My brother Colin was trying to get Blaztorch (an action figure) from me, and I wouldn’t let him take it from me, so he pushed me into the wood pile where the mouse trap was. And then my finger got caught in it. And then we went to the hospital, and my mommy, daddy, and Colin drove me there, to the hospital in our van, because it was far away. And the doctor put the bandage on this finger. (Billy, a 4-year-old) (Ceci & Bruck, 1998)

There was only one problem with Billy’s detailed recollection of this slightly traumatic event—the event never happened!

The 4-year-old who delivered this utterly convincing rendition of his “memory” of catching his finger in a mousetrap was part of an experiment. The purpose of the experiment was to determine when children’s testimony about abuse and injuries to themselves can be believed. The situation was somewhat unusual—once a week for 10 weeks, children in the experiment were asked leading questions about events that had never happened to them. For example, Billy had been asked such questions as “Tell me if this has ever happened to you. Do you remember going to the hospital with a mousetrap on your finger?” “Can you tell me more?” “What happened next?” The quotation above is of Billy telling a different adult about his experience.

Although the situation may seem contrived, it is not very different from that which children frequently face in child abuse cases. It has been estimated that child witnesses are interviewed an average of 30 times before their cases come to trial (Whitcomb, 1992). Nor are the questions asked of child witnesses any less leading. Consider the following sequence from a highly publicized 1989 trial in which the head of a daycare center was charged with abusing the children who attended the center. Some of the abuse was believed to involve kitchen utensils:

Prosecutor: Did she touch you with a spoon?
Child: No.
P: No? OK. Did you like it when she touched you with a spoon?
C: No.
P: No? Why not?
C: I don’t know.
P: You don’t know?
C: No.
P: What did you say to Kelly when she touched you?
C: I don’t like that.

What makes the reliability of children’s memory in such cases so critical is that mistakes in either direction are disastrous. If a jury does not believe a child who accurately reports abuse, the perpetrator may abuse other children. If the jury believes a child who falsely reports abuse, an innocent person may spend years in jail. So how can we know when children should be believed? Are younger children, who may not distinguish as clearly between fantasy and reality, more likely than older children to report events that never happened? Or are older children, who can imagine a greater range of events, more likely to do so? What kind of questioning is needed to get children to testify about events that are uncomfortable for them to discuss, without leading them to report events that never happened? With more than 100,000 children testifying in legal cases each year (Ceci & Bruck, 1993, 1998), and more than 40 percent of children who testify in sexual abuse cases being below age 5 (Gray, 1993), answering these questions about children’s memory is critically important.

Psychological research is especially useful for determining the reliability of children’s eyewitness testimony. In experiments, unlike in court cases, we can know for sure what really happened and can use that as a comparison point for children’s reports. The answers that are starting to emerge from such experiments tell us a great deal about memory development in general and about children’s eyewitness testimony in particular.

Children’s Eyewitness Testimony

People often think of memory as a series of photographs, or a movie, of their experiences. If this were the case, eyewitness testimony would not be a problem; the witness would simply recount exactly what happened. However, at no age
child witnesses are interviewed an average of 10 times before their cases come to trial (Whitcomb, 1992). Nor are the questions asked of child witnesses any less leading. Consider the following sequence from a highly publicized 1989 trial in which the head of a daycare center was charged with abusing the children who attended the center. Some of the abuse was believed to involve kitchen utensils:

PROSECUTOR: Did she touch you with a spoon?

CHILD: No. Did you like it when she touched you with a spoon?

C: No.

P: No? Why not?

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is memory nearly this complete or this accurate. Adults, like children, fail to remember what they saw, "remember" events that never happened, and combine separate experiences into a single composite. Preschoolers' memories are somehow less accurate than those of older individuals, but the difference is one of degree rather than kind—everyone has memory lapses and confusions.

A useful way of thinking about memory is to divide it into three phases, ordered along the dimension of time: encoding, storage, and retrieval. Memory for any event requires encoding the important information when the event occurs, then storing the information in memory for later use, and finally retrieving it when it is needed. Each step offers potential pitfalls. People may not take in all of the important information at the time when the event occurs; they may take in the information but store it in a form that is vulnerable to forgetting; or they may encode and store it effectively, but be unable to retrieve it when it is needed.

**ENCODING**

When people encode information, they form two types of representations: verbatim and gist (Brainerd, Reyna, Howe, & Kingma, 1990). Verbatim representations include the literal details of the situation: the exact words spoken, the expressions on the people's faces, the color of the walls, and so on. Gist involves the meaning or essence of the events: Who did what to whom. People encode both types of information, but the representations of gist last much longer than the verbatim information. Everyday experience illustrates the difference: when you read a story, you remember the exact words only briefly, but you may remember the basic plot for years.

Part of the reason for this is that the encoding places greater emphasis on verbatim information, relative to gist (Brainerd et al., 1990). Since everyone forgets verbatim information more quickly than the gist of what happened, the young children's emphasis on verbatim information leads to more forgetting. Like older children, younger ones encode the gist of events; however, their relative emphasis on gist is not as great. They also fail to encode some important aspects of events altogether.

A large part of the reason for younger children's less complete encoding of gist concerns their lesser knowledge. Memory for an event does not occur in a vacuum; it reflects people's prior knowledge about what is important and what is plausible in the situation. For example, in a study in which 3- to 7-year-olds were asked about a visit to a doctor, 3-year-olds very rarely said "yes" when asked such outlandish questions as "Did the nurse lick your knee?" In contrast, 3-year-olds quite often answered such questions affirmatively, especially when questioned a long time (three months) after the visit (Gordon, Ornestein, Chubb, Nida, & Baker-Ward, 1991). Older children's greater knowledge of what does and does not go on during visits to the doctor's office presumably helped them both to encode what actually occurred during the visit and to rule out the possibility that a nurse could have licked their knee there.

Prior knowledge is a two-edged sword, though. It generally leads to more accurate recall, but it can also produce distortions. Stereotypes about other people are one source of such distortions. Consider what happened when a group of preschoolers heard stories that depicted a character named Sam Stone as a clumsy oaf (Leichtman & Ceci, 1995). After four such stories, a man introduced as Sam Stone visited the classroom for two minutes; the visit was pleasant but uneventful. The following day, it was "discovered" that a teddy bear was dirty and a book was torn; the question was who was responsible.

The children's prior knowledge about Sam Stone by itself did not lead to many claims that he was responsible for the damage. However, when the stereotype was paired with leading questions that suggested that Stone was the culprit, 72 percent of 3- and 4-year-olds claimed that Stone had done it, 44 percent claimed they had seen him do it, and 21 percent maintained their claim even when asked, "You didn't really see him do it, did you?" Children who had not heard the stories before the visit were less likely to make these claims, as were older preschoolers (5- and 6-year-olds) who had heard them.

As illustrated by this example, people's memories are not limited to what actually happened. Instead, memories are a mixture of what people see, what they know, and what they infer. Children's inferences are frequently correct, but sometimes they are mistaken. Thus, in the Sam Stone experiment, some children reported seeing him soak the teddy bear with water and smear crayon on it (which could have explained the condition they found it in the next day). These plausible inferences are much of what make it so difficult even for experts to discern when children's testimony is accurate and when it is not. When more than 100 clinicians and researchers who specialize in issues regarding children's eye-witness testimony were shown videotapes of children talking about what Sam Stone had done, they were unable to identify which children were reporting accurately and which were not (Leichtman & Ceci, 1995).

**STORAGE**

Better storage of information also contributes to older children's more accurate memory. One aspect of this phenomenon that is particularly relevant for eyewitness testimony involves suggestibility. Children below age 6, in particular, tend to be more suggestible than older children, in the sense that their recall of events can be greatly influenced by experiences that occur after the original event but before the time of retrieval, that is, while the information is stored (Bruck & Ceci, 1999). Thus, when asked leading questions after the relevant events occurred, preschoolers often change their recall in directions consistent with the implications of the questions they are asked (Clarke-Stewart, Thompson, & Lepore, 1989;
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Goodman & Clarke-Stewart, 1991. Suggestive questions can lead children to "recall" not just unimportant events but also events affecting their bodies, such as nurses blowing in their ears (Ornstein, Gordon, & Larus, 1992), pediatricians sticking fingers or sticks into their genitals (Bruck, Ceci, Fracansky, & Renick, 1995), and strangers putting yucky things in their mouths (Poole & Lindsay, 1995). Older children and adults are also suggestible, but much less so than preschoolers.

Another technique that is commonly used in legal cases, but that can distort children’s memories, is asking them to imagine events and then asking them to report whether the imagined event occurred. Such imagining often leads to children reporting the imagined event as real and continuing to do so thereafter (Foley, Harris, & Herman, 1994; Parker, 1995). The same phenomenon occurs when children are asked to draw events that did not actually occur—they often report later that such events actually happened (Bruck, Melnyk, & Ceci, 2000). Preschoolers are especially likely to show difficulties in reality monitoring, which is the ability to distinguish what they imagined or thought about from what actually happened.

A final influence on the quality of stored information is time. As time passes, people forget. The forgetting is especially marked in young children. Even when they remember as much as older children immediately after the event, they forget the material more rapidly (Braiden & Reyna, 1995). Much of the forgetting occurs relatively soon after the event, but forgetting continues indefinitely. Over periods of one to two years, periods that are comparable to those that often elapse between the original abuse and trial dates, the accuracy of children’s recall deteriorates considerably. Relative to their recollections immediately after the event, children become more likely to omit important information and to include information that is plausible but that did not happen (Goodman, Hirschman, Hepps, & Rudy, 1991; Poole & White, 1993).

RETRIEVAL

When asked open-ended questions about events (for example, “What happened at school today?”), children tend to provide accurate and relevant information. However, they also often underreport what happened, particularly during the preschool years. Asking more specific questions leads to greater reporting of events that actually happened. For example, when 5- and 7-year-old girls were questioned following a genital examination, they did not admit any genital contact unless asked such specific questions as “Did the doctor touch you here?” (Seyffritz, Goodman, Nichols, & Moan, 1991). As long as the questions do not indicate that the questioner prefers a certain answer, asking specific questions soon after an initial event seems to protect memories from decaying more than it produces false recollections (Ceci & Bruck, 1998).

The conditions under which children are asked to retrieve information greatly influence what and how much they remember. One important influence is whether they need to recall the information from memory (“Where did the doctor touch you?”) or just to recognize it (“Did the doctor touch your tongue?”). People of all ages find recognition much easier than recall.

Children also remember more when they are encouraged to think deeply about the event. For example, when 5- and 6-year-olds were asked to draw as well as tell what happened when they visited a fire station, they recalled more than when they were simply asked to talk about the visit (Butler, Gross, & Hayne, 1995). Presumably, drawing the fire station caused them to think about the visit more deeply. Along the same lines, children are more accurate at reporting events that they directly participated in than events that they observed or heard about (Gebbo, Mega, & Pipe, 2002). It is likely that children think more deeply about events they actually experience than about events they simply see or hear about.

