

Chapter 2

Conceptual Knowledge About Cognitive Activities

Abstract Empirical research concerning developmental changes in children's understanding of cognitive activities is reviewed. Age-related changes in children's knowledge of seven aspects of cognitive functioning are considered: (a) the stream of consciousness, (b) attention, (c) memory, (d) inference, (e) imagination, (f) relations between thoughts and emotions, and (g) the controllability of thoughts. Three general levels of understanding are distinguished: (a) occurrence knowledge: knowledge of the occurrence of particular cognitive activity, (b) organizational knowledge: knowledge of similarities and differences in the functions of cognitive activities, and (c) epistemological thought: broad, abstract thinking about the nature of knowledge and mind.

When my son was five and half years old, we had the following conversation in the kitchen:

Matthew: Can I have some juice?

Me: Sure. What kind? Apple or orange?

Matthew: I don't know.

Me: Then I'll give you apple.

Matthew: That's not the one I want.

Me: What do you want?

Matthew: You know...

Me: Which one?

Matthew: You know which one because I told you it's not apple.

Clearly, Matthew understood the logic of deduction by elimination, and despite not being particularly helpful in his choice of communicative strategies, he was generous enough to credit me with the ability to infer his juice preference. Thus, his knowledge of reasoning allowed him to infer my knowledge. Two days later, while driving to a Fourth of July fireworks display, he explained, "In my imagination I can see the fireworks. A brown sky with exploding colors." In addition to his previous recognition that people may actively reason about the world, drawing

conclusions by combining premises, here Matthew also revealed knowledge about another sort of cognitive activity. Commenting on his own internal fireworks display indicated awareness that the mind can generate thoughts and images extending beyond the immediate situation. My goal in this chapter is largely descriptive. I review empirical research on children's understanding of mental states and cognitive activities, using the distinctions among occurrence knowledge, organizational knowledge, and epistemological thought to frame the literature.

Knowledge about the mind is evident in early childhood, as 2 and 3-year-olds talk and reason about both their own mental states and those of others. In everyday conversation 2 and 3-year-olds frequently refer to mental states, including emotions and desires, and 4-year-olds increasing talk about knowledge, thoughts, and beliefs (Bartsch and Wellman 1995; Dunn 1999; Wellman et al. 1995), and even preverbal infants display sensitivity to others intentions, knowledge, and beliefs (Onishi and Baillargeon 2005; Woodward 2009). In experimental studies, 2 and 3-year-olds demonstrate awareness of another person's visual perspective and recognition of others' knowledge or ignorance (e.g., Flavell et al. 1978; Moll and Tomasello 2006; Pillow 1989a; Pratt and Bryant 1990). Although 3-year-olds typically have difficulty in understanding false beliefs, by 4–5 years of age children appreciate that a person's beliefs may contrast with reality (e.g., Hogrefe et al. 1986). Young children also distinguish among basic emotions, such as happiness, sadness, anger, and fear, and relate specific emotions to different kinds of situations (Harris 1989). In addition, young children appear to have some understanding of intentions. By 3 years of age, children distinguish between intended outcomes and unintended outcomes (Shultz and Wells 1985), and by 5 years of age children appear to understand that intentions play a causal role in producing action (Astington 1993). Thus, by three years of age, children have begun to recognize knowledge, ignorance, desire, and emotion, and around 4–5 years of age children begin to understand belief (see Flavell and Miller 1998 for a review). Children's early understanding of mental states, such as desire, intention, knowledge and beliefs, is impressive, especially in view of the once prevalent assumption that young children do not clearly differentiate between mental states and physical events and are unable to conceive of another person's perspective as different from their own (e.g., Broughton 1978; Piaget 1929; Selman 1980).

Despite their impressive understanding of mental states, young children's social understanding is far from mature. Wellman (1990) proposed that young children and adults share the same basic conceptual framework for reasoning about human action. According to Wellman, both children and adults understand human action within a framework of belief-desire reasoning. Within this framework, actions are seen to result from desires and beliefs, desires often are seen to be derived from physiological states or emotions, and beliefs often are seen to result from perceptual experiences. Therefore, observed actions are explained in terms of a person's beliefs and desires, and information about beliefs and desires is used to predict future actions. This view is supported by evidence that 3 and 4-year-olds often explain and predict actions in terms of desires and beliefs (Bartsch and

Wellman 1989). Thus, concepts of mental states are central to children's understanding of human behavior from an early age. Although the same basic mentalistic framework for social understanding persists from early childhood through adulthood, Wellman further proposed that a more elaborated understanding of mental functioning and human action emerges later in childhood. This more elaborated framework includes both a greater variety of concepts and new links among core concepts. For example, in addition to realizing that beliefs derive from perceptual experience, adults and older children also realize that cognitive activities, such as reasoning, remembering, and forgetting, can influence beliefs. This proposed shift from a simple belief-desire framework to a more elaborated framework implies that during middle and late childhood, children's should develop greater understanding of cognitive processes that generate, select, manipulate, transform, or operate on mental states (i.e., attending, remembering, forgetting, inferring, guessing, using problem solving strategies or memory strategies, etc.) and concepts of cognitive processes should become increasingly central to children's understanding of psychological functioning and behavior.

Several theorists have suggested a more specific transition in children's understanding of cognitive activities occurs at approximately 6 or 7 years of age (Chandler 1988; Chandler and Boyes 1982; Higgins 1981; Pillow 1988, 1995; Taylor 1988). Chandler (1988) (Chandler and Boyes 1982; Carpendale and Chandler 1996) proposed that prior to age 6 or 7 years children regard knowledge as an objective copy of external reality and do not grasp the possibility of multiple, subjective interpretations of the same input, and Taylor (1988) suggested that young children equate seeing with knowing. Higgins (1981) made a similar distinction between differences in situational viewpoints, which are due to persons being in different circumstances, and individual viewpoints, which are due to persons having different individual characteristics such as personality traits, attitudes, or beliefs. According to Higgins (1981) differences in situational viewpoints may be easier to understand. These theories imply that (a) young children should understand a direct connection between perceptual experience and knowledge, (b) young children may not recognize how cognitive activities mediate between perceived information and a person's representation of the world, and (c) beginning around 6 or 7 years of age children should begin to understand that individuals differing in their prior experience or expectations may interpret the same information differently. More generally, children age years or older may begin to recognize the occurrence and effects of processes such as memory, attention, and inference (Pillow 1995).

The prediction that young children recognize the perceptual origins of mental states is supported by studies of early perspective-taking. As early as 2 years of age, children's non-verbal behavior demonstrates awareness of another person's visual perspective (e.g., Flavell et al. 1978; Moll and Tomasello 2006). Three-year-olds can report what object another person sees, and 4 and 5-year-olds can report how an object looks to another person (e.g., Masangkay et al. 1974). Three and four-year-olds also recognize that another person's knowledge or ignorance about a hidden toy depends upon the person has seen the toy or not (Pillow 1989a; Pratt and Bryant 1990).

Despite this early understanding of perceptual influences on knowledge, young children often do not seem to appreciate those activities such as selective attention, inference, or interpretation also may influence knowledge and belief (Pillow 1995). Knowledge of cognitive activities begins to appear between 5 and 7 years of age. For example, 5 and 6-year-olds recognize that people attend selectively (e.g., Flavell et al. 1995; Pillow 1989b), interpret information constructively (e.g., Carpendale and Chandler 1996; Pillow and Henrichon 1996), and make deductive inferences (e.g., Sodian and Wimmer 1987). However, young children do appear to understand some instances of cognitive activity. In particular, 3 and 4-year-olds recognize that encountering a situation associated with past emotional experiences can cue present thoughts and feelings (Lagattuta and Wellman 2001). This research is reviewed below.

