, Peterson reported comparable levels of performance across time (cf. Peterson & Walen, 2001). Similarly, Burgwyn-Bailes, Baker-Ward, Gordon, and Ornstein (2001), in a smaller study of children's memory for emergency plastic surgical treatment, also reported no forgetting over a 1-year interval.

Two potentially important differences seem to characterize investigations in which information is lost over time (see also Pipe et al., 1999; Poole & White, 1993) from those in which performance remains constant over long delays (see also Fivush et al., 2004). Forgetting appears to be observed for events that involve relatively low levels of arousal and comparatively little opportunity for reinstatement. In contrast, memory performance seems to remain constant across time for more salient experiences that prompt the continued involvement of adult caregivers and hence provide many opportunities for rehearsal or continued encoding. Consistent with this interpretation, McGuigan and Salmon (2004) recently provided experimental evidence that elaborative postevent talk with an adult, in comparison to preevent elaborative talk and empty talk during the event, resulted in higher levels of correct recall among 3- and 5-year-old children who reported a staged event after a 2-week delay. Moreover, researchers conducting

Table 6
Regression Models of the Influences on Open-Ended Recall at the Initial and 6-Month Interviews

Variable	*B*	*SE B*	β	R^2	ΔR^2
Initial assessment					
Model 1	.004	.002	.311†	.097	.097†
Model 2	.006	.002	.448*	.296	.200*
Model 3	.452	.193	.348*	.389	.093*
6-month assessment					
Model 1	.001	.002	.098†	.010	.010†
Model 2	.005	.002	.371*	.147	.137*
Model 3	.238	.220	.188†	.174	.027†

Note. Model 1 = Peabody Picture Vocabulary Test—Revised (PPVT–R) only; Model 2 = PPVT–R and age in months; Model 3 = PPVT–R, age in months, and knowledge scores.
† $p > .05$. * $p < .01$.

previous investigations of children's memory for pediatric checkups (Baker-Ward et al., 1993; Ornstein, Baker-Ward, et al., 1997) have reported low levels of overall stress among the children, and even though anxiety was not measured in this study, it can be assumed that the routine physical examination involved low levels of arousal. Other investigations in which forgetting has been reported have involved staged laboratory events that were designed to be moderately pleasant and most likely did not elicit extended parent–child discussion (e.g., Flin, Boon, Knox, & Bull, 1992; Jones & Pipe, 2002; Pipe, Gee, Wilson, & Egerton, 1999).

Although this argument would seem to contradict the widely reported negative relation between stress and remembering observed among individuals who have experienced a given event (e.g., Merritt, Ornstein, & Spicker, 1994; Peters, 1997), when comparisons are made across events, the distinctiveness of highly arousing situations could be expected to make them more memorable than routine occurrences (see Howe, Courage, Vernescu, & Hunt, 2000). Moreover, events with negative consequences such as injuries requiring emergency medical treatment are likely to elicit activity from caregivers who want to prevent reoccurrences or must provide assistance in the aftermath of a painful experience. It thus seems likely that such behaviors would provide opportunities for reinstating the experience and increasing the coherence of the underlying representation, resulting in enhanced memory. Of course, in the absence of direct investigation, this possibility remains speculative.

Repeated Questioning

Principe et al. (2000) studied children's memory for the details of a physical examination over a 12-week delay and found that an additional interview 6 weeks after the examination served to alleviate some forgetting. In contrast to these findings, in the present study, the performance of the children who received an additional interview at 3 months—midway through the 6-month retention interval—was not facilitated. It seems likely that the discrepancy between these two studies revolves around the state of the memory representation at the time of the additional interviews, 6 weeks in the Principe et al. (2000) investigation and 3 months in the present study. Given that reinstatement operations are most effective after there has been some but not complete forgetting (Rovee-Collier & Hayne, 1987), it appears as though the additional interview given here was ill-timed, because a significant amount of information was lost by the time of the 3-month interview. Indeed, performance remained constant across the final 3 months of the retention interval, with no differences observed between participants who did and did not receive the intervening interview. This finding has implications for the understanding of children's testimony and the management of child witnesses. Legal proceedings generally involve delays of weeks or months, and children's memories may fade over this interval without reinstatement through additional opportunities for recall (e.g., through nonsuggestive interviews; see Principe et al., 2000).