The expectations of the person asking the questions also influence children’s memories of events. When the questioner believes that certain events happened, preschoolers are more likely to report those events (Ceci, Loftus, Leichtman, & Bruck, 1994; Goodman & Clarke-Stewart, 1991). Biased interviewers convey their expectations in a variety of ways, such as by setting an accusatory emotional tone for the interview, by providing misinformation, and by using highly specific, leading questions (Bruck & Ceci, 1999). In an effort to be cooperative, children sometimes tell the adult what he or she seems to want to hear.

The frequency with which questions are asked also influences children’s memory performance. Children often provide different answers when asked the same question more than once. This is not entirely attributable to forgetting; not infrequently, a child will not remember an important detail at an earlier time but will remember it later. Young children may also change their answers when a question is repeated in an effort to please the interviewer. For example, Poole and White (1991) found that when 4-year-olds were asked repeated yes/no questions about an event they had witnessed, they often changed their answers, both within a single interview and across interviews.

CONCLUSIONS ABOUT CHILDREN’S EYEWITNESS TESTIMONY

Studies of children’s memory for events lead to the following five conclusions about their eyewitness testimony:

1. Children’s recounting of events reflects what they encoded initially, their experiences during the storage interval, and the conditions under which they retrieved the information.

2. In the absence of interviewer bias, even preschoolers accurately recall much that is relevant to legal cases. The testimony may be lacking in detail, but what they say is generally accurate.
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2. In the absence of interviewer bias, even preschoolers accurately recall much that is relevant to legal cases. The testimony may be lacking in detail, but what they say is generally accurate.
3. Preschoolers are especially vulnerable to the effects of misleading questions and stereotypes. Everyone is vulnerable to these influences, but preschoolers are more influenced by them than older children or adults.
4. The vulnerability is present with events that involve children’s own bodies and events with sexual overtones, as well as with less personal experiences.
5. To obtain the most accurate and complete recall, questions should be asked in a neutral fashion, they should be sufficiently specific to elicit memories that might otherwise not be reported, and the questioning should not be repeated more often than necessary.

**WHAT DEVELOPS IN MEMORY DEVELOPMENT?**

As suggested by the data concerning eyewitness testimony, older children generally remember more accurately than younger ones. But why is this the case? Four types of explanations seem most likely.

One explanation is that older children have superior basic processes and capacities. Translated into a terms of a computer analogy, this view suggests that development occurs in the hardware of memory—its absolute capacity or speed of operation. A second explanation emphasizes strategies. Older children know a greater variety of memory strategies than younger children and use them more often, more efficiently, and more flexibly. A third explanation highlights metacognition—knowledge about one’s own cognitive activities. Older children better understand how memory works; they may use this knowledge to choose strategies and allocate memory resources more effectively. Finally, older children have greater prior knowledge of the types of content they need to remember; this greater content knowledge may be a major source of their superior memory.

Of course, these four hypotheses are not mutually exclusive; all of them, or any combination of them, could contribute to the superiority of older children’s memory (Brown & DeLoache, 1976).

In the remainder of this chapter we consider the contributions to memory development of these four potential sources of change (Table 7.1). Just to preview what will emerge, it appears that some of the sources of development contribute more than others, and that some play large roles in certain periods of childhood but not others. It may be worthwhile to apply what you have learned about eyewitness testimony and about children’s thinking in general to predict which of these sources of memory development will be most influential in infancy and early childhood, in middle childhood, and in late childhood and adolescence.

**Basic Processes and Capacities**

Basic processes are frequently used, rapidly executed memory activities such as association, generalization, recognition, and recall. They are among the building blocks of cognition, in the sense that all more complex cognitive activities are built by combining them in different ways. Because they are used so frequently, age-related differences in them could account for an enormous number of other differences in memory.

The role of basic processes in memory functioning is especially dominant early in life. Infants do not possess memory strategies, they are ignorant about the workings of their own memory, and they lack knowledge of the world. Still, they manage to learn and remember a great deal. Their relatively skillful execution of basic processes is what makes this possible.
3. Preschoolers are especially vulnerable to the effects of misleading questions and stereotypes. Everyone is vulnerable to these influences, but preschoolers are more influenced by them than older children or adults.
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SUBSTANTIAL POSTNATAL BRAIN MATURATION MAY BE NECESSARY BEFORE INFANTS CAN FORM EXPlict MEMORIES.

NEXT WE CONSIDER SOME SPECIFIC PROCESSES THAT PRODUCE MEMORIES: ASSOCIATION, RECOGNITION, RECALL AND GENERALIZATION.

ASSOCIATION

Association is one of the most basic of basic processes. It is difficult to even imagine cognitive development taking place without the ability to associate stimuli with responses. Not surprisingly, given its centrality, the ability to associate stimuli and responses is present from birth. In one experiment that demonstrated this fact (Sigelund & Lipsitt, 1966), whenever a buzzer sounded, newborns received a sweet solution for turning to the right, and whenever a tone sounded, they received the solution for turning to the left. The newborns quickly learned to turn to the correct side, indicating that they associated one sound with turning left and the other with turning right.

RECOGNITION

As with association, recognition is present from birth. This is apparent in newborns’ patterns of habituation and dishabituation. When newborns are exposed to an stimulus repeatedly, their ability to recognize that stimulus is reduced. When they are exposed to a different picture or stimulus, their ability to recognize it immediately increases (Werner & Sigelund, 1970). Thus, they implicitly recognize the old picture as familiar, and reduce the time they spend looking at it, and then recognize the new picture as unfamiliar, and look longer at it.

Infants’ recognition of objects is surprisingly durable. Even two weeks after they are habituated to a particular form, 3-month-olds continue to prefer to look at other forms that they have not been previously (Pianta, Fagan, & Miranda, 1975). Further, as noted in Chapter 1, the rate at which 7-month-olds habituate to stimuli predicts their later IQs quite accurately (Rose et al., 1992; Rose & Feldman, 1993). This may be due either to infants and children who quickly recognize objects having more time and energy to learn about other aspects of the world or to rapid habituation in infancy being indicative of generally more efficient information processing.

On what basis do infants recognize objects as familiar? To answer this question, Strauss and Cohen (1978) habituated 5-month-olds to an object with a particular size, color, form, and orientation (for example, a large, black arrow pointing down). Later, the infants were shown the original object plus another one that varied in one or more of these attributes. The alternative object might be a large, white arrow pointing down. In the example, for the infants to prefer
EXPLICIT AND IMPLICIT MEMORY

Basic processes allow children to form both explicit memories and implicit memories. Explicit memories are ones that can be described verbally, that are conscious, or that can be visualized as a mental image (Nelson, 1995). Implicit memories are ones that are not evident in these ways but that can be detected in other, less direct ways, such as patterns of solution times or physiological responses.

A study by Newcombe and Fox (1994) illustrates the difference. They showed 9-year-olds pictures of preschool classmates from five years earlier and pictures taken at the same time of children who went to another preschool. Roughly half of the 9-year-olds showed some explicit recognition of their preschool classmates; they were more likely to say that a child who attended preschool with them was in their class than to say that a child who did not was. The other half of the 9-year-olds did not show such explicit recognition. Regardless of whether the children showed such explicit memory, however, they showed physiological reactions characteristic of memory more often when they saw pictures of children from their original class than when they saw pictures of other children. These physiological responses indicated implicit recognition, regardless of whether the children consciously recognized their former classmates.

Implicit memory is not limited to physiological responses; it is also evident in behavior. For example, when children have seen pictures previously, they can recognize blurry versions of them more often than when they have not seen the pictures, even though they have no conscious awareness of having seen the pictures previously (Drummeny & Newcombe, 1995). As a second example, children are better at matching full faces with partial faces when the faces are those of children they once knew (such as former classmates) than when the faces are those of unfamiliar children (Lie & Newcombe, 1999).

Infants form implicit memories from birth onward, but they may not form explicit ones until 6 to 8 months of age (Nadel & Zola-Morgan, 1984; Nelson, 1995). The evidence for this view includes both behavioral and physiological data. The behaviors indicative of memory that infants show before this age (such as looking at novel objects more than familiar ones) elicit especially active processing in parts of the brain associated with implicit processing, such as the striatum and the cerebellum. The behaviors indicative of memory that infants show after this age but not before it (such as reproducing sequences of behaviors after an extended delay) draw heavily on brain structures associated with explicit processing, such as the prefrontal cortex and the amygdala. Some of the structures associated with explicit memory, especially the prefrontal cortex, mature very late, which may explain why young infants do not appear to form such memories. Yet other structures, in particular the hypothalamus, are sufficiently mature in the first few months after birth to support implicit processing, but seem to require further maturation to support explicit processing. Thus, substantial postnatal brain maturation may be necessary before infants can form explicit memories.

Next we consider some specific processes that produce memories: association, recognition, recall and generalization.

ASSOCIATION

Association is one of the most basic of basic processes. It is difficult to even imagine cognitive development taking place without the ability to associate stimuli with responses. Not surprisingly, given its centrality, the ability to associate stimuli and responses is present from birth. In one experiment that demonstrated this fact (Seigland & Lipsitt, 1966), whenever a buzzer sounded, newborns received a sweet solution for turning to the right, and whenever another tone sounded, they received the solution for turning to the left. The newborns quickly learned to turn to the correct side, indicating that they associated one sound with turning left and the other with turning right.

RECOGNITION

As with association, recognition is present from birth. This is apparent in newborns' patterns of habituation and dishabituation. When newborn primate infants are presented a picture repeatedly, their looking at it gradually falls off; when they are shown a different picture, their looking immediately increases (Werner & Seigland, 1978). Thus, they implicitly recognize the old picture as familiar, and reduce the time they spend looking at it, and then recognize the new picture as unfamiliar, and look longer at it.

Infants' recognition of objects is surprisingly durable. Even two weeks after they are habituated to a particular form, 2-month-olds continue to prefer to look at other forms that they have not seen previously (Pianta, Fagan, & Miranda, 1978). Further, as noted in Chapter 1, the rate at which 7-month-olds habituate to stimuli predicts their later IQs quite accurately (Rose et al., 1992; Rose & Feldman, 1993). This may be due either to infants and children who quickly recognize objects having more time and energy to learn about other aspects of the world or to rapid habituation in infancy being indicative of generally more efficient information processing.

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the new object, they would need to remember the color of the original, for this is the only dimension that differentiates the new object from the old one.

Immediately after 5-month-olds were shown the original stimulus, they remembered all four attributes. Fifteen minutes later, they remembered only form and color. Twenty-four hours later, they remembered only the form. Thus, infants’ recognition of the type of object they saw (for example, an arrow) is quite durable, but their memory for its properties, such as size, orientation, and color, is less enduring. This enduring importance of form in infants’ memory is reminiscent of their reliance on shape in inferring early word meanings (Chapter 6).

Recognition is strikingly accurate even at young ages: 2-year-olds recognize pictures more accurately than adults recall them (Perlmutter & Lange, 1978). By 4 years, the accuracy of recognition is truly remarkable. In one study, 4-year-olds answered correctly 100 percent of questions concerning whether they had seen a picture earlier, despite their having seen as many as 25 other pictures between their two exposures to the repeated one (Brown & Scott, 1971). Even when preschoolers were asked to recognize small differences—for example, whether a dog in the picture was sitting or standing—they still recognized correctly 95 percent of the pictures (Brown & Campione, 1972). The ability to recognize subtle distinctions improves further beyond the preschool period (Sophian & Stigler, 1981), but in general, recognition is excellent from early in development.