2.1 Levels of Understanding

Three aspects of conceptual understanding of cognitive activities can be distinguished: (a) occurrence knowledge, (b) organizational knowledge, and (c) epistemological thought. These three aspects of children's conceptual knowledge of cognitive activities are not a sequence of distinct developmental stages. Because each has a gradual, protracted development, they may overlap each other, and influence each other, to some degree. Nevertheless, a general developmental progression can be traced in the research literature. Much of children's occurrence knowledge first appears during the transition from early to middle childhood (roughly 5–7 years of age) and increases thereafter. Knowledge of mental functioning is organized during early childhood; however, an adult-like organization of knowledge about mental activities begins to emerge during late childhood (roughly 9–10 years of age) and is further refined between late childhood and early adulthood. Some forms of epistemological thought are evident during early adolescence (roughly 13–14 years of age), but epistemological thought continues to develop through adulthood, and there are substantial individual differences among adults' intuitive epistemologies. Distinguishing occurrence knowledge, organizational knowledge, and epistemological thought provides a useful framework for organizing the empirical literature on children's concepts of cognition and examining developmental trends. Below, I describe empirical evidence concerning developmental changes in knowledge of the occurrence of cognitive activities, in the organization of children's concepts of cognition, and in epistemological thought. I also consider developmental relations among these three levels of understanding.

2.1.1 Occurrence Knowledge

Occurrence knowledge refers to understanding that cognitive activities occur, including recognition of the typical outcomes of a cognitive activity and

recognition of situations in which an activity is likely to occur. Occurrence knowledge includes both knowledge of automatic activities and knowledge of the availability and effects of deliberate strategic activities. Adults typically know about a variety of cognitive activities, but their knowledge may be limited. Even adults may not possess explicit models of specific information-processing mechanisms. Instead, conceptions of cognitive activities often may consist of (a) knowledge of the outcomes of cognitive activities, (b) knowledge of the antecedent conditions, both internal and external, that precede those outcomes, (c) some notion of mental activity linking antecedents and outcomes, and (d) knowledge of some properties of cognitive activities. For instance, rather than having a detailed model of a selective attention mechanism, people generally may know that a person watching television in a crowded room, with several conversations going on nearby, may comprehend and remember information from the television program, but not know what was said in the surrounding conversations. This outcome may be attributed to a process of paying attention or blocking out extraneous information, and this process may be regarded as limited in capacity, effortful, and subject to distraction, depending upon an individual's particular knowledge and beliefs about attention.

Children's understanding of seven aspects of cognitive functioning is considered below: (a) the stream of consciousness, (b) attention, (c) memory, (d) inference, (e) imagination, (f) relations between thoughts and emotions, and (g) the controllability of thoughts. Knowing about the stream of consciousness, attention, memory, and inference is central to understanding the mind as an active processor of information. Knowledge of the stream of consciousness suggests recognition of continual cognitive activity as a fundamental part of mental life, and knowledge of attention, memory, and inference is central for understanding how people process and represent information about the environment. Knowledge of imagination would indicate awareness of processes that internally generated and not necessarily aimed at representing external reality. Recognizing that cognition and emotion influence each other is important for understanding that cognitive processes do not occur in isolation but are part of a larger system. Because cognition involves both controlled and automatic processes, learning about the limits of deliberate control is central for understanding the nature of mental life. Of course, children and adults also may learn about other aspects of cognition, such as planning, decision-making, mathematical calculation, reading, and even cognitive monitoring. However, there are research literatures on the seven aspects of cognition covered here, and this research provides a picture of children's developing understanding of cognitive activity.

2.1.1.1 Knowledge of the Stream of Consciousness

Knowledge of the stream of consciousness could include recognition that there is ongoing, continual mental activity and recognition that one thought can cue associated thoughts. Flavell and his colleagues have investigated children's

understanding of both of these aspects of consciousness. Young children often do not seem aware that thoughts continue to occur in the absence of overt activity. Compared to children ages 5–7 years, 4-year-olds are less likely to attribute thoughts to a person who is waiting quietly, listening, looking, or reading (Flavell et al. 1993, 1995). For example, most 4-year-olds judge that the mind of person who is waiting quietly is “empty of thoughts and ideas” or “not doing anything”, unlike 6–7-year-olds and adults who credit the waiting person with having “some thoughts and ideas.” (Flavell et al. 1993). In fact, 4-year-olds often under-attribute thought even to a person who is described as looking, listening, or reading (Flavell et al. 1995). In addition, 4-year-olds often deny the possibility of covert inner speech (Flavell et al. 1997), but most 4-year-olds do attribute thought to a person silently puzzling over a problem (Flavell et al. 1993). Thus, although 4-year-olds have some understanding that conscious thought may occur even in the absence of overt activity, they do not regard the stream of consciousness as continuous, nor do they associate conscious thought with inner speech. By 5–8 years of age children begin to show greater knowledge of conscious mental activity.

Young children demonstrate some limited understanding of cognitive cuing. In a simple hiding task, 3-year-olds often recognize placing a closely associated cue at the location where a target item is hidden (e.g., placing a picture of a hose over a folder containing a picture of a firefighter), may help another person find the hidden object; however, 3-year-olds typically fail to recognize the utility of more remote or arbitrary cues (e.g., placing a picture of sailboat over a folder containing a picture of mailman who enjoys sailing) (Gordon and Flavell 1977). Furthermore, prior to 8 or 9 years of age children have difficulty in evaluating the informativeness of a cue (Beal 1985), and prior to 6 years of age children often fail to distinguish between strongly associated and weakly associated cues when choosing a cue to either facilitate or hinder another person’s search for a hidden object (Sodian and Schneider 1990). Understanding of emotional may begin relatively early. Thus, 3 and 4-year-olds show some appreciation that being reminded of past emotional experiences can cue associated thoughts that affect a person’s current emotional state (Lagattuta and Wellman 2001).

Overall, studies of children’s understanding of the occurrence of ongoing thought and cognitive cuing indicated that 3 and 4-year-olds have only limited knowledge of the stream of consciousness, but 5–8-year-olds are becoming increasingly aware of the ongoing flow of mental activity.

2.1.1.2 Knowledge of Attention

Developing a concept of attention is an important part of understanding the subjectivity of knowledge. Because our attentional capacity is limited and we attend selectively, at any moment we process only a portion of the information available around us. Therefore, recognition of attentional filtering implies understanding that cognitive processes mediate between the external world and our knowledge of that world.

Children begin to understand attention as limited in capacity and selective between approximately 5 and 8 years of age. Most 4-year-olds, unlike older children, do not appreciate that a person who is focusing attentively on one message or thought probably would not fully process other information or experience additional unrelated thoughts at the same instant (Flavell et al. 1993, 1995; Miller and Bigi 1979; Pillow 1989b). For example, 7-year-olds judge that noise, such as a radio, might interfere with their ability to hear their mother calling, but only children 8-years or older recognize that reading an interesting book might result in not hearing their mother (Miller and Bigi 1979). Similarly, when asked to predict their own performance, 4-year-olds typically do not realize that focusing attention on one message or task might hinder comprehension of an incidental message (Pillow 1989b). Six and 8-year-olds judge that they would not understand an incidental message while focusing on a target task.