Of course, one could argue that this null effect actually reflects the positive impact of two sets of reinstating activities: the interview at 3 months for those children who experienced it and parallel but unplanned encounters with medically relevant stimuli (including return visits to the pediatrician) for those children who were not interviewed at 3 months. Although data regarding naturally occurring experiences that might serve to reinstate memory were not obtained in this investigation, neither Baker-Ward et al. (1993) nor Principe et al. (2000) observed any systematic effects of unplanned return visits to the doctor. Moreover, even if such visits did impact remembering, there is no reason to expect that they would be experienced more frequently by the children who did not receive the additional interview than by those who were seen midway through the delay interval. As such, it seems likely that the failure to find an influence of the extra interview on later memory at the 6-month assessment stems from information loss over the 3 months prior to the interview. However, to examine these issues, it is clearly necessary to carry out further work in which potentially reinstating and interfering experiences are carefully timed so as to be presented at various points along the retention–forgetting function.

Effects of Knowledge

Although knowledge is assigned considerable importance in theoretical accounts of memory development (e.g., Chi & Ceci, 1987), surprisingly little empirical evidence examines directly the role of continuous variations in prior knowledge on memory performance over time (see Schneider & Pressley, 1997). As such, the present study was designed to augment previous investigations of the effects of expertise (e.g., Chi, 1978) and the impact of scripts (e.g., Myles-Worsley, Cromer, & Dodd, 1986) on recall by examining the effects of variations in children's prior knowledge regarding an experienced event. Moreover, in contrast to previous work examining linkages between continuous variations in event extant knowledge and recall in which the normative measures of knowledge and indices of remembering were obtained from different samples of children (e.g., Clubb et al., 1993), in this study, knowledge and memory scores were computed from the same participants. By changing the unit of analysis from the feature of the physical examination to the individual child in this manner and by including children of different ages in the investigation, it was possible to increase the sensitivity of the knowledge–memory analysis.

Although the precision of the design was increased in this manner, the children's prior knowledge of medical routines was still measured at a rather gross level, in terms of the component features of the examination nominated in response to general questions about what happens during pediatric checkups. Nonetheless, a clear relation between such knowledge and open-ended recall at the initial interview was observed, and, after controlling for age, the children's knowledge scores explained a significant proportion of the variance in open-ended recall at the initial interview but not at the 6-month memory assessment. Moreover, knowledge was unrelated to forgetting over a 6-month interval. This pattern of results suggests that knowledge affected the encoding of information but was less important in terms of the maintenance of information across the extended 6-month delay interval.

The view that knowledge affects memory primarily in terms of the encoding of information is basically consistent with the conclusions Bender et al. (1996) made after using multinomial mathematical models to reanalyze aspects of Baker-Ward et al.'s (1993) findings concerning children's recall of the details of a well-child checkup. However, even though Bender et al. suggested that knowledge influenced recall primarily at encoding, they also observed a lesser effect of knowledge on information retrieval. In addition, Ornstein et al. (1998)—in an experiment in which children received an unusual mock physical examination in which certain extremely common and expected features (e.g., using the stethoscope to check the heart) were omitted—found that children's errors after 3 months were knowledge driven, suggesting a continuing impact of knowledge on retrieval, particularly as information fades over time. These hints of a continuing influence of knowledge are thus somewhat inconsistent with the recall data obtained in this investigation, as is the failure to find linkages between the children's knowledge and their abilities to reject questions about actions that did not take place in the medical examination.