**Imitation and Recall**

Soon after birth, infants recall actions well enough to later imitate them. For example, when 6-week-olds see adults engage in activities that the infants sometimes do on their own, such as sticking out their tongues or opening and closing their mouths, they do that activity more often 24 hours later than do infants who did not see the adult engage in the activity (Meltzoff & Moore, 1994). The imitation is specific to the activity the infant saw. Infants who saw the adult stick out his tongue increased their frequency of tongue protrusions but not their frequency of opening and closing their mouths. Infants who saw the adult open and close his mouth showed the opposite pattern. To imitate these actions, infants must recall what they earlier saw.

The range of activities that infants imitate and the length of time over which they imitate them expand considerably over the next year. By 9 months of age, infants are capable of recalling and imitating 24 hours later not only naturally occurring actions but arbitrary ones such as pressing a button to trigger a beeping sound (Meltzoff, 1988). By the age of 14 months, infants will repeat even more unusual actions after more time has passed. For example, they will press their forehead against a panel to make a light go on four months after they saw an adult do it (Meltzoff, 1995b). The developmental changes in the activities that infants will imitate is reminiscent of Piaget’s hypothesized circular reactions, in which infants first only repeat activities that involve their own bodies and later repeatedly engage in activities involving external objects. Such early imitation provides infants a way of learning from other people, as well as demonstrating that infants are capable of recalling activities months after they saw them.

**Insight, Generalization, and Integration of Experiences**

Several of infants’ basic capabilities have been revealed in a series of experiments involving mobiles (Rovee-Collier, 1995, 1999). In these experiments, a mobile is placed above an infant’s crib, and a string is tied to the infant’s ankle and to the mobile, so that the mobile moves and makes noise when the infant kicks that leg (Figure 7.1). Three-month-olds’ learning on this task often comes quite abruptly. At a certain point in the session, they suddenly begin kicking much more often (Rovee & Fagen, 1976). The abruptness of the change suggests that infants, like adults, may from time to time have insights about how things work.

Three-month-olds’ encoding of the relation between their kicking and the mobile’s moving is often surprisingly literal, though. Even differences that seem

![Figure 7.1](https://example.com/image.jpg)
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totally irrelevant to adults, such as having a different color cloth on the infants’ crib on the second occasion, lead 3-month-olds not to generalize their earlier learning to a new mobile. However, given exposure to several similar mobiles, they learn to generalize to new ones (Rovee-Collier, 1989). Thus, 3-month-olds have the capacity to generalize, but they display it only under highly facilitative circumstances.

Infants also are able to integrate related experiences that occur fairly close in time. If 3-month-olds encounter the mobile a second time within three days of the initial exposure, they will better recall the relation five to seven days later than if they encountered the mobile only once or if they encountered it on two occasions separated by four days or more (Rovee-Collier, Evancio, & Earley, 1995).

To explain such integration of memories over time, Rovee-Collier (1995) proposed the construct of a time window. The basic idea is that there is a certain period during which children can integrate information and strengthen initial memories (the time when the window is open). Once this period ends, the window is closed, and even highly similar occurrences are stored separately and not integrated with the original one. The duration for which the time window is open is determined in large part by forgetting of the initial information; once information is forgotten, the time window is closed. Since older children generally forget more slowly, their time windows tend to be longer for any given task.

Presenting the second, similar event toward the end of the time window, when memories of the details of the original event are less strong than they were originally but not yet forgotten, is especially effective in preserving initial memories. This is true not only for infants, but also for older children and adults (Rovee-Collier, 1995; Rovee-Collier, Adler, & Borza, 1994). The finding has an interesting implication for eyewitness testimony: Asking children questions toward the end of their time window for the original event, when their memory of it is starting to weaken, may be especially effective for preserving the memory (Brainerd & Ornstein, 1990).

INHIBITION

To think well, we must prevent irrelevant ideas from intruding. Because concepts tend to be associated both with ideas that are relevant and ones that are irrelevant in the particular situation, efficient use of memory and other cognitive processes involves inhibiting ideas that are not useful in the situation. Illustratively, if you are trying to master a new physics concept, it may be helpful to inhibit thoughts of what you are planning to have for dinner.

The frontal lobe seems to play a crucial role in inhibition. It is one of the last areas of the brain to develop, showing substantial development toward the end of the first year, and also between 4 and 7 years and beyond (Luria, 1973; Thacher, Lyon, Rumsey, & Krasnegor, 1996). The effects of this neural development during infancy can be seen on ability to perform tasks that require inhibition of response tendencies, such as Piaget’s A-not-B task. On this task, infants see an object hidden and retrieve it several times at Location B; then they see it hidden at Location A. To succeed, the infants must inhibit the tendency to reach where the reward has been obtained in the past, and reach where it is now. Adult monkeys can ordinarily perform this task; however, if their frontal cortex is removed or frozen, they lose the ability and instead reach to the former hiding place (Diamond, 1985; Goldman-Rakic, 1987). Such experiments cannot be performed on human infants. However, it has been learned that between 6 and 12 months, the time when human infants become able to perform the task, they show increasing electrical activity in the frontal lobe while performing it (Bell & Fox, 1992). The improved inhibitory capabilities allow more enduring memory for the new location. Thus, Diamond (1985) found a steady increase in the delay that infants could tolerate and still search where the object was most recently hidden. At 7 months, infants would search at the correct location with delays as long as 2 seconds; at 9 months, with delays as long as 6 seconds; and at 11 months, with delays as long as 10 seconds (Figure 7.2). Further parallel developments between ability to inhibit responses and frontal lobe functioning are present between four and seven years. An everyday example of this development is ability to play “Simon Says.” When the adult has

FIGURE 7.2 Delays at which infants between 7 and 12 months can succeed on the A-not-B task (after Diamond, 1985).
totally irrelevant to adults, such as having a different color cloth on the infants' crib on the second occasion, lead 3-month-olds not to generalize their earlier learning to a new mobile. However, given exposure to several similar mobiles, they learn to generalize to new ones (Rovee-Collier, 1989). Thus, 3-month-olds have the capacity to generalize, but they display it only under highly facilitative circumstances.

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been saying "Simon Says" but then fails to say it, 4-year-olds find it difficult to inhibit executing the command. Seven-year-olds find it much easier to show the needed inhibition. Many similar changes occur between 4 and 7 years on tasks that require inhibition (Dempster, 1992). For example, to remember lists of words, children must focus on words on the most recent list and inhibit associated terms and words from other lists. Part of 4- and 5-year-olds' difficulty on such tasks is that they fail to inhibit such related terms and recall them as being on the new list (Harnishfeger & Bjorklund, 1994). Similarly, to exhibit conservation of liquid quantity, children must inhibit the perceptual information that the tall, thin glass looks like it has more water, and focus on the fact that nothing was added or subtracted (Dempster, 1992). Again, 4- and 5-year-olds have difficulty doing this. Supporting the view that young children's difficulty on the conservation task lies in ignoring interfering information, if the misleading cues are removed—for example by putting a shield in front of the glasses containing the liquid—4-year-olds consistently succeed on the task (Bruner, 1966). Thus, growing ability to inhibit inappropriate responses and to block out interfering information seem to contribute considerably to cognitive development during infancy and early childhood.

**PROCESSING CAPACITY**

One of the most controversial issues about children's thinking is whether the amount of information that they can actively process at one time (their working memory capacity) changes with age. There is no question about the potential importance of such changes. If young children cannot simultaneously process as much information as older ones, their ability to learn and remember should be less than that of older children. But does working memory capacity in fact expand?

This question has been addressed by examining how many randomly selected letters or single-digit numbers children of different ages can remember. Figure 7.3 illustrates that the number increases steadily with age. Most 5-year-olds can correctly recall lists of four digits, but not longer ones, whereas most adults can recall lists with seven digits. Such data have led a number of investigators, among them Pascual-Leone (1970, 1989), to propose that the absolute number of symbols that people can hold in working memory more than doubles from infancy to adulthood.

Although the data are clear, the implications for whether working memory capacity changes with age are not so obvious. The demand on cognitive resources that a task imposes reflects both the child's resources and the task. Developmental improvements in performance can be produced either by an increase in the child's resources or by a decrease in the resources the child expends in doing the task. Consider some reasons why older children might remember longer lists of numbers, even if the absolute capacity of their working memory did not differ from that of younger children. The older children know more about numbers. This greater familiarity could help them remember the numbers more efficiently. They also know more strategies, such as rehearsal, for enhancing their recall. They also are more skillful in choosing when to use the strategies they know. Thus, it is clear that older children can store more material in working memory, but it remains unknown (and perhaps unknowable) whether this is due to change in the actual capacity of working memory or to changes in knowledge and strategies that allow more material to be stored within the same capacity (as in the car trunk analogy in Chapter 3).

**PROCESSING SPEED**

Speed of information processing, like the number of numbers that can be held in memory, increases greatly with age. This has been found for immediate processing (Howling, Spencer, Robb, & Schalme, 1978; LeBlanc, Muise, & Blanchard, 1992), processing of information in working memory (Hale, 1980; Hale et al., 1997; Hitch & Towse, 1995; Miller & Vernon, 1997), and retrieval of information from long-term memory (Hale, 1990; Kail, 1986, 1988; Whitney, 1986). The general form of the improvement is not in dispute. As shown in Figure 7.4, processing speed increases most rapidly at young ages, with the rate of change slowing thereafter, though speed continues to increase well into adolescence (Kail, 1991). However, considerable controversy has arisen over whether the increased speed is due to greater use of more efficient strategies, to greater familiarity with the items being processed, or to increases in speed per se.
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recall), generalize, and perform other basic processes. These capacities allow them to remember a tremendous amount before they possess strategies, understanding of memory, or content knowledge. Further, without basic capacities, all other memory activities would be futile. For example, rehearsing a phone number would be pointless if we could not associate the phone number with the person whose number it was. The number of associations that are made, the length of time over which experiences are recalled, the time window within which experiences are integrated, the variety of circumstances over which generalizations are drawn, and the speed with which all of these processes are executed increase substantially during and after infancy. However, basic processes allow infants to learn and remember from the earliest days of life.

**Basic Processes and the Puzzle of Infantile Amnesia**

Given that infants can recognize, associate, and learn, why are adults almost never able to remember anything that happened to them in their early years? Think about it: What do you remember about your life before you were 37? Although some people's earliest memories date from around age 2 (Eacott & Crawley, 1998; 1999; Weigle & Bauer, 2000), most people remember very little that occurred before the age of 3 (Bruce, Dolan, & Phillips-Grant, 2000; Pillemer & White, 1989; Rubin, 2000). Adults' memories of the few years after age 3 also tend to be scanty. Most people remember only a few events, usually ones that were extremely meaningful and distinctive, such as a trip to Disneyland, being in a hospital, or a sibling being born. The phenomenon is not limited to human beings; rats and many other mammals also show little recall of events that occurred early in their lives (Spears, 1984).