Furthermore, many 4-year-olds also do not understand that while concentrating on a cognitive task, a person probably would not be thinking about another irrelevant topic (Flavell et al. 1995), or that during a very brief instant a person would likely be thinking of only one thing rather than several (Flavell et al. 1993). By 5–6 years of age children begin to understand that thought may be focused on a single topic at a particular moment. In addition, many 5-year-olds also refer to a person's focus of attention to explain the person's failure to act in accordance with information available from an unattended source (Pillow and Lovett 1998). When deciding who a request for information should be addressed to, most 5-year-olds select a person whose attention is not already engaged, whereas 4-year-olds do not discriminate between a person who is listening to a radio and an adjacent person who is not listening to the radio (Pillow 1989b).

Studies of children's understanding of attention indicate that most 3- and 4-year-olds do not appreciate that attention is limited and selective. Some knowledge of attention begins to appear around 5-years of age, and understanding of attention increases during the elementary school years.

2.1.1.3 Knowledge About Memory

Knowledge of memory develops gradually from early childhood to adulthood. Although young children demonstrate some knowledge of the processes of remembering and forgetting, they know little about the effectiveness of deliberate memory strategies, such as rehearsal or categorization. During the elementary school years children increasingly differentiate among effective and ineffective strategies.

Preschool children have at least some partial understanding of remembering and forgetting. Four-year-olds, but not 3-year-olds, recognize that remembering and forgetting require prior knowledge of the remembered or forgotten information (Lyon and Flavell 1994). Five-year-olds invoke forgetting to explain mistaken actions (Pillow and Lovett 1998). However, young children's understanding of the terms "remember" and "forget" is fragile; they sometimes use these terms to refer

to correct versus incorrect action, regardless of a person's prior knowledge (Wellman and Johnson 1979). Young children also have limited knowledge of factors that influence memory performance. Four-year-olds recognize that increasing the number of items on a list makes recall more difficult (Wellman 1977) and that longer retention intervals increase the likelihood of forgetting (Lyon and Flavell 1993). As mentioned previously, 3 and 4-year-olds also demonstrate some awareness that reminders of past emotional experiences can cue thoughts that influence a person's current emotion, but children's understanding of emotional cuing increases between 3 and 7 years of age (Lagattuta and Wellman 2001). With emotionally neutral materials, children under five years usually do not fully appreciate how associated cues can trigger retrieval (Gordon and Flavell 1977; Sodian and Schneider 1990). In addition, before 9 or 10 years of age, children do not know that a list of taxonomically related items is easier to recall than a list of unrelated words (Moynahan 1978). These results suggest that young children have some awareness of memory activities, but their knowledge of memory continues to increase well into the elementary school years.

Moreover, young children know little about the effectiveness of deliberate memory strategies. When asked to compare the effectiveness of strategies for free recall, 4-year-olds judged looking at the items to be recalled as more effective than naming, rehearsing, or categorizing them, and kindergartners showed no preference among these four strategies, but second-grade children judged rehearsal and categorization as more effective than naming or looking (Justice 1986). Fourth-grade children also judge categorization and rehearsal as equally effective memory strategies, whereas sixth-grade children regard categorization as more effective (Justice 1985). In addition, when selecting a strategy to aid either memorization or comprehension of verbal instructions, first-grade children often did not distinguish between a strategy that was effective for only memorization and a strategy that was effective only for comprehension, but third-grade children consistently selected the appropriate strategy for each goal (Lovett and Pillow 1995). Thus, knowledge of remembering and forgetting begins in early childhood, but develops greatly during the elementary school years.

2.1.1.4 Knowledge About Inference and Reasoning

Awareness of inferential activities is important for the development of logical reasoning, understanding science, critical thinking, and social competence. Understanding the nature of inference and logic has been argued to contribute to the development of logical reasoning during both childhood and adulthood (Moshman 1990). Scientific thinking involves awareness of theories, evidence, and the process of drawing conclusions from evidence (Carey and Smith 1993; Kuhn and Pearsall 2000). To critically analyze competing arguments or opinions, one must evaluate the reasoning and evidence on which each view is based (King and Kitchener 1994). In addition, recognizing another person's inferences can help children to assess another person's knowledge and beliefs. Such assessments help

children to understand others' actions and also help to guide children's behavior during social interactions. Below I will consider research on: (a) children's understanding of inferences as a source of knowledge, (b) children's differentiation of inference from other patterns of thought and children's differentiation among different patterns of inference, and (c) children's evaluation of evidence.

Young children appear to know little about the occurrence of inferential activities, the contribution of inference to knowledge, or the difference between reasoning and other thought processes. Before 6- years of age, children often do not recognize that knowledge can be acquired through deductive inference (Keenan et al. 1994; Pillow 1999; Sodian and Wimmer 1987; Varouxaki et al. 1999). For example, after observing another person receive information that would enable the person to deduce the color of a hidden object, 4 and 5-year-olds often denied that the person knew the object's color, whereas 6-year-olds understood that another person could infer the hidden object's color without directly observing it (Sodian and Wimmer 1987). Although reducing memory demands improved 4-year-olds performance on a similar inference attribution task, 4-year-olds nevertheless often failed to attribute inferential knowledge to another observer (Keenan et al. 1994). Ruffman (1996) reported that 5-year-olds recognized that another observer might reach a false belief through inference, but often did not recognize that another observer might arrive at a true belief by inference. Thus, understanding of deductive inference as a source of knowledge does not appear to be demonstrated consistently until about 6-years of age.

Understanding of inference as a source of belief also could be demonstrated by recognition that individuals may arrive at different interpretations of ambiguous or incomplete information. The age at which children begin to understand interpretive inferences has been a topic of debate. According to Perner (1991), around 4 years of age children develop a concept of beliefs as representations of external circumstances. Furthermore, Perner (1991) argues that understanding the possibility of individual differences in representation implies understanding of the possibility of interpretive differences. Thus, Perner (1991) hypothesized that acquiring a representational understanding of belief at age 4 enables children to comprehend the possibility of false belief, to discover that beliefs are acquired through perceptual experience, and to understand beliefs as products of active interpretation. In contrast to Perner's position, several theorists have suggested that understanding of interpretation does not begin until approximately 6 or 7 years of age (Chandler 1988; Higgins 1981; Pillow 1995; Taylor 1988). Chandler (1988; Carpendale and Chandler 1996) distinguishes between understanding beliefs as products of direct perceptual experience and understanding beliefs as products of an active, constructive process that involves interpreting new experiences in light of prior beliefs. According to Chandler (1988; Carpendale and Chandler 1996), 4 and 5-year-old children understand the direct perceptual origins of belief, but only beginning around age 7 years do children begin to the interpretive origins of beliefs.

Several studies indicate that young children typically do not recognize that beliefs can be acquired through interpretive inferences (Carpendale and Chandler

1996; Chandler and Helm 1984; Taylor 1988; Taylor et al. 1991). For example, Chandler and Helm (1984) showed 4, 7, and 11-year-old children line drawings, covered the drawings so that only a small portion was visible, and then asked children to describe how this restricted portion of the drawing would be interpreted by another child who had not seen the entire drawing. Four-year-olds consistently attributed their own knowledge of the complete picture to the naive viewer who saw only the restricted view, but 7 and 11-year-olds recognized that the naive viewer would not be able to identify the subject of the drawing. Taylor (1988) also found that children under age 7 or 8 years often failed to appreciate that a naive observer would not be able to identify a drawing by seeing a small uninformative region. Carpendale and Chandler (1996) reported that although 8-year-olds recognized that ambiguous stimuli could be interpreted in more than one way, 5 and 6-year-olds did not (Carpendale and Chandler 1996). In addition, preschool children often do not realize that a listener may not understand the intended meaning of an ambiguous verbal message (Beal and Flavell 1983; Roberts and Patterson 1983; Sodian 1988).