To some extent, these discrepancies concerning the extended impact of knowledge on the encoding of information may stem from methodological differences across various studies. For example, although the questions about actions that did not occur during the physical examination reflected medical themes, the majority of them were based on actions that could be expected to take place during doctor visits that were prompted by illnesses or accidents and not during routine pediatric checkups. As such, the bulk of these lures may have been too easy and thus not sensitive enough to tap into the type of "autosuggestibility" (Binet, 1900; Brainerd & Reyna, 1995) that may underlie the knowledge-driven errors in children's delayed reports that were observed by Ornstein et al. (1998). It should also be noted that constructive processes in children's long-term memory reports—derived from the use of prior knowledge to fill in the gaps as memory fades—would be undetectable in this investigation, as such errors would, in fact, be indistinguishable from correct recall. Hence, forgetting may be underestimated in this investigation. Accordingly, the results are best interpreted as demonstrating an effect of knowledge on encoding but should not be construed as ruling out knowledge effects in other aspects of memory performance. Of course, additional research in which knowledge is measured more precisely than was the case in this investigation (see Baker-Ward et al., 1997) and in which the interaction between episodic and generic memory is assessed through carefully designed manipulations (as in the Ornstein et al., 1998, study) would no doubt contribute to an understanding of the complex associations between knowledge and remembering.

Implications for Development

The results of this investigation replicated and extended previous findings regarding age-related changes in memory performance. First, age effects were apparent in open-ended recall at each interview occasion. As has been consistently demonstrated (e.g., Ornstein, Baker-Ward, et al., 1997), older children provide more information than do younger children in response to general probes. Although age differences were not apparent in specific recall in response to yes–no questions, this result should not be interpreted as indicating that developmental differences in memory performance can be eliminated in the presence of appropriate task supports. Rather, because the questioning was hierarchically determined, the number of items available to be recalled in response to specific probes was affected by the level of open-ended recall. Second, it was once again demonstrated that age differences in performance are consistent across time, even when the delayed interview is 6 months after the event. Although older children provided more information than did younger children at each assessment, there is no evidence that rates of forgetting differed across age. It should be noted, however, that the performance of the younger children was somewhat more variable than that of the older children, as was expected on the basis of the literature (e.g., Gordon & Follmer, 1994).

As noted above, knowledge effects were most apparent in this investigation in initial recall. However, the presence of age differences in the children's reports immediately after the physical examination raises the question of the extent to which knowledge is simply a proxy for age. Of course, knowledge about medical routines would be expected to increase with age, as a consequence of children's experiences with doctors and their exposure to the media. Indeed, consistent with expectation, age-related increases in the children's knowledge scores were observed, with the young and older groups nominating 24% and 35% of the features of a checkup during the knowledge assessment prior to the doctor's visit, respectively. The results of this investigation, however, establish that knowledge has effects on memory that cannot be explained by collinearity with age. Correlations between knowledge and recall scores decreased only slightly when age was controlled. Moreover, in exploratory hierarchical regression analyses, knowledge explained a significant portion of variance after age had been entered into the model.

Concluding Remarks

In summary, although the findings reported here fit well with recent explorations of children's long-term memory retention, they also raise a number of important questions for future investigations. The within-participant linkages between knowledge and remembering that were documented, over and above the effects of age, suggest the importance of fine-grained analyses of children's knowledge. Moreover, the observation of knowledge effects primarily at the initial assessment point—in contrast to other demonstrations of the long-term impact of knowledge—mandates a serious commitment to exploring the continuing role of knowledge from encoding to delayed recall with research designs that enable the detection of knowledge-driven errors. In addition, the drop in recall over the course of 3 months, the flat retention function out to 6 months, and the failure to find a facilitative effect of an additional interview at 3 months all suggest the need for serious study of the course of retention and the timing of potentially reinstating experiences. Research addressing these issues will certainly contribute to an emerging understanding of factors associated with the development of children's abilities to report the details of salient personally experienced events over long delay intervals.

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