How might this inability to recall early experiences be explained? The sheer passage of time does not account for it; recall from Chapter 3 people's excellent recognition of pictures of people who attended high school with them 35 years earlier. Another seemingly plausible explanation, that infants do not form enduring memories at this point in development, also is incorrect. Children between 2% and 3 years old can remember experiences that occurred many months before, and some remember experiences that occurred during their first year of life (Meyers, Clifton, & Clarkson, 1987; Peterson, 2002). Similarly, 1-year-olds who are exposed to simple sequences of actions (such as making and stirring a gang) demonstrate recall of those sequences up to a year later (Bauer, Wenneker, Droppik, & Wenneker, 2000), with memory becoming increasingly robust and long-lasting over the age range 13 to 20 months (see Figure 7.5). Nor does Freud's (1905/1953) hypothesis that infantile amnesia reflects repression of sexually charged episodes explain the phenomenon. While such repression may occur, people cannot remember ordinary events from the infant and toddler periods either.

**Evaluation**

Basic processes are large and direct contributors to memory development from the first days out of the womb. Even very young infants associate, recognize,
Recent evidence suggests that speed of processing per se increases with maturation. At a given age, children who are more physically mature (that is, a greater percentage of the height that would be expected from their parents' heights) process information more quickly (Eaton & Ritchot, 1995). Although practice also produces faster information processing, the relation between age and processing speed does not seem to be reducible to older children having more practice at the tasks. The mathematical function that best describes the increase in processing speed with age is different from the one that best describes the improvements that come with practice (Kail, 1991; Miller & Vernon, 1997). Further, similar increases in processing speed are present for tasks that children rarely encounter (for example, mental rotation) as for ones they encounter daily (such as reading and arithmetic). Thus, speed of processing increases with age, above and beyond increases attributable to practice and superior strategies. The faster processing leads to improved performance on many tasks.

**Evaluation**

Basic processes are large and direct contributors to memory development from the first days out of the womb. Even very young infants associate, recognize, recall, generalize, and perform other basic processes. These capacities allow them to remember a tremendous amount before they possess strategies, understanding of memory, or content knowledge. Further, without basic capacities, all other memory activities would be futile. For example, rehearsing a phone number would be pointless if we could not associate the phone number with the person whose number it was. The number of associations that are made, the length of time over which experiences are recalled, the time window within which experiences are integrated, the variety of circumstances over which generalizations are drawn, and the speed with which all of these processes are executed increase substantially during and after infancy. However, basic processes allow infants to learn and remember from the earliest days of life.

**Basic Processes and the Puzzle of Infantile Amnesia**

Given that infants can recognize, associate, and learn, why are adults almost never able to remember anything that happened to them in their early years? Think about it: What do you remember about your life before you were 3? Although some people's earliest memories date from around age 2 (Eacott & Crawley, 1998, 1999; Weigle & Bauer, 2000), most people remember very little that occurred before the age of 3 (Bruce, Dolan, & Phillips-Grant, 2000; Pillemer & White, 1989; Rubin, 2000). Adults' memories of the few years after age 3 also tend to be scanty. Most people remember only a few events, usually ones that were extremely meaningful and distinctive, such as a trip to Disneyland, being in a hospital, or a sibling being born. The phenomenon is not limited to human beings; rats and many other mammals also show little recall of events that occurred early in their lives (Spear, 1984).

How might this inability to recall early experiences be explained? The sheer passage of time does not account for it; recall from Chapter 3 people's excellent recognition of pictures of people who attended high school with them 35 years earlier. Another seemingly plausible explanation, that infants do not form enduring memories at this point in development, also is incorrect. Children between 2 and 3 years old can remember experiences that occurred many months before, and some remember experiences that occurred during their first year of life (Myers, Clifton, & Clarkson, 1987; Peterson, 2002). Similarly, 1-year-olds who are exposed to simple sequences of actions (such as making and striking a gong) demonstrate recall of those sequences up to a year later (Bauer, Wenner, Droppik, & Weisner, 2000), with memory becoming increasingly robust and lasting over the age range 13 to 20 months (see Figure 7.5). Nor does Freud's (1905/1953) hypothesis that infantile amnesia reflects repression of sexually charged episodes explain the phenomenon. While such repression may occur, people cannot remember ordinary events from the infant and toddler periods either.
Three other explanations seem more promising. One involves physiological changes relevant to memory. Maturation of the frontal lobes of the brain continues throughout childhood. This part of the brain, and in particular, the prefrontal cortex, may be critical for remembering particular episodes in ways that can later be retrieved (Diamond, 1990; Newcombe, Drummey, Fox, Lie, & Ortinger-Alberts, 2000; Schacter, 1987). Demonstrations of infants’ and toddlers’ long-term memory typically involve their repeating sequences of actions that they had earlier seen or done (e.g., Bauer, 1996; Bauer et al., 2000). The brain’s level of physiological maturation may support these types of memories, but not ones requiring explicit verbal descriptions.

A second explanation involves the influence of the social world on children’s talk about the past. Adults often engage young children in conversations about past events. Early on, adults provide most of the structure and content for these conversations, scaffolding children’s memories of past events (for example, “Remember when Aunt Molly came to visit?”). Some mothers use a highly elaborative style, encouraging children to provide many details about past events and frequently expanding on children’s contributions to the conversations. Other mothers use a less elaborative style, asking specific questions but rarely prompting for details (Fivush & Freeman, 1998). Numerous studies have shown that children whose mothers use a highly elaborative style remember more than children whose mothers are less elaborative (Haden, Haine, & Fivush, 1997; Harley & Reese, 1999; Leichtman, Pillemer, Wang, & Koreishi, 2000). However, regardless of parental style, over time children begin to participate more actively in conversations about the past, bringing up past events as topics and describing the events themselves (Nelson & Fivush, 2000).

Participating in adult-guided conversations about past events may help young children store information in ways that will endure into later childhood and adulthood (Fivush & Hammood, 1990; Hudson, 1990). Through hearing and telling stories with a clear beginning, middle, and ending, children may learn to extract the gist of events in ways that they will be able to describe many years later. Consistent with this view, parents and children increasingly engage in discussions of past events when children are around 3 years old. However, hearing such stories is not sufficient for younger children to form enduring memories. Telling such stories to 2-year-olds does not seem to produce long-lasting, verbalizable memories (Goleman, 1993).

A third likely explanation for infantile amnesia involves incompatibilities between the ways in which infants encode information and the ways in which older children and adults retrieve it. Whether people can remember an event depends critically on the fit between the way in which they earlier encoded the information and the way in which they later attempt to retrieve it. The better able the person is to reconstruct the perspective from which the material was encoded, the more likely that recall will be successful.

A variety of factors can create mismatches between very young children’s encoding and older children’s and adults’ retrieval efforts. The world looks very different to a person whose head is only two or three feet above the ground than to one whose head is five or six feet above it. General knowledge of categories of events (a birthday party; visit to the doctor’s office; baseball game) helps older individuals encode their experiences (“I remember the baseball game I went to on my seventh birthday”), but again infants and toddlers are unlikely to encode many experiences within such knowledge structures (Nelson, 1993). Likewise, infants and toddlers do not use language to encode events, but recall in older children is often mediated by verbal cues and questions. Children have some ability to encode pre-verbal memories into verbal form, particularly if they re-experience the context in which the original event occurred (Bauer, Kroupina, Schwade, Dropik, & Wewerka, 1998). However, children who experience events before the onset of narrative skills seldom recall them in verbal form at a later time (Petersen & Rideout, 1998). This holds true even for traumatic events such as injuries that require emergency care.

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infants and toddlers do not form extremely enduring memories, even when they hear stories that promote such remembering in preschoolers. Hearing the stories may lead preschoolers to encode aspects of events that allow them to form memories they can access as adults. Conversely, improved encoding of what they hear may help them better understand and remember stories, and thus make the stories more useful for remembering future events. Thus, all three explanations—physiological maturation, hearing and producing stories about past events, and improved encoding of key aspects of events—seem likely to be involved in overcoming infantile amnesia.

Strategies

A nine-year-old boy memorized the license plate number of a getaway car following an armed robbery; a court was told Monday... The boy and his friend... looked in the drug store window and saw a man grab a 14-year-old cashier’s neck... After the robbery, the boys mentally repeated the license number until they gave it to police. (Edmonton Journal, January 13, 1987, cited in Kail, 1984)

Without using this memory strategy, known as rehearsal, the boys almost certainly would have forgotten the license number before they could tell the police. But what are memory strategies, how do children acquire them, and how do they choose when to use them?

Strategies are “cognitive or behavioral activities that are under the deliberate control of the subject and are employed so as to enhance memory performance” (Naus & Ornstein, 1983, p. 12). Children employ strategies in all phases of memorization when they encode material, when they store it, and when they retrieve it. Many age-related improvements in memory reflect acquisition of new strategies, refinement of existing ones, and application of existing strategies to additional situations.

Although many particulars vary with the strategy, certain features characterize the development of all strategies (Waters & Andrews, 1983). When children first acquire a memory strategy, they use it in only some of the situations where it is applicable. They limit it to materials for which the strategy is easy to use and to situations that are relatively undemanding. They also are quite rigid in applying the strategy and often fail to adapt to shifting task demands. All of this changes with development. Older children use strategies in more diverse situations, including ones that make the strategies difficult to execute; they use higher-quality versions of strategies; they tailor them to the particulars of the situation; and they derive greater benefits from using the strategies.

Another general feature of strategy use is that it varies with children’s experience. For example, German second- and third-graders use certain strategies for organizing material more often than do American age peers (Kurtz, Schneider, Carr, Borkowski, & Rellinger, 1990). Why is this the case? It does not appear to be any inherent difference between German and American children. After children of both nationalities receive brief training in the organizational strategy, they use it equally often. Instead, the source seems to be differences in adults’ approaches. When asked whether they teach children such strategies, German parents and teachers reported doing so considerably more often than did American parents and teachers (Kurtz et al., 1990).

We next consider some of the specific strategies that children use, how their use changes with age, and why the changes occur.

SEARCHING FOR OBJECTS

Even before their second birthday, children begin to use rudimentary strategies. Several of these strategies are evident in the way they search for hidden objects. In one study (DeLoache, Cassidy, & Brown, 1983), 18- to 24-month-olds saw a Big Bird doll hidden under various objects such as pillows. They then had to wait three or four minutes until the experimenter asked them to find the doll. The toddlers engaged in a variety of strategies to keep alive their memories of the doll’s location. While waiting, they looked at the hiding place, pointed to it, and named the hidden object. They did not engage in these activities nearly as frequently when Big Bird was in plain sight, Thus indicating that the strategies were limited to situations in which they were needed to remember Big Bird’s location.

Very young children’s use of such strategies is fragile; they use them only under the most favorable circumstances. Thus, when an object was hidden under one of three identical cups, rather than under a more distinctive object such as a pillow, 2-year-olds did not engage in strategies such as watching or touching the correct cup. In contrast, 3-year-olds extended to these non-featured objects the types of strategic activities, such as naming and pointing, that younger children applied only to more distinctive objects (Wellman, Ritter, & Flavell, 1975). In general, familiarity with the task setting leads to more consistent and efficient strategy use (Schneider & Sodman, 1986).

Development of strategies for finding hidden objects continues for a number of years. For example, when asked to find an object hidden under one of six identical cups placed on a spinning turntable, 8-year-olds spontaneously used the strategy of picking up from the table a gold star or a paper clip and placing the marker on the relevant cup; 5-year-olds usually required hints from the experimenter to use this strategy; 3-year-olds either did not use the strategy at all or did so only after a great deal of prompting (Beal & Fleisch, 1987; Ritter, 1978).