Likewise, around 7 years of age children begin to recognize that prior experience can bias a person's interpretation of incomplete or ambiguous information (Pillow 1991; Pillow and Henrichon 1996; Pillow and Mash 1999). For instance, Pillow (1991) investigated children's understanding that prior expectations may bias the interpretation of social events. Children aged 4–8 years were told stories in which one character, the actor, performed an action that could be interpreted in either of two ways (e.g., as taking something out of or putting it into a container). Two other characters, the observers, held contrasting biases concerning the actor (one liked the actor, the other did not). When asked what action each observer thought the actor was performing, both 6 and 8-year-olds correctly attributed negative interpretations to negatively biased observers and positive interpretations to positively biased observers. Four-year-olds responded randomly, despite remembering the information in the stories. Pillow and Henrichon (1996) reported similar results, but presented children with ambiguous restricted view pictures rather than ambiguous story events. Pillow and Mash (1999) conducted a direct comparison of children's attribution of false beliefs based on direct perceptual experience and false beliefs based on a biased interpretation of an ambiguous picture. Four and 5-year-olds accurately attributed false beliefs based on direct perception, but did not attribute false beliefs based on inferential or interpretive processes. This result supports the view that understanding differences in interpretation is distinct from understanding the possibility of false belief, with understanding of interpretive differences developing somewhat later. Lagatutta et al. (2010) found that as children become aware that observers with different past experiences may interpret ambiguous stimuli differently, children sometimes exaggerate differences in viewpoint. That is, 6–7-year-olds sometimes attributed different interpretations to observers with different past experiences even when the observers viewed informative, rather than ambiguous pictures, making differences in the observers' past experiences irrelevant for interpreting the pictures. Children's over-attribution of different viewpoints is consistent with a change in

children's understanding of interpretative activity during the early elementary school years.

In some circumstances, children appear to understand interpretive processes before the age of six years. Barquero et al. (2003) reported that children as young as 5 years of age sometimes recognize that expectations may bias the interpretation of an ambiguous picture. For example, when told that an observer consistently likes drawings of houses and thinks any drawing is a picture of house, most 5, 6, and 7-year-olds responded that the observer would misinterpret a partially hidden drawing as being a picture of a house. However, children usually did not attribute a biased interpretation when an observer's expectation was based solely on past experience. Moreover, children often did not recognize that a naive observer might misinterpret an ambiguous portion of a partially hidden drawing. Although understanding of interpretive differences may begin around 5 years of age, children's understanding develops gradually and does not appear to be consistent across tasks and contexts until age 7 or 8 years. By 7 or 8 years of age children also recognize that self-interest may influence a person's construal of an event; however, children of this age typically regard self-interested interpretations of events as deliberate falsehoods, but by early adolescence children begin to recognize that bias may operate unconsciously (Mills and Keil 2005).

In addition to recognizing inference as a source of information, elementary school children learn to distinguish inferences from other thought processes. Six- and 7-year-olds distinguish problem solving based on reasoning from short cuts that do not involve reasoning, such as flipping a coin (Amsterlaw 2006). Six- and -seven-year-olds also distinguish deductive reasoning from guessing by rating deductive conclusions as more certain than arbitrary guesses (Pillow 2002; Pillow et al. 2000). Furthermore, 8–9-year-olds rate deductive inferences as more certain than inductive inferences, and 9–10-year-olds and adults rate inductions based on stronger evidence as more certain than inductions based on weaker evidence (Pillow and Pearson 2009). By late childhood or early adolescence children distinguish logically necessary inferences from invalid inferences (Miller et al. 2000; Morris 2000; Moshman and Franks 1986).

Young children sometimes have difficulty in recognizing ambiguity in evidence and determining what inferences a given pattern of information affords. For example, Pierraut-LeBonniec (1980) presented children with objects made either from straight sticks alone or from straight and curved sticks. Children also were shown a box containing only straight sticks and a box containing straight sticks and curved sticks. Then children were asked which box had been used to make each object. Because both boxes contained straight sticks, the object consisting of only straight sticks was an indeterminate problem: either box could have been used to construct it. The object made from straight and curved sticks was a determinate problem because only one box could have been used to construct it. Five-year-olds readily selected the correct box on determinate problems, but for indeterminate problems children almost always chose a specific box, as if they failed to recognize the indeterminacy of the evidence.

Subsequently, Fay and Klahr (1996) employed a similar procedure to question children more directly about the determinacy of evidence. Three types of construction pieces, straight sticks, curves, and squares were combined to create objects consisting of either: (a) straight sticks only, (b) curves only, (c) squares only, (d) straight sticks and curves, or (e) straight sticks and squares. Two boxes of construction pieces were presented along with each target object. For some problems (one vs. two feature), one box contained only one type of construction piece and the other box contained two types of pieces, including the type in the first box. For other problems (two vs. two feature), both boxes contained two types of pieces, with one type being included in both boxes and one type being unique to each box. Five-year-olds usually did not recognize indeterminacy on one vs. two feature problems, but performed somewhat better on two vs. two feature problems, reporting indeterminacy about half of the time. In a second experiment, children often overlooked indeterminacy on problems where the pieces in one box matched the target object and the other box was closed so that its contents were not visible. Fay and Klahr (1996) concluded that children often follow a positive capture rule. That is, when children identify a single matching box, they judge that they can tell which box was used to construct the target object. Klahr and Chen (2003) provided further evidence that 4 and 5-year-olds tend to use the positive capture strategy.

Examining children's ability to select an effective empirical test for deciding between two conflicting hypotheses, Sodian et al. (1991) found that children aged 6–9 years usually differentiated between a conclusive test and an inconclusive test. For example, in one experiment, children were told a story about two brothers who knew there was a mouse in their house, but had not observed it directly. The brothers had different beliefs about the size of the mouse. To determine whether the mouse was small or large, the brothers could either put out a box with a small opening containing food or box with a large opening containing food. Most children of all ages selected the box with the small opening, which provided conclusive evidence concerning whether the mouse was small enough to enter the box and eat the food. Thus, Sodian et al. (1991) argued that elementary school children can reason about what kind of evidence is conclusive for testing a hypothesis.

Studies of children's understanding of inference and children's evaluation of evidence indicate that preschool children often do not recognize the occurrence of inferences, preschool have difficulty in detecting ambiguity and recognizing the possibility of contrasting interpretations of evidence, and preschool children often do not appreciate the occurrence of biased interpretation. However, during the early elementary school years children begin to understand the occurrence of inference and interpretation.

2.1.1.5 Knowledge of Imagination

Attention, memory, inference, and interpretation typically are involved in processing and representing information about the world. Children also learn about

cognitive activities, such as imagining or pretending, that generate representations not intended to reflect reality. Studies of children's understanding of pretending indicate that although 4-year-olds demonstrate understanding of pretending as a mental, rather than purely physical, activity in some circumstances (e.g., Joseph 1998; Sobel and Lillard 2001), children do not demonstrate consistent understanding of pretending as a psychological process prior to 8 years of age (e.g., Lillard 1998). Young children differentiate between imaginary and real entities. Three- to five-year-old children appreciate that unlike real objects, imagined objects cannot be touched, cannot be seen by others, and do not persist over time (Wellman and Estes 1986). Children aged 3–5 years also regard the content of imagination as controllable, though belief in the controllability of imagination increases between 5 and 8 years of age (Woolley and Boerger 2002). Thus, awareness of imagination as deliberate activity that generates fictional mental states appears early in childhood. In contrast to other cognitive activities, such as selective attention, inference, or the stream of consciousness, children begin to learn about imagination at a relatively young age. Children's early knowledge of imagination may reflect its voluntary and effortful nature.