REHEARSING

When verbatim recall is essential, repeating information over and over can be very helpful. School-age children often use this strategy to good advantage, as was illustrated in the license plate anecdote at the beginning of this section.
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However, children younger than age 6 or 7 would have been considerably less likely to repeatedly rehearse the numbers in the license. In one study of the uses of such rehearsal, 5- and 10-year-olds were shown seven pictures and saw the experimenter point to three of them. The children knew they would need to point to the same three pictures in the same order after waiting for 15 seconds. Far more 10- than 5-year-olds moved their lips or audibly repeated the pictures’ names and over in the 15 seconds between when the pictures were presented and when the children were asked to name them. Those children who rehearsed in this way recalled more than those who did not (Flavell, Beach, & Chinsky, 1986).

Sometimes these results are interpreted to mean that 5-year-olds do not rehearse and that older children do. The reality is more complex, though. Trial-by-trial examination of children’s serial recall has shown that on some trials, most 5-year-olds rehearse in the same way as older children (McGilly & Siegler, 1989, 1990). They also recall correctly more often on trials where they rehearse than on trials where they do not.

Teaching rehearsal strategies leads 5-year-olds to use them more and to recall more than they did previously. However, the levels of recall do not rise to the levels of older children, and the young children often do not continue rehearsing more often in new situations (Hagen, Hargrove, & Ross, 1973).

ORGANIZING

When people need to recall material, but not necessarily in the original order, they often reorganize it into easier-to-remember forms. For example, when 10-year-olds are asked to remember the terms “couch, banana, dog, chair, apple, rat, table, cow, orange,” they often organize the terms into three categories—furniture, fruit, and animals. Then they try to remember by thinking to themselves something like, “Furniture, let’s see, was there a table, yes, ‘table’; was there a lamp, no, was there a chair, yes ‘chair’;” and so on.

The development of such organizational strategies largely parallels the development of rehearsal. As with rehearsal, 5- and 6-year-olds use organizational strategies less often than 9- and 10-year-olds (Carr, Kurtz, Schneider, Turner, & Borkowski, 1989). However, like older children, younger children sometimes do use organizational strategies (Bjorklund & Coyle, 1995), and children who use such strategies tend to remember more than those who do not (Schneider, 1986). The same type of trial-to-trial variability that is present in rehearsal strategies is also evident in use of organizational strategies (Coyle & Bjorklund, 1997).

Many children display a fairly abrupt transition from not using organizational strategies to using them quite consistently. This rapid “jump” in performance has been documented in research on individual children’s memory performance over a series of weekly sessions (Schlagmueller & Schneider, 2002).

Children appear to recognize the benefits of organizational strategies, and once they have discovered the strategies, they use them regularly.

Children can learn organizational strategies as early as 4 or 5 years, and learning the strategies helps them remember more (Lange & Pierce, 1992). On the other hand, they often do not transfer the learning to new situations, even to ones that resemble the original one (Williams & Goulet, 1975).

SELECTIVE ATTENTION

As noted in the Chapter 5 discussion of attention-getting properties of stimuli, much of infants’ attention has an elicited, involuntary feel to it. Children soon begin to attend more selectively, though, to information important for meeting their goals. For example, 4-year-olds who are told that they later will need to remember some toys tend to name those toys more often during the waiting period (Baker-Ward, Ornstein, & Holden, 1984). This suggests that they selectively attend to the toys they need to remember.

As with rehearsal and organization, selective attention strategies become considerably more prevalent between preschool and middle childhood. The increasing selectivity is particularly tangible in the task shown in Figure 7.6. Children see two rows of boxes, with six boxes in each row. Inside each box is a toy animal or household object: the boxes with animals have a picture of a cat on top, and those with household objects have a picture of a house. Some children are told that they will need to remember where each animal is, others that they will need to remember where each household object is. Then they are
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given a study period, during which they can open any boxes they think will help them remember the location of the relevant objects. A sensible strategy for a child who needed to remember the animals would be to open each box marked with a cage, to find out which animal was in each one.

The selectivity with which children focus their attention on the relevant category increases greatly between ages 3 and 8 (DeMarie-Dreblow & Miller, 1988; Miller & Seler, 1994). The least advanced children, who also tend to be the youngest children, look indiscriminately in both types of boxes during the study period. Somewhat more advanced children look more often in the boxes of the relevant category but still also look fairly often in the boxes in the other category. Yet more advanced children look almost exclusively in the boxes of the relevant category but do not recall more than those children who also look at some irrelevant boxes. Only the most advanced children both limit their attention completely to the relevant boxes, and remember more than children who deploy their attention less selectively.

Part of older children's superior deployment of attention involves its greater systematicity: This was demonstrated in an analysis of 4- to 8-year-olds' eye movements (Vurpillot, 1968). The children were shown pictures of houses with six windows, like those in Figure 7.7. They needed to determine whether the house on the left was identical to that on the right, and if not, where they differed. Ideally, children would scan a window in the house on the left, then the corresponding window in the house on the right, then another window in the first house, then the corresponding window in the second house, and so on until they either found a difference or had examined all of the windows. Systematically proceeding through the different windows, for example from top to bottom and left to right, also seemed a desirable way to deploy attention, because it would assure that all windows would be compared without repetition.

With age, children's scanning became increasingly systematic. Older children more often looked back and forth between corresponding windows in the two houses and more often proceeded down a column or across a row within a house. They also more often examined all windows before answering that the houses were identical. To summarize, with age, children's attention becomes more focused on relevant information and more systematic.

**ALTERNATIVE EXPLANATIONS OF STRATEGIC CHANGE**

These findings raise the question: Why would children not use a helpful strategy? Initial attempts to account for this phenomenon focused on two reasons why preschoolers might not use rehearsal. One was that they have a mediational deficiency (Reese, 1962). According to this view, young children do not use strategies such as rehearsal because the strategies do not lead to them recalling more than if they do not use them. The other proposed explanation was that young children's infrequent use of such strategies was due to a production deficiency (Flavell, 1970). According to this view, the problem was children not choosing to use the strategy, even though using it would have aided their memory.

Today, neither of these positions seems to provide an adequate explanation. The mediational-deficiency hypothesis fails to explain why young children's recall usually increases when they are taught strategies. The production-deficiency hypothesis does not explain why most 5-year-olds sometimes rehearse, nor why they sometimes would choose to rehearse and other times not.

What seems necessary to understand preschoolers' limited use of rehearsal and other memory strategies is a deeper appreciation of the costs as well as the benefits of using a strategy. In many cases, young children both realize fewer benefits from using strategies and incur greater costs than older children. When people first learn a strategy, the costs in mental effort required to use it are greater than they will be later on. For example, rehearsing a set of numbers while simultaneously performing another task (such as tapping one's index finger on a table as fast as possible) produces greater decrements in performance.
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**Alternative Explanations of Strategic Change**

These findings raise the question: Why would children not use a helpful strategy? Initial attempts to account for this phenomenon focused on two reasons why preschoolers might not use rehearsal. One was that they have a **medialational deficiency** (Reese, 1962). According to this view, young children do not use strategies such as rehearsal because the strategies do not lead to them recalling more than if they do not use them. The other proposed explanation was that young children's infrequent use of such strategies was due to a **production deficiency** (Flavell, 1970). According to this view, the problem was children not choosing to use the strategy, even though using it would have aided their memory.

Today, neither of these positions seems to provide an adequate explanation. The mediation-deficiency hypothesis fails to explain why young children's recall usually increases when they are taught strategies. The production-deficiency hypothesis does not explain why most 5-year-olds sometimes rehearse, nor why they sometimes would choose to rehearse and other times not.

What seems necessary to understand preschoolers' limited use of rehearsal and other memory strategies is a deeper appreciation of the costs as well as the benefits of using a strategy. In many cases, young children both realize fewer benefits from using strategies and incur greater costs than older children. When people first learn a strategy, the costs in mental effort required to use it are greater than they will be later on. For example, rehearsing a set of numbers while simultaneously performing another task (such as tapping one's index finger on a table as fast as possible) produces greater decrements in performance.
on the secondary task for younger than for older children (Cutting, 1984, 1985, Kee & Howell, 1988). The greater decrease in young children's tapping rate seems to be due to the greater mental resources they need to expend in order to rehearse.

This analysis suggests that young children's use of a strategy can be raised either by increasing the benefits or decreasing the costs of using it. Consistent with this prediction, children more often rehearse, and rehearse in more sophisticated ways, when the benefits to them of using the strategy are increased, for example by paying them money for successful recall (Kunzinger & Wittryo, 1984). Strategy use also increases when the costs of using the strategy are decreased, for example by presenting material that is relatively easy to rehearse (Ornstein, Medlin, Stone, & Naus, 1985; Ornstein & Naus, 1985). Children's use of a strategy thus is sensitive to both its costs and its benefits. Increases with age in strategy use reflect both greater benefits and lower costs to the older children.

The concepts of mediation and production deficiencies were proposed to explain why children often do not use strategies that would improve their recall if they used them. The opposite phenomenon also occurs: fairly often, children use strategies that do not initially help them remember better (Bjorklund & Coyle, 1995; Miller, 1990; Miller & Seier, 1994). This phenomenon has been termed a utilization deficiency. The lack of improved recall seems to reflect the cost in mental resources of using the strategies negating the benefits that the strategies convey. Consistent with this analysis, when an experimenter reduces the mental effort needed to use a strategy by executing part of it for the child, younger children benefit from strategies that otherwise would not increase their recall (DeMarie-Drelow & Miller, 1988; Miller, Woody-Ramsey, & Aloise, 1991).

The existence of utilization deficiencies raises the question of why children would ever use strategies that do not help their recall. A key to answering this question may lie in the fact that utilization deficiencies generally occur with newly acquired strategies. The efficiency of executing any procedure increases with practice; this finding is so consistent that it is referred to as the "law of practice" (Newell & Rosenbloom, 1981). Thus, if a newly learned strategy already yields performance as successful, or even almost as successful, as a well-practiced strategy, the odds are excellent that with practice, the new strategy will yield more successful performance. So why not use it? Utilization deficiencies thus may reflect the cognitive system acting as if it implicitly knows the law of practice.

**EVALUATION**

Age-related improvements in the frequency of use and quality of children's strategies play a large role in memory development between the preschool years and adolescence. During this time, frequency and quality of rehearsal, organization, and selective attention improve greatly. Development of memory strategies is not limited to changes in how often the strategies are used. Older children also use more effective versions of the strategies, use them in difficult as well as easy contexts, and generally increase their recall more substantially when they use them.

One intriguing phenomenon related to memory strategies is that training children to use such strategies is no guarantee of their continued use. This raises the question, "How do children decide which strategy to use?". One possibility is that children rely on their metacognitive knowledge (knowledge of relevant strategies, task difficulty, and their own cognitive capacities) to make such decisions.