2.1.1.6 Knowledge About Relations Between Thought and Emotion

Because thoughts can trigger emotions and emotions likewise can trigger thoughts, understanding connections among cognitions and emotions is an important part of learning about cognitive activity. Research on children's understanding of emotion has examined (a) children's knowledge of emotional cuing, (b) children's understanding that an event may vary in emotional meaning for different individuals, (c) children's knowledge of thoughts accompanying emotional experiences such as guilt and (d) children's knowledge of emotional control strategies. Based on these studies, understanding of relations between thoughts and emotions appears to develop gradually from early childhood through late childhood.

Studies of emotional cuing indicate that some initial knowledge of links between thoughts and emotions appears during early childhood. Lagatutta et al. (1997) told children brief stories about a child story character who experienced a mildly sad event. At a later time and in happier circumstances, the story character encountered a cue associated with the earlier sad event. The story character then began to feel sad again. Children were asked to explain the story character's sadness. For example, in one story Mary's rabbit was chased away by dog with black spots. Several days later Mary felt sad again when her friend wanted her to play with his spotted puppy. Two types of explanations were of particular interest. Cognitive cuing responses explained that the character felt sad because seeing the cue led the character to think about the earlier sad event (e.g., "She thinks about her rabbit when she sees that puppy"). Cue responses explained that seeing the cue made the character sad, but did not mention thoughts about the prior sad event (e.g., "She's sad because she sees the dog."). Although 3-year-olds rarely gave cognitive cuing responses, they frequently gave cue responses, indicating some

awareness of a connection between the cue and the character's emotion. Four-year-olds gave each type of response about half of the time, and 5-year-olds gave cognitive cuing responses, rather than cue responses, to the majority of stories. Thus, by 5 years of age children were able to articulate the link connecting past emotional experiences to currently present cue and current thoughts and emotions. In a subsequent study, Lagattuta and Wellman (2001) presented stories with characters who felt sad, angry, or happy following an initial event. At a later time, when the character encountered a cue associated with the initial event, the character felt an emotion congruent with that event rather than their present circumstances. Most 3, 4, and 5-year-olds explained the story character's emotion in terms of the past event. In addition, half of 3-year-olds and the majority of older children explained that the character's anger or sadness resulted from remembering the initial event. As was the case in the previous study, by age 5 the majority of children 'provided complete cognitive cuing responses.

Nonetheless, children's knowledge of the link between thought and emotion appears to be limited. In the absence of external cues related to an emotion, younger children do not necessarily invoke thoughts as a possible influence on emotional states. For instance, Flavell et al. (2001) reported that 8-year-olds and adults often explained a sudden change in emotion without any obvious external cause by appealing to the occurrence of emotionally significant thoughts, 5-year-olds did not. In addition, unlike 5-year-olds, older children and adults also suggested that thoughts can influence emotions (e.g., people can make themselves feel happy by thinking about something happy).

Prior to 8 years of age children also have difficulty in understanding individual differences in emotional responses to the same situation. For example, Gnepp and Gould (1985) investigated children's use of contextual information to make personalized inferences of emotion (i.e., using personal information about an individual to infer his or her emotional reaction to an event). When told about a prior event that could color a story character's response to a second event (e.g., a child's best friend previously said, "I don't like you anymore" and then the child saw the best friend on the playground), 10-year-olds and adults made personalized inferences about the character's emotions. That is, the older children and adults recognized that the prior event would influence the character's appraisal of the second event, which in turn would influence the character's emotional reaction to the second event (e.g., judging that the child would be sad when seeing the best friend because of thoughts about their falling out). Seven and eight-year-olds made personalized inferences much of the time, but not as often as older children, and 5-year-olds rarely made personalized inferences. Likewise, younger children often overlook information about an individual's personality traits when judging emotional reactions (Gnepp and Chilamkurti 1988).

Because complex emotions such as guilt, embarrassment, shame, or pride, involve characteristic combinations of affect and thought, full understanding of complex emotions entails some awareness of the intersection of emotion and cognition. Harris (1989) argues that even young children advance beyond a simple understanding of emotions as associated with or caused by particular situations.

Instead, according to Harris, by 4 years of age children understand emotions as derived from a person's desires and by 6 years children also view beliefs as consequential. For example, children were told that an elephant named Ellie only like to drink Coke and would not drink anything else. A monkey named Mickey emptied a Coke can and filled it with milk. (In an alternative version of the story, Mickey filled a milk container with Coke). Children were asked to predict Ellie's emotion both before and after discovering the contents of the can. Both 4-year-olds and 6-year-olds predicted that Ellie would feel sad upon discovering that a Coke can contained milk and would feel happy to find that a milk container held Coke. Furthermore, children's predictions were reversed when Ellie's favorite drink was milk. Thus, both age groups recognized that Ellie's response was mediated by her desire (Harris et al. 1989). However, before Ellie discovered the true contents of the misleading containers, 4 and 6-year-olds differed in their predictions. Six-year-olds based their predictions on Ellie's belief. They predicted she would feel happy when she, albeit mistakenly, believed the container held her preferred beverage and would feel sad when she believed it did not. In contrast, 4-year-olds overlooked Ellie's belief and predicted she would be happy whenever the container held her preferred drink, despite that fact that she thought otherwise.

Comprehending complex emotions presents an additional challenge beyond understanding that basic emotions such as happiness and sadness are mediated by mental states such as desires and beliefs. The experience of complex emotions depends upon one's sense of having met or failed to meet standards of behavior valued by the self and others. Thus, pride results not merely from achieving a desired outcome, but from awareness of personal responsibility for accomplishing a valued goal. Guilt occurs when one feels responsible for violating standards of moral behavior and deserving negative evaluations from self and others. Embarrassment and shame also reflect awareness of evaluation in terms of normative or moral standards. Younger children often do not appear to take account of personal responsibility or moral standards when predicting emotional responses. Thus, when judging a story character's pride or guilt, 5 and 6-year-olds do not differentiate between events with controllable versus uncontrollable outcomes (Graham 1988). In addition, 4 and 5-year-olds often predict that a child who victimizes another child, for example by taking the other child's possessions, will feel happy about the outcome, whereas 8-year-olds more often expect the victimizer to experience unpleasant emotions due to moral qualms (Arsenio Rivka 1992; Nunner-Winkler and Sodian 1988). As these results suggest, by approximately 8 years of age children recognize that emotional responses may be mediated by thoughts about violation of moral standards and responsibility for misdeeds. However, when provided information about a character's thoughts after the character had decided to break a rule, 4 and 5-year-olds predicted that a transgressor who was thinking about the rule or about possible negative outcomes felt worse compared to a transgressor who was thinking about the desire that motivated the transgression (Lagattuta 2008). Therefore, young children appear to be capable of thinking about diverse affective responses to a rule-violation, and young children also can reason about the link between thoughts and emotions.

Simultaneously inferring both the thoughts and the emotions that follow a transgression may be more challenging.

In addition to the relatively automatic effects of cognition on emotion, children also learn about deliberate strategies for controlling or managing their emotions. In a series of studies, Harris and colleagues interviewed children about their own strategies for controlling negative emotions (Harris 1989; Harris and Lipian 1989; Harris et al. 1981). From ages 6 to 15-years there were differences in the strategies children suggested. Six-year-olds, 10 and 11-year-olds, and 15-year-olds all mentioned coping with unhappiness by changing the situation, but children aged 10 or older were more likely to mention the possibility of redirecting their thoughts or engaging in a distracting activity. Thus, knowledge of cognitive strategies for deliberate control of emotion appears to increase in later childhood.

Research on children's understanding of emotion indicates that some awareness of the link between thoughts and feelings is apparent in early childhood, but knowledge of the relation between cognition and emotion increases in sophistication at later ages. This research has examined children's understanding that thoughts can influence emotions. Children's awareness of the reciprocal possibility, that emotions can influence thoughts, appears to have received little attention. However, Flavell et al. (2001) reported that 8-year-olds and adults, but not 5-year-olds, recognized that a person who is feeling sad also is likely to be thinking sad thoughts. Children's understanding of bidirectional influence between thoughts and emotions remains to be investigated. Although understanding of the connection between cognition and emotion appears to develop gradually into late childhood and adolescence, young children's knowledge of cognitive cuing of emotion is noteworthy. The salience and personal significance of affective states may enhance awareness of situations and thoughts associated with them, thereby facilitating early learning about emotional cues and their consequences.

2.1.1.7 Knowledge About the Controllability of Thoughts

As children learn about cognitive processes such as attention, memory, and reasoning, they also learn about some general characteristics of cognitive activity. Controllability is one such characteristic. Theories of cognition often distinguish between controlled processes and automatic processes (e.g., Hasher and Zacks 1979). Controlled processes require attention, and thus are more effortful and are subject to deliberate conscious control. Automatic processes can be performed without allocating attention to them, and they may occur outside of consciousness and may be involuntary or not directly controllable. Intuitions about the controllability of mental states are included in older children's and adults' naive theories of mental functioning. Children know about the occurrence of both controlled processes, such as deliberate memory strategies, and automatic processes, such as cognitive and emotional cuing during the elementary school years, but knowledge about the controllability (and especially, uncontrollability) of mental states develops relatively late. For example, Flavell et al. (1998) found that 13-year-olds

and adults were more likely than 5 and 9-year-olds to recognize that upon seeing a shot needle, a child awaiting a shot would automatically think about receiving an injection or that a child who hears a strange noise would wonder about it, even if these children did not want to think about anything. They also found that older children and adults were more likely than 5-year-olds to judge that a person could not go three days without thinking about anything. Flavell and Green (1999) investigated children's and adults' intuitions about the ability to intentionally cease various mental states. Seven-year-olds, 10-year-olds, and adults were presented with examples of mental states that should be hard to extinguish deliberately (e.g., a strong desire or a strong fear) or easy to change (e.g., a visual fixation or the content of imagination). Although even the 7-year-olds judged some mental states as harder to control than others, 10-year-olds and adults more clearly distinguished the hard to control states from the easy to control states.

Pillow and Pearson (2011) investigated children's and adults' judgments about the controllability of four processes, object recognition, deductive inference, interpretive inference, and pretending. First-grade, third-grade, and fifth-grade children and adults engaged in each of these tasks and then, using a five-point scale, rated how easy it would be to think of an alternative outcome for each task. For object recognition, participants saw a picture of an elephant, and were asked: "When you looked at the picture, did you have to see an elephant or could you see a giraffe instead? Show me with the arrow. Put the arrow here if it would be very easy. Put the arrow here if it would be very hard, and put the arrow here if it would be very easy". For the deduction task, participants saw a toy car and a toy dinosaur. After they were hidden in separate containers, participants viewed one toy and were asked what toy was in the other container. Then they rated how hard it would be to think the other alternative was in the container. For interpretive inference, participants viewed a sequence of three pictures of the same type (e.g., three sharks). While viewing a small ambiguous portion of a fourth picture (e.g., a triangle seen through an aperture), they were asked to identify it (typically, as a shark). Then participants rated the difficulty of thinking the fourth picture was something else. For the pretend trial, participants were asked to pretend there was something in an empty box, and then rated the difficulty of pretending something else. Because object recognition is automatic and pretend is controlled, those tasks provided standards for comparison. If participants distinguished between automatic and controlled tasks, they should give high difficulty ratings for object recognition (i.e., judging that is difficult to look at an elephant and voluntarily see a giraffe) and low difficulty ratings for pretend (i.e., judging that it is easy to pretend various things are in an empty box). Although first-grade children did not distinguish among the four tasks in their ratings, third- and fifth-grade children gave higher ratings for object recognition than for either interpretive inference or pretend. Adults gave higher ratings for object recognition and deductive inference, compared to interpretive inference or pretend. Thus, a distinction between automatic and controlled processes is evident among adults and appears to emerge as early as third grade.

2.1.2 Organizational Knowledge

As children acquire knowledge of the occurrence, function, and characteristics of specific cognitive activities, they develop the potential to reflect on, compare, and organize these psychological concepts. Organizational knowledge refers to beliefs about functional relations, similarities, and differences among cognitive activities. During early childhood, knowledge of mental functioning is organized in terms of relations among beliefs, desires, action, and perception, and during middle childhood this simple belief-desire reasoning begins to be elaborated into a conception of the mind as an active information processor, in which children understand that processes such as reasoning, remembering, learning, and imagining contribute to the formation of beliefs (e.g., Chandler 1987; Wellman 1990). By late childhood, having acquired knowledge of the occurrence of cognitive activities, children begin to organize this knowledge in terms of similarities in the characteristics and functions of different cognitive processes (e.g., Schwanenflugel et al. 1998). Because organizational knowledge represents recognition of the mind as an information-processing entity, such knowledge potentially provides a foundation for thinking about the origin and nature of knowledge in general. In this section, research on the organization of children's concepts of cognitive activities is reviewed. This research suggests that between middle childhood and adulthood, concepts of cognition are increasingly organized in terms of features such as the reception of input or the generation of output, degree of certainty, memory, attentional, and inferential demands, and deliberate effortful processing.

Schwanenflugel and Fabricius and their colleagues have investigated developmental changes in the organization of concepts of cognition by examining children's and adults' judgments of similarity among cognitive activities. In two studies, 8-year-olds, 10-year-olds, and adults rated the similarity of how their mind is used in a variety of activities, such as "learning a new board game from the instructions on the box" (comprehension), "saying happy birthday on the right day to your friend who told you her birthday a long time ago" (memory), "listening to announcements being made a lunch time in a noisy cafeteria" (attention), "knowing that your mother baked cookies for your school party by seeing the dirty dishes" (inference), etc. (Fabricius et al. 1989; Schwanenflugel et al. 1994). Over this age range, multidimensional scaling analyses indicated an increased emphasis on similarities in the cognitive processing demands, as opposed to more superficial features, of the tasks. For example, Schwanenflugel et al. (1994) found that adults organized the activities primarily in terms of a memory dimension, reflecting whether or not memory was a major component of an activity (e.g., list memory and prospective memory vs. attention or inference), and also used an inference dimension (e.g., inference and recognition vs. attention and planning) and an attention dimension (e.g., attention and comparison vs. planning and comprehension). Ten-year-old children organized the activities in terms of a memory dimension primarily, and also included an attention dimension and a planning dimension (e.g., planning and prospective memory vs. comprehension and

inference). In contrast, 8-year-olds organized the activities mainly in terms of whether they involved going somewhere or staying in one place and whether the activity was something the individual wants to do or something someone else wants the individual to do. Eight-year-olds also organized items in terms of whether they required memory, but this dimension played a weaker role in their similarity ratings compared to adults' ratings. Fabricius et al. (1989) did not find evidence for a memory dimension in 8-year-olds' ratings. Instead, in that study, 8-year-olds judged similarity mainly in terms of sensory features of the tasks, such as the degree to which they involved seeing or hearing.