**Metacognition**

Metacognition can be divided into two types of knowledge: explicit, conscious, factual knowledge and implicit, unconscious, procedural knowledge (Brown, Bransford, Ferrara, & Campione, 1983). As an example of explicit metacognitive knowledge, even preschoolers are consciously aware that it is easier to remember a few items than many. However, much metacognitive knowledge is unconscious; the knowledge influences behavior without our being aware of it. Such implicit metacognitive knowledge is apparent when good readers slow down their reading when a book becomes difficult, without even realizing they are doing so. In this section, we examine the development of both explicit and implicit metacognitive knowledge and how they affect children's ability to remember.

**EXPLICIT METACOGNITIVE KNOWLEDGE**

Children beyond preschool age and adults possess a large fund of explicit knowledge about thinking in general and memory in particular. This knowledge includes information about tasks ("It's easier to remember the main point of a passage than to remember the passage verbatim"), information about strategies ("Rehearsing a telephone number is useful for remembering it"), and information about people ("Older children usually remember more than younger ones"). Much of this knowledge seems to be acquired between ages 5 and 10.

Probably our most basic knowledge of memory is that it is fallible. Almost all children beyond age 6 know that they forget, but a substantial minority of 5-year-olds (30 percent) deny that they ever do (Kornitzer, Leorand, & Flavell, 1975). Young children's overoptimism about their memory capacities can be seen in other contexts as well. For example, when 4-year-olds were asked how many of 10 pictures they would remember, most thought they would remember all 10 (Flavell, Friedrchs, & Hoyt, 1970). Their estimates of what they would remember were higher than those of older children, even though they actually remembered
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less. The preschoolers’ overoptimism may reflect wishful thinking as well as lesser abstract knowledge, when asked to predict how much other children would remember, they were less overoptimistic than in predicting their own performance (Stipek, 1984).

During elementary school and beyond, children and adolescents acquire a wide range of knowledge about how tasks, strategies, and characteristics of learners affect memory (Schneider & Bjorklund, 1998; Weinert, 1986). Approximately half of first-graders know that it is easier to remember the gist of a story than it is to remember the story verbatim; virtually all fifth graders know this (Kreutzer et al., 1979). Similarly, approximately half of first graders know that recognition is easier than recall, whereas virtually all fifth graders do (Sper & Flavell, 1979). The growth in metacognitive knowledge during this period may be stimulated by the increasing amount of remembering children need to do at school, and by the feedback they receive on whether they have remembered correctly.

Much research on this type of explicit factual knowledge of cognition has been motivated by the plausible assumption that children’s increasing knowledge about memory and about the general cognitive system leads them to choose better strategies and to remember more effectively. Evidence for this intuitively reasonable position has been surprisingly hard to obtain. Early investigations revealed only weak relations (Cavanaugh & Perlmuter, 1982). More recent analyses of the results of many studies have yielded evidence of something stronger relations between metamemnmonic knowledge and memory performance (Schneider & Bjorklund, 1998; Schneider & Pressley, 1989). Still, the relation is not as strong as many people’s intuitions would suggest.

IMPLICIT METACOGNITIVE KNOWLEDGE

In contrast to their limited explicit, factual knowledge about memory, toddlers and preschoolers show impressive implicit knowledge. This is especially evident in their monitoring of their own cognitive activities. For example, 2-year-olds show that they monitor their use of language when they spontaneously correct their mistakes in pronunciation, grammar, and naming of objects. They also show such monitoring in comments on their own and others’ use of language, and in their adjusting what they say to listeners’ knowledge and general cognitive level (Clark, 1978). For example, Siegler’s 2½-year-old daughter once told him, “You’re a ‘he,’ Todd’s a ‘he,’ and girls are ‘she’s.”’ Two weeks later, she encountered difficulty pronouncing the word “hippopotamus” and explained, “I can’t say it because I can’t make my mouth move the right way.”

Such self-monitoring enables even young children to experience a feeling of knowing that can help them anticipate how well they will later remember. Illustratively, in one study, 4- and 5-year-olds were shown photographs of children whom they knew to varying degrees. Even when 4- and 5-year-olds did not remember the name that went with a photo, they accurately predicted whether they would be able to remember the name if given the set of names of all of the children in the photos (Cuitice, Somerville, & Wellman, 1983).

Despite this early ability to monitor thought processes well enough to experience feelings of knowing, and despite the fact that such monitoring improves further during the elementary school period (Zabrucky & Ratner, 1986), the skill is far from perfectly developed even among older students (Pressley, 1995; Zabrucky & Ratner, 1986) and adults (Narens, Graf, & Nelson, 1996; Reder & Schunn, 1996). Problems are especially persistent in monitoring one’s understanding well enough to detect a lack of understanding of what other people are saying. For example, even a fairly large percentage of college students failed to detect the blatant contradictions in the following paragraph:

Some snakes have a poisonous bite, but some snakes are harmless and even help us. The garden snake, for example, helps us by keeping bad insects away from our gardens. Garden snakes eat these insects. They find the insects by listening for them. The insects make a special noise. Garden snakes do not have ears. They cannot hear the sounds of the insects. That is how they are able to find the insects. (Elliott-Faust, 1984; cited in Schneider & Pressley, 1989, p. 167)

Good readers and poor ones differ greatly in ability to monitor their comprehension. Older and better readers slow down and often return to the place in the text where comprehension difficulties began. In contrast, younger and poorer readers rarely return to problem spots (Garnier & Reis, 1981; Whiteman, 1975). The situation is paradoxical; the younger and less-skilled readers have more reason to re-read (because they typically understand less well on the first reading), but they do so less often.

Self-monitoring skills are especially critical for choosing what and how much to study. Not surprisingly, older children more effectively monitor their knowledge, and more effectively adapt their study strategies to how well they know the material. The amount of time children study before saying that they know material increases steadily from age 4 at least through age 12 or 13, presumably because older children’s monitoring of their knowledge reveals that they have not mastered the material until later in the studying process (Duffresne & Kobaiga, 1989; Flavell et al., 1979). Older children also focus more of their attention on material they have not yet mastered, again presumably because their monitoring suggests that this material needs the greatest attention (Bisanz, Vesonder, & Voss, 1978).

Allocating study time is a tricky business, though. Consider just the dilemma posed in receiving the results of earlier tests and then studying for later tests on the same material. Is the best strategy to concentrate primarily on the topics that caused the most errors earlier, or is it better to devote study time to other topics as well? Focusing on the sections that you didn’t remember should help performance on that material, but might lead to worse performance on the material you correctly recalled the first time. On the other hand, reviewing the better-learned portions might be a waste of time.
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Not surprisingly, children who are just learning to study have difficulty making these choices. In one experiment where children were given a chance to study after performing partially correctly on an initial memory test (Masur, McEntyre, & Flavell, 1973), 7- and 9-year-olds took different paths. The 9-year-olds focused on the items they had not remembered; the 7-year-olds distributed their attention more widely. The 9-year-olds' strategy sounds more sophisticated, but it was no more helpful than that of the 7-year-olds. The two strategies led to equal improvements in recall on the second test. The items children forget between the first and second testings cancel out the items that they previously had not remembered but later did. Some problems just do not have good solutions.

**EVALUATION**

Metacognition is at the same time intriguing and frustrating as an explanation of memory development. Part of the appeal resides in the plausibility of its central premise—that what children know about memory influences how they attempt to remember. Another part lies in the potential generality of the influence of metacognitive skills and knowledge. For example, knowing the relative usefulness of strategies could improve children's strategy choices in a wide range of situations. Yet another part of the appeal resides in the potential benefits of teaching metacognitive knowledge and skills. Metacognitive knowledge and skills are potentially both instructive and broadly applicable. This makes them better candidates for instruction than basic processes, which are difficult if not impossible to change. Teaching metacognitive knowledge also offers an advantage over teaching specific strategies that can only be used in narrow circumstances, such as rehearsal, which can only be used for rote memorization. Improved knowledge of metacognitive skills, such as how to monitor comprehension, can have broadly beneficial effects on children's learning (Baker, 1994; Borkowski, Johnston, & Reid, 1987; Palincsar & Brown, 1984; Pressley, 1995).

The frustrating aspect of metacognition becomes apparent when we try to determine whether children's increasing metacognitive knowledge helps them remember better. Both memory performance and knowledge about memory improve with age. However, the relation between memory performance and amount of knowledge about memory is not especially strong (Schneider & Bjorklund, 1998). This raises the question of how much impact metacognition actually has on memory development.

One useful way of thinking about the issue is summarized in the proverb, "Many a slip 'twixt the cup and the lip." Metacognitive knowledge may influence memory performance only when each of a relatively long series of conditions is met. Consider what might be involved in a girl's using metacognitive knowledge to choose a strategy for remembering verbatim a long list of numbers.

The girl would need to know that her memory was not perfect and that she might not remember all of the numbers. When she heard the particular list of numbers, she would need to monitor her own memory well enough to recognize that her storage of the numbers was insufficient to hold them in memory without using some strategy. She also would need to know a relevant strategy, such as rehearsal, and would need to choose it rather than a less effective alternative. Finally, for her to use the relevant strategy more often in the future, she would need to attribute whatever benefit she derived to using the strategy rather than to some other factor, such as trying harder.

This perspective makes understandable both the considerable success that can be gained from teaching children metacognitive skills and the frequent findings of weak relations in the everyday environment between metacognitive knowledge and memory performance. If all links in the chain are present, as would often occur in carefully planned instructional programs, metacognitive knowledge can considerably aid memory performance. If even one link is missing, however, as would often occur in the everyday environment, the relation can disappear.

Consider how this seems to operate in one area—transfer of strategies to new situations. Even if children know a strategy, use it, and witness improved memory as a result, they rarely transfer the strategy to new situations unless they also attribute the improvement in memory to the use of the strategy (Borkowski, Carr, & Pressley, 1987; Fabriucis & Hagen, 1984; Pressley, Levin, & Gahala, 1984). Children and adults who have been taught to use a strategy that improves their memory often attribute the improvement to factors other than the strategy. For example, Fabriucis and Hagen (1984) created a situation in which 6- and 7-year-olds sometimes used an organizational strategy and sometimes did not. The children recalled considerably more when they used the strategy. Although all children had the opportunity to make this observation, only some attributed the difference to using the strategy. Others attributed the success to looking longer, using their brain more, or slowing down. The children's attributions concerning the cause of their success predicted whether they employed the strategy a week later in a slightly different situation. Fully 99 percent of children who earlier attributed their success to the use of the new strategy used it on the second occasion, compared with 32 percent of those who thought other factors responsible.

Whatever the theoretical status of metacognitive knowledge, its practical importance is clear. In the discussion of children's reading in Chapter 11, we will encounter a remarkably successful training program initiated by Palincsar and Brown (1984) to teach poor readers to understand better what they are reading. The program teaches them to effectively monitor their comprehension of the text they are reading and also supplies strategies for dealing with failures to comprehend. Anything that works as well as this program is well worth learning more about.
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Content Knowledge

Older children know more than younger ones about almost everything. In general, the more that people know about a topic, the better they learn and remember new information about it. Therefore, greater content knowledge would lead older children to remember more, even if there were no other differences between them and younger children.

Prior knowledge of related content affects memory in several ways. It influences how much and what children recall. It influences their execution of basic processes and strategies, their metacognitive knowledge, and their acquisition of new strategies. Under some circumstances, it exerts a greater influence than all other factors combined. Evidence concerning each of these points is discussed next.

**Effects on How Much Children Remember**

The fact that older children regularly recall more than younger ones is due in large part to the older children knowing more about the material they are trying to remember. Content knowledge exerts such a large impact that more knowledgeable children often remember more than less knowledgeable adults. For example, when shown chess positions on a board and then asked to reconstruct them from memory on an empty board, 10-year-old chess experts outperformed adults who were novices at the game (Chi, 1978). This finding was not attributable to the children being smarter or possessing better memories. When the children and adults were given a standard digit span task, the adults remembered more (Figure 7.8). Later comparisons of child chess experts with equally proficient adult experts showed that the children recalled chess configurations just as well (Schneider, Gruber, Gold, & Opwis, 1993). Children generally remember more than adults about types of content that they know better, such as titles of children’s TV programs and books (Lindberg, 1980, 1991; Schneider & Bjorklund, 1998). Thus, differences in content knowledge can outweigh all of adults’ other memory advantages.

Differences in content knowledge also can influence memory for that type of content more than the child’s overall IQ does. Schneider, Korkel, and Weinert (1989) examined German children’s memory for a story about a fictitious young soccer player and his experiences in “the big game.” The children who heard the story included equal numbers of children with high soccer knowledge and above-average IQs, high soccer knowledge and below-average IQs, low soccer knowledge and above-average IQs, and low soccer knowledge and below-average IQs.

As might be expected, children with high soccer knowledge remembered more about the stories, drew a greater number of correct inferences, and noticed more inconsistencies within the story than those with lower knowledge.

Surprisingly, though, at each level of expertise, higher-IQ children did not remember any more about the soccer game than did lower-IQ children. High-IQ children acquire expertise faster (Johnson & Mervis, 1994), and this may lead to their becoming expert on a greater range of topics. When knowledge is equivalent, however, memory for new information also tends to be equal.

**Effects on What Children Remember**

As noted in the discussion of children’s eyewitness testimony, what children know before an experience greatly influences what they remember about it. Thus, preschoolers who already knew that Sam Stone was a clumsy old “remembered” that he was the one who had soiled the teddy bear during his visit to the classroom. Knowledge that children gain after an experience can also influence what they remember. Greenhoot (2000) presented kindergarten children with stories about encounters between a target character and another child, and then assessed children’s memory for events in the stories. Several days later, children were given some additional information about the story protagonist—either information that suggested that the protagonist was nice and well-liked, or information that suggested that the protagonist was mean and disliked. After receiving this information, children were interviewed again about the initial stories. Children revised their memories of the stories in ways that were consistent with the new information that they had acquired. Children who learned that the
Content Knowledge

Older children know more than younger ones about almost everything. In general, the more that people know about a topic, the better they learn and remember new information about it. Therefore, greater content knowledge would lead older children to remember more, even if there were no other differences between them and younger children.

Prior knowledge of related content affects memory in several ways. It influences how much and what children recall. It influences their execution of basic processes and strategies, their metacognitive knowledge, and their acquisition of new strategies. Under some circumstances, it exerts a greater influence than all other factors combined. Evidence concerning each of these points is discussed next.

**Effects on How Much Children Remember**

The fact that older children regularly recall more than younger ones is due in large part to the older children knowing more about the material they are trying to remember. Content knowledge exerts such a large impact that more knowledgeable children often remember more than less knowledgeable adults. For example, when shown chess positions on a board and then asked to reconstruct them from memory on an empty board, 10-year-old chess experts outperformed adults who were novices at the game (Chi, 1978). This finding was not attributable to the children being smarter or possessing better memories. When the children and adults were given a standard digit span task, the adults remembered more (Figure 7.8). Later comparisons of child chess experts with equally proficient adult experts showed that the children recalled chess configurations just as well (Schneider, Gruber, Gold, & Opwis, 1993). Children generally remember more than adults about types of content that they know better, such as titles of children’s TV programs and books (Lindberg, 1980, 1991; Schneider & Bjorklund, 1998). Thus, differences in content knowledge can outweigh all of adults’ other memory advantages.

Differences in content knowledge also can influence memory for that type of content more than the child’s overall IQ does. Schneider, Korkel, and Weinert (1989) examined German children’s memory for a story about a fictitious young soccer player and his experiences in “the big game.” The children who heard the story included equal numbers of children with high soccer knowledge and above-average IQs, high soccer knowledge and below-average IQs, and low soccer knowledge and below-average IQs.

As might be expected, children with high soccer knowledge remembered more about the stories, drew a greater number of correct inferences, and noticed more inconsistencies within the story than those with lower knowledge.

![Figure 7.8](image.png)

**Figure 7.8** Number of chess pieces and numbers recalled by 8- to 10-year-old chess experts and adult chess novices immediately after presentation (after Chi, 1978). The child chess experts recalled the positions of more chess pieces, but did not recall more numbers than the adults.

Surprisingly, though, at each level of expertise, higher-IQ children did not remember any more about the soccer game than did lower-IQ children. High-IQ children acquire expertise faster (Johnson & Mervis, 1994), and this may lead to their becoming expert on a greater range of topics. When knowledge is equivalent, however, memory for new information also tends to be equal.

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Billy when you got there?" "Did you have something to eat at the party?" The sequence of questions helps children realize both what is important and the order in which the important events usually occur (Nelson, 1993). Children use scripts not only to recall their own experiences but also to remember stories about other people, such as fairy tales. Many stories that are told or read to children follow a standard form in which the setting is described, an event happens, characters have an internal response, they set a goal, they attempt to reach the goal, and they obtain (or fail to obtain) the goal (Trabasso, van den Broek, & Suh, 1989). Often several such sequences occur, in which earlier outcomes create new goals and attempts by the characters to meet the goals.

Typically, 3-year-olds' retellings of such stories omit the characters' main goals and internal reactions, and they include details that are unrelated to the main sequence (Trabasso & Nickels, 1992; Trabasso & Stein, 1995). The retellings of 4-year-olds focus more exclusively on relevant actions, but they still often omit the characters' goals and intentions. Not until age 5 do children's retellings consistently include all of the key parts of the story. Thus, between ages 3 and 5, children both narrow their script for fairy tales so that it focuses on the most important events and broaden it to include the psychological states that impel the characters' actions.

**Content Knowledge as an Explanation for Other Memory Changes**

Changes in basic capacities, strategies, and metacognition contribute to age-related improvements in children's memory for specific content. The inverse is also true, however: Increasing content knowledge improves efficiency of basic processes, acquisition and execution of strategies, and metacognitive knowledge.

First consider the effect of increasing content knowledge on efficiency of execution of basic processes. At least from age 5, children automatically encode the relative frequency of events, and do so very accurately. However, 5-year-olds' encoding of frequency information is even more accurate when the content is familiar (such as pictures of classmates) than when it is not (pictures of children who are strangers) (Harris, Durso, Mandler, & Jones, 1990). Similarly, the more that people know about the content they are trying to remember, the more material they can maintain in working memory (Huttenlocher & Burke, 1976).

Next consider how content knowledge influences the use and efficiency of memory strategies. Children use strategies such as organization more often for remembering groups of familiar items than for remembering groups of less familiar ones (Bjorklund, Muir-Bea dou d, & Schneider, 1990). Moreover, the greater efficiency when strategies are executed with familiar content is sufficient so that 5-year-olds who rehearse familiar items subsequently remember as much as 11-year-olds who rehearse unfamiliar ones (Zem ber & Naus, 1985).
protagonist was nice and well-liked reported more positive behaviors, and chil-
dren who learned that the protagonist was mean and disliked reported more
negative behaviors. Thus, knowledge gained after the original experience of the
stories led children to alter their memory reports.
Knowledge sometimes leads children to remember incorrectly, but it more
often helps them remember correctly. Much of this benefit comes from the
knowledge allowing children to draw correct inferences. Thus, young children
who hear a story about a helpless creature with a broken wing remember that
the story was about a bird, even when that fact is not explicitly mentioned
(Paris, 1975). Similarly, knowledge helps children remember what did not hap-
pen. Recall how the 7-year-olds, but not the 3-year-olds, knew that the nurse at
the doctor’s office had not licked their knees. Thus, content knowledge helps
people remember both what happened and what did not.

SCRIPTS
Many events recur frequently in similar forms. When children bake cookies, at-
tend birthday parties, eat meals, or go to doctor appointments, the particulars
vary from occasion to occasion, but the basic structure is the same. For example,
going to a doctor’s office generally involves going to the office, telling the re-
ceptionist that you are there, sitting in the waiting room, getting up when your
name is called, going with the nurse to another room, and waiting for the doc-
 tor or nurse to come and do whatever they’re going to do.

By the age of 3, children represent such routine activities in the form of
scripts, which are knowledge structures that describe the way that events usu-
ally go. Even preschoolers possess scripts for eating at their daycare center and
at restaurants (Nelson, 1978), attending birthday parties (Nelson & Hudson,
1988), going about their daily routine (Fivush & Ham mond, 1990), and engag-
ing in other familiar activities. The scripts are especially apparent in children’s
mistakes in remembering events that for the most part conform to the script but
that deviate in certain particulars (Fivush & Ham mond, 1990; Nelson & Hudson,
1988). For example, when preschoolers eat at a nice restaurant, they often recall
paying before eating, as they would have done at a fast-food restaurant. Such
collusions between the script and particular events are particularly prevalent
in the preschool period. By age 7, children discriminate more clearly between
what usually happens and what happened on the particular occasion (Farrar &

Which experiences lead children to form scripts? One influence seems to be
the stories that parents tell them and the questions that the parents ask about
past events. For example, Hudson (1990) observed that in most families, parents’
requests for young children to recall information largely center on recalling past
events. Parents tend to ask the questions in an order that parallels the usual
order of activities: “How did we get to the birthday party?” “What did you give

Billy when you got there?” “Did you have something to eat at the party?” The
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CONTENT KNOWLEDGE AS AN EXPLANATION
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Familiar content also facilitates learning of new strategies. Chi (1981) examined a 5-year-old’s learning of an alphabetic retrieval strategy for her classmates’ names. (First think if any names start with A; then think if any names start with B, etc.) Although the strategy was novel, the girl learned it and applied it to recalling her classmates’ names rather easily. However, the same girl could not then apply the alphabetic strategy she had already learned in the familiar context to remembering a new set of names of people she had never met.

These results may hold an important implication for how children learn new strategies. Early in the acquisition process, they may employ strategies effectively only on familiar content. Practice using the strategies with the familiar content may lead to execution of the strategies becoming automatized and making fewer demands on the children’s processing resources. This automatization, in turn, allows children to apply the strategies to more demanding, unfamiliar content. Thus, the familiar content may serve as a kind of practice field upon which children exercise emerging memory strategies.

Finally, content knowledge influences metacognition. Child chess experts not only remember more than adult novices about chess positions they see, but also more accurately predict the relatively large number of viewings required before they will be able to perfectly reconstruct from memory the positions on the board. Clearly, all aspects of memory are influenced by content knowledge.