In two further studies, children and adults were asked to rate the similarity of pairs of mental verbs (e.g., know, understand, think, guess, memorize, notice, explain, etc.) in terms of how the mind is used in the activities referred to by each verb (Schwanenflugel et al. 1996, 1998). Schwanenflugel et al. (1996) reported that two major dimensions emerged in multidimensional scaling analyses of similarity ratings by children and adults: information-processing and certainty. The information-processing dimension ranged from perceptual processing of input (e.g., hear, attend, notice) to production of output (e.g., decide, invent), with processes that mediate between the two near the middle of the dimension (e.g., think, memorize). The certainty dimension ranged from verbs implying high certainty at one end (e.g., know, understand, memorize) to those indicating less certainty in the middle (e.g., think) and those indicating low certainty at the opposite end (e.g., guess). Both dimensions appeared in the multidimensional scaling solutions for 8-year-olds, 10-year-olds, and adults; however, the relative weights of these dimensions changed with age. Children emphasized information-processing more than certainty, and adults emphasized certainty more. Also, adults weighted certainty more heavily than did children. Schwanenflugel et al. (1998) reported a similar pattern of results. They presented children and adults with a list of mental verbs and a set of scenarios depicting different mental activities. For each scenario, participants were asked to select all of the verbs that described how they would use their minds in that situation. As in the previous study, the verbs were organized in terms of certainty and information-processing dimensions, and adults emphasized certainty more than did 8 or 10-year-olds.

By adulthood further refinements appear in the organization of psychological concepts. Schwanenflugel et al. (1994) found that adults distinguished recall from recognition memory, and divided recall into list memory and prospective memory. In addition, Parault and Schwanenflugel (2000) reported that adults distinguish varieties of attention. Similarity judgments indicated that adults treat attentional orienting (automatic attention to salient events), divided attention (monitoring two sources at once), perceptual comparison (intermittently sampling and comparing multiple pieces of information), and attentional inhibition (suppressing a behavior) as distinct categories of cognitive activity. Adults also organized attentional activities along an effort dimension, with voluntary, effortful concentration at one end and automatic attentional orienting at the other end.

Schwanenflugel et al. (1994, 1998) argue that the organizational changes documented in this program of research demonstrate that an understanding of

constructive processing develops during middle childhood. That is, during middle childhood there is growing awareness of inferential and interpretive activities, accompanied by the realization that cognitive activities differ in certainty, with activities that are highly inferential or based on little information being less certain. Compared to children, adults are more aware of the selective nature of attention and information-processing. As children's understanding of the occurrence of cognitive activities becomes elaborated and organized, a more abstract, conception of the mind emerges. Children progress beyond an initial recognition of specific cognitive events toward a more general conception of thinking. Moshman's (1998) distinction between inference and thinking provides insight into this metacognitive change. According to Moshman, inference is a process of generating new cognitions from old cognitions, and thinking consists of the deliberate coordination of inferences to serve purposes such as planning, problem solving, decision-making, etc. As children develop an understanding of thinking, they come to view cognitive acts as organized, systematic, and purposeful, rather than as separate occurrences of specific activities. Viewing thought in terms of deliberately related cognitive acts implies knowledge of the mind as organized processor of information. Schwanenflugel et al. (1994) suggest that children's subjective experiences of uncertainty and ambiguity help to motivate the building of this constructive theory of mind.

2.1.3 Epistemological Thought and Metacognitive Theories

The understanding of cognitive activities that emerges from middle childhood through adolescence constitutes an important advancement in children's appreciation of subjectivity. Although some understanding of subjectivity appears early in childhood, this understanding is limited. For example, 4 and 5-year-olds understand that another person may hold a mistaken belief (e.g., Wimmer and Perner 1983). This early understanding is limited to recognition that differences in individuals' objective circumstances (i.e., witnessing different events) can produce differences in subjective states. By 7 years of age children begin to recognize that psychological processes contribute to the creation of subjective differences, as evidenced by children's understanding of differences in interpretation (e.g., Carpendale and Chandler 1996; Pillow and Henrichon 1996). At this age understanding of subjectivity also remains limited. Chandler (1987) distinguished between a case-specific understanding of interpretive differences and a more general understanding of knowledge as inherently constructive. A case-specific understanding, of the sort demonstrated by 7-year-olds, refers to the ability to recognition that a specific piece of ambiguous information may be misinterpreted by a naive or biased observer. In contrast, a general understanding of the mind as constructive entails recognition of the pervasive role of psychological processes in the formation of knowledge and beliefs. According to Kuhn et al. (1988), appreciation of interpretive activity as an inherent part of knowledge begins to emerge

during adolescence, but often does not develop until adulthood. In this section, three theoretical perspectives on epistemological development are described and some empirical findings concerning age-related changes in epistemological thought are briefly summarized.

Together, the occurrence knowledge of cognitive activities that develops during middle childhood and the organizational knowledge that begins in late childhood may provide a foundation for more advanced epistemological thought during adolescence. As older children and adolescents increasingly organize their knowledge of cognitive activities in terms of concepts of information-processing and certainty (e.g. Schwanenflugel et al. 1996) and distinguish between theory and evidence (e.g., Koslowski 1996; Kuhn et al. 1995), they may glean general insights concerning the relationship between the mind and the world. Such reflections may lead to a new appreciation of subjectivity. Thus, Schraw and Moshman (1995) argued that from late childhood through adolescence, children gradually consolidate their knowledge of cognition and integrate it with cognitive monitoring. Through this process they construct metacognitive theories; that is, a systematized framework of knowledge about cognition that can be used to predict and explain events. Schraw and Moshman distinguish systematic metacognitive theories from earlier developing, but not yet systematized, knowledge of specific cognitive processes, or metacognitive knowledge.

The notion that adolescents and adults develop an increasingly systematic and abstract view of the mind and knowledge is central to theories of epistemological development. In response to college students' course evaluations, Perry (1970) conducted a longitudinal study of students' views of knowledge, intellectual authority, and education, interviewing students at the end of each of their four years of college. Based on this study, Perry (1970) proposed a developmental progression in epistemological thought during late adolescence and early adulthood. Perry (1970) suggested many first year college students take a strongly objectivist view of knowledge, which assumes that correct answers exist for all questions and are known by authorities. As they progress through college, students typically come to view knowledge as subjective, recognizing that because even the authorities' knowledge remains incomplete, differences of opinion exist. Moreover, some individuals take the strongly subjectivist stance that, in the absence of certain authoritative knowledge, all opinions are equally valid and merely a matter of preference. By the end of four years of college, Perry found a more complex view of knowledge becoming increasingly common. While continuing to assume that all knowledge is relative, some students also recognized that opinions are derived from evidence and reasoning. Instead of all opinions being equally valid, differing opinions, and the evidence and reasoning supporting them, can be evaluated, with the result that some views may be judged more plausible than others. Moshman (2005) has termed this progression of epistemological stances objectivist, subjectivist, and rationalist epistemology.

Following Perry's pioneering work, several theories of epistemological thought have been proposed and a large body of empirical research has been conducted (for reviews see King and Kitchener 1994; Hofer and Pintrich 2002). The general

progression from objectivist epistemology to subjectivist, and then rationalist, epistemology has continued to be a central theme in many more recent theoretical frameworks (e.g., Chandler 1987; King and Kitchener 1994; Kuhn et al. 1988; Moshman 2005). In their influential seven stage model, Kitchener and King (1981) proposed stages characterized by the assumption knowledge is objective and complete (Stage 1), the assumption that knowledge is inherently uncertain and opinions are personal preferences (Stage 4) and the assumption that viewpoints can be evaluated in terms of the evidence and reasoning supporting them (Stages 6 and 7). Both cross-sectional and longitudinal studies indicate that progress through these stages occurs gradually during adolescence and adulthood, with stage of reasoning being correlated with both age and education (e.g., King and Kitchener 1994).