**How Does Content Knowledge Aid Memory?**

Content knowledge aids memory through a number of mechanisms. One is encoding of distinctive features. By focusing attention on distinctive features, content knowledge helps children remember different entities. For example, part of the way that scripts aid memory is by indicating what children should encode. When they go to a birthday party, the script indicates that they should be sure to note the present they gave to the birthday child, the presents that other children gave, the games that were played, the type of cake that was served, and any favors that they brought home. Similarly, much of the benefit of expertise is in knowing which information should be encoded. Chess experts can so accurately recall board configurations primarily because they encode groups of pieces that have certain functions—protecting the king, attacking the bishop, and so on—and relate them to the overall situation. When presented with a random configuration of chess pieces, experts are no better than novices at recalling the arrangement (Chi, 1978). Thus, part of how content knowledge helps memory is by enhancing encoding.

Another key mechanism through which content knowledge exercises its effects is spreading activation. When people think about a topic, the topic becomes activated, in the sense that people can quickly retrieve information about it. The activation automatically spreads from topics that are receiving attention to others that are associated with it, thus facilitating retrieval of information about them.

For example, when children think about their summer vacation, they may remember eating lobster at the vacation site, which may remind them of eating lobster on other occasions, eating mussels and clams on other occasions, and so on. If someone asked them just after they had this thought whether mussels have shells, they probably would be able to answer “yes” more quickly than usual.

As children learn about a topic, spreading activation helps them remember increasingly effectively. Consider why children who are knowledgeable about a topic might use organizational strategies more effectively and more often (Rabinowitz & Chi, 1987). Suppose two 8-year-old boys, differing in knowledge of birds, both needed to remember a set of words including “hawk,” “penguin,” and “chicken.” The more knowledgeable boy probably would know that all three are birds, whereas the less knowledgeable one would probably know only that hawks are. For the more knowledgeable boy, activation would spread among all three terms and the general category of birds, whereas for the less knowledgeable one, activation would spread only between “bird” and “hawk.” This would lead to the more knowledgeable boy being more likely to use “birds” as a category for organizing his memory of the three examples, and it would help his recall to a greater extent if he did so (since the “bird” category would activate all three original terms). Thus, spreading activation may lead knowledgeable children to use strategies more often and to the strategies aiding their recall to a greater extent.

**Evaluation**

Any explanation of memory development must reserve a large place for increasing knowledge of specific content. Content knowledge increases steadily from infancy through adulthood. It is clearly related to how well children remember, as was evident in the studies of memory for chess positions, for soccer, and for fairy tales. It provides scripts within which children can organize new information, allows them to check on the plausibility of their memories, facilitates their drawing of inferences, and helps them encode distinctive features of objects and events. It also contributes to the development of other competencies that have been proposed as explanations of memory development, such as basic capacities, strategies, and metacognition. Without question, increasing content knowledge is a large part of the reason why older children remember more than younger ones.

**What Develops When in Memory Development?**

Different aspects of memory may not only contribute different amounts to memory development, but also may make their greatest contributions at different times. Table 7.2 summarizes the contributions of basic processes and capacities, strategies, metacognition, and content knowledge during several periods of life.
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<thead>
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<th>Age</th>
<th>Source of Development</th>
<th>Strategies</th>
<th>Metacognition</th>
<th>Content Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 Years</td>
<td>Basic Capacities</td>
<td>Speed of processing increases.</td>
<td>Acquisition and increasing knowledge.</td>
<td>Substantially increasing content knowledge. Also increasingly monitoring of ongoing knowledge.</td>
</tr>
<tr>
<td>5-6 Years</td>
<td>Basic Capacities</td>
<td>Speed of processing increases.</td>
<td>Acquisition and increasing knowledge.</td>
<td>Substantially increasing content knowledge. Also increasingly monitoring of ongoing knowledge.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speed of processing increases.</td>
<td>Increasing automaticity of strategies.</td>
<td>Substantially increasing content knowledge. Also increasingly monitoring of ongoing knowledge.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speed of processing increases.</td>
<td>Relating knowledge.</td>
<td>Substantially increasing content knowledge. Also increasingly monitoring of ongoing knowledge.</td>
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</tr>
</tbody>
</table>

Many basic processes, such as ability to associate objects with each other and to recognize familiar objects, are present at birth. These processes are crucial in enabling children to learn and remember from the first days of life. It is unknown whether the absolute capacity of memory increases with age. However, speed of processing increases from birth through late adolescence, and this helps the functional capacity of memory to increase regardless of whether the absolute capacity increases.

Memory strategies begin to contribute to memory development somewhat later than basic capacities. The earliest known strategies appear in the second year, but many other important strategies, such as rehearsal, organization, and elaboration, become prominent between ages 5 and 7. The quality of the strategies, their frequency of use, and the flexibility with which they are tailored to the demands of specific situations continue to develop well into later childhood and adolescence.

Two types of metacognitive skills, explicit factual knowledge about memory and implicit procedural knowledge, seem to have different developmental courses. Implicit metacognitive knowledge is evident quite early. Even toddlers sometimes monitor their comprehension and develop feelings of knowing, though the range of situations in which they do so continues to grow for many years thereafter. In contrast, explicit knowledge about memory appears to develop primarily between ages 5 and 15, perhaps in response to attending school and needing to remember a great deal of arbitrary information.

Content knowledge contributes to memory development from infancy onward. It influences both how much and what children remember. It also affects the efficiency of execution of basic processes, learning of new strategies, and metacognitive knowledge about memory. Together, basic capacities, strategies, metacognition, and content knowledge account for the two essential features of memory development: first, that even newborn infants have the ability to learn and to remember what they learned, and second, that the effectiveness of memory continues to improve throughout infancy, early childhood, middle childhood, and adolescence.

**Summary**

Children are being called increasingly often to testify in court cases. Research on the accuracy of their testimony indicates that when they are asked open-ended and unbiased questions, even preschoolers' recall is accurate and relevant. However, asking biased questions and inducing stereotypes may lead children, especially preschoolers, to report events that never happened. To obtain accurate and complete memory reports, interviewers should ask questions in a neutral fashion, the questions should be sufficiently specific to elicit memories that children might not otherwise report, and the questioning should not be repeated more often than necessary.
TABLE 7.2 Contributions of Four Aspects of Memory During Several Periods of Development

<table>
<thead>
<tr>
<th>Source of Development</th>
<th>0-5</th>
<th>5-10</th>
<th>10-Adulthood</th>
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<tr>
<td>Basic Capacities</td>
<td>Many capacities present: association, generalization, recognition, etc. By age 5, if not earlier, absolute capacity of sensory memory at adult-like levels.</td>
<td>Speed of processing increases.</td>
<td>Speed of processing continues to increase.</td>
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<td>Strategies</td>
<td>A few rudimentary strategies such as naming, pointing, and selective attention.</td>
<td>Acquisition and increasing use of many strategies: rehearsal, organization, etc. Increasing factual knowledge about memory. Improved monitoring of ongoing performance.</td>
<td>Continuing improvement in quality of all strategies.</td>
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<tr>
<td>Metacognition</td>
<td>Little factual knowledge about memory. Some monitoring of ongoing performance.</td>
<td>Steadily increasing metacognitive knowledge helps memory in areas in which the knowledge exists.</td>
<td>Continuing improvements.</td>
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<td>Content Knowledge</td>
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Summary

Children are being asked increasingly often to testify in court cases. Research on the accuracy of their testimony indicates that when they are asked open-ended and unbiased questions, even preschoolers' recall is as accurate as that of older children. However, the accuracy of their testimony is often influenced by the way questions are phrased and the context in which they are asked. Children's memory for events that occur in their daily lives is often inaccurate, but they may improve with practice and feedback. Younger children may benefit from techniques such as role-plays and stories to help them remember events. Older children, on the other hand, may benefit from strategies such as rehearsal and organization. Metacognitive knowledge about memory, which includes awareness of memory processes, strategies, and memory limitations, is an important factor in memory development. Children who are aware of their memory limitations are more likely to use effective strategies to improve their memory. Metacognitive knowledge and the ability to reflect on one's own memory performance are important predictors of memory performance. 

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Memory development has been attributed to changes in four types of causes: basic processes and capacities, strategies, metacognition, and content knowledge. Basic capacities and processes, such as the abilities to associate and recognize, are already present in newborns. By age 3 months, infants display many other basic processes. They generalize, remember the gist of events, and even show insight. Processing speed increases throughout childhood and adolescence. The number of symbols that can be held in working memory also improves gradually over this period, but it is unclear whether this is due to changes in the absolute capacity of memory or to other improvements. Despite the fact that children are capable of most basic memory processes from a very young age, most people remember almost nothing that occurred before the age of 3 years. This phenomenon is termed "infantile amnesia," and it is likely due to a combination of several factors. Possible causes of infantile amnesia include physiological changes in the brain, changes in the ways that children talk about past events with other people, and incompatibilities between the ways in which infants encode information and the ways in which older children and adults retrieve it.

The use of broadly applicable memory strategies such as rehearsal, organization, and selective attention increases rapidly between 5 years and adolescence. Children who use such strategies typically remember more than those who do not. Changes in the quality of strategies and the range of situations in which they are used continue well beyond the ages at which they are first adopted. Strategies can be taught to children earlier than the children would ordinarily use them. However, children who have received such training often fail to use the strategies in subsequent situations, and they use them less effectively than older children. This may be due to a combination of lesser benefits and greater costs to the children of using the strategies, as well as to the children's not perceiving the connection between using the strategy and remembering better. Overall, learning of these strategies seems to account for an important part of memory development, particularly in middle childhood and beyond.

Metacognition includes two distinct types of knowledge: explicit and implicit. Explicit knowledge about memory is conscious and verbalizable. It involves factual knowledge about strategies, tasks, and capacities. Implicit knowledge, in contrast, is not conscious or verbalizable; it involves such processes as monitoring one's comprehension and feelings of knowing. Implicit knowledge of memory is already evident among toddlers. Explicit knowledge is not evident as early, but between ages 5 and 10, it too becomes quite extensive. Development of both types of metacognitive knowledge continues throughout life.

Knowledge of related content greatly affects children's memory at all ages. Content knowledge allows children to remember more than they otherwise would, influences their ability to learn strategies, helps them make plausible inferences, and allows them to form scripts for remembering sequences of events. Under some circumstances, differences in content knowledge can outweigh all other changes in memory that come with age and experience. Children who are experts on topics such as chess and soccer exhibit truly impressive memory in their area of expertise, though their memory in other areas is unexceptional. Encoding of distinctive features and spreading activation appear to be two of the mechanisms that help children with high content knowledge to better remember new information.

**Recommended Readings**


Memory development has been attributed to changes in four types of causes: basic processes and capacities, strategies, metacognition, and context knowledge. Basic capacities and processes, such as the abilities to associate and recognize, are already present in newborns. By age 3 months, infants display many other basic processes. They generalize, remember the gist of events, and even show insight. Processing speed increases throughout childhood and adolescence. The number of symbols that can be held in working memory also improves gradually over this period, but it is unclear whether this is due to changes in the absolute capacity of memory or to other improvements. Despite the fact that children are capable of most basic memory processes from a very young age, most people remember almost nothing that occurred before the age of 3 years. This phenomenon is termed "infantile amnesia," and it is likely due to a combination of several factors. Possible causes of infantile amnesia include physiological changes in the brain, changes in the ways that children talk about past events with other people, and incompatibilities between the ways in which infants encode information and the ways in which older children and adults retrieve it.

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