In their examination of the development scientific thinking and epistemology, Kuhn et al. (1988) identified a progression in adolescents' and adults' reasoning about the relation between theory and evidence which roughly parallels the stages proposed by Perry (1970) and King and Kitchener (1994). For example, in one study they assessed participants' understanding of discrepant accounts of a fictitious war provided by historians from each of the opposing sides. Level 0 participants viewed accounts of historical events as accurate statements of fact, whereas at Levels 1 and 2 participants recognized that historical accounts could be incomplete, but across these first three levels of epistemological thinking, participants did not realize that accounts could be interpretations that differ from the events they describe. Awareness of interpretive differences between historical accounts emerged in Level 3, but these discrepancies were regarded as equally valid differences in opinion. Level 4 thinking treated differences in interpretation as differences in emphasis, rather than as constructions based on different world views. At Level 5 knowledge was recognized as the inherently subjective product of interpretive processes that are entrenched within cultural belief systems. Participants' level of reasoning increased with age and education level from early adolescence through adulthood. During sixth-grade children's responses ranged from Level 0 to Level 2. Some adolescents provided Level 3 responses in ninth-grade, but most responded at Levels 1 or Level 2. Level 4 and 5 responses first appeared during twelfth-grade and became somewhat more frequent during adulthood; however Level 5 responses remained rare among both non-student adults and graduate students. More recently, Kuhn (2001) has distinguished among three levels of epistemological thought: absolutist, multiplist, and evaluativist. These three levels generally parallel Moshman's objectivist, subjectivist, and rationalist epistemologies. Kuhn (2001) proposes that a multiplist conception of knowledge is most likely to emerge during adolescence, but an evaluativist conception develops gradually, over a period of years, and so may be achieved later.

The studies reported by Perry (1970), Kitchener and King (1981), and Kuhn et al. (1988) indicate that rationalist thought develops primarily during adulthood. Substantial individual differences were reported in all three studies, and the most advanced levels of epistemological thought may be relatively infrequent. For instance, Thoermer and Sodian (2002) reported that in interviews with both first

year undergraduate students and advanced graduate students pursuing degrees in biology, chemistry, or physics, explicit discussion of the influence of theories on the interpretation of data was rare. In contrast, Clinchy et al. (1977) found rationalist thought among students in their senior year at a progressive high school that encouraged critical thinking. Questioning adolescents about issues relevant to their own experience (e.g., whether 16-year-olds are sufficiently responsible to drive), Chandler et al. (1990) found an increase in rationalist thinking, which they term post skeptical rationalism, from eight to twelfth-grade.

Beliefs about the origin of different viewpoints and the importance of evidence for resolving disagreements appear to vary according to both age and the type of issue in question (Robinson and Apperly 1998; Rowley and Robinson 2002). For example, Rowley and Robinson (2002) investigated adolescents' and adults' explanations of differences in the interpretation of evidence. Adolescents and adults were presented with a value-laden dispute and a scientific dispute. The value-laden dispute was a disagreement between parents and students about whether a drivers' education course should be offered at a hypothetical high school. The scientific dispute concerned the cause of a skin disease. In each case, the opposing views were based on limited sample of evidence. All age groups, 13–15 year olds, 16–17 year olds, 18–20 year olds, and 40–60 year olds, recognized the possibility that individuals could interpret the same sample of evidence in different ways. In addition, participants of all ages also explained the value-laden dispute as reflecting internal psychological factors, i.e., differences in pre-existing biases, opinions, and motives, and all age groups agreed that additional evidence would not be helpful in resolving the disagreement. Adolescents and adults differed in the views regarding the scientific dispute. Adults, aged 18–20 and 40–60, typically attributed the disagreement to insufficient evidence, an external factor, and judged that additional evidence would be effective for changing views about the cause of the skin disease. In contrast, younger adolescents, 13–15-year-olds, were more likely emphasize internal psychological factors as the explanation for the dispute and less likely to view additional evidence as effective for resolving the disagreement. Thus, overall adolescents discriminated less between the two types of disputes than did adults.

Individual differences in epistemological values influence reasoning. Klaczynski (2000) investigated biases in adolescents' reasoning. Adolescents were asked to evaluate evidence relevant to their beliefs about relations between either social class or religion and variables such as parenting, morality, and satisfaction with life. When reasoning about social class or religion, adolescents used more sophisticated scientific reasoning strategies when rejecting evidence that was inconsistent with their prior theories, and made more superficial heuristic judgments when evaluating evidence that was consistent with their prior theories. Moreover, adolescents' theories became more extreme or polarized following presentation of evidence. However, both of these effects were influenced by adolescents' epistemological attitudes. Measures of four aspects of adolescents' epistemological dispositions were combined into an overall epistemological disposition score. The four measures assessed enjoyment of intellectual challenges,

openness to revising beliefs, tendencies to avoid uncertainty, contradictory propositions, or ill-defined problems, and reliance on rationality rather than intuition. Composite epistemological disposition scores moderated both reasoning biases and belief polarization. Thus, adolescents who were more “knowledge-driven”, or open to uncertainty, consideration of other views, etc., were more likely to use sophisticated scientific reasoning, less likely to use biased reasoning, and less likely to polarize their beliefs compared to adolescents who were more “belief-driven”.

Although similarities and differences among the forms of subjectivist and rationalist thought documented in adolescence and adulthood remain to be clarified (Chandler et al. 2002), research on epistemological development indicates that increasingly sophisticated views of mental activity emerge across this age span. For many adolescents and adults, recognition of subjective psychological states and processes has implications for views of the nature of knowledge and the relation between the mind and reality. Moreover, in addition to age-related changes, individual differences in epistemological thought emerge during adolescence and remain important through adulthood.

2.2 Developmental Trends

In reviewing research on children’s understanding of cognition, I have distinguished among knowledge of the occurrence of particular cognitive activities, knowledge of the organization of cognitive activities, and more abstract epistemological thought about the nature of knowledge, mind, and reality. As these distinctions imply, with increased age the content of children’s knowledge about cognition may grow more elaborate and abstract. In addition, as suggested by Schraw and Moshman (1995), there also may be a trend toward increasingly explicit understanding of cognition. Each of these trends will be discussed briefly below.

Several theorists have proposed developmental changes in the generality of children’s metacognitive knowledge. As mentioned earlier, Chandler (1987) suggested that children’s initial understanding of interpretive processes is case-specific. In a particular instance, children may recognize that an observer may misinterpret ambiguous information. However, this momentary recognition occurs on a case-by-case basis and is not yet integrated into a general view of knowledge as constructed through cognitive activity. Similarly, Schraw and Moshman (1995) distinguished metacognitive knowledge and metacognitive theories. Metacognitive knowledge includes declarative knowledge about cognitive processes, whereas metacognitive theories are broader frameworks constructed to systematize such knowledge and achieve a more formal understanding of cognitive activities. The basic understanding of cognitive activities that I have termed occurrence knowledge may begin as case-specific knowledge of particular cognitive phenomena. Children may begin by noticing instances of remembering, forgetting, attending

selectively, or making inferences, etc. As experience with a particular type of cognitive event accumulates, children may begin to conceptualize that process, with knowledge of individual cognitive activities remaining relatively isolated at first. Eventually children may begin to notice similarities and differences among cognitive activities, perhaps involving their functions or the contexts in which they occur. Gradually children may begin to represent, at least implicitly, features or dimensions along which cognitive activities may be compared, and knowledge of the organization of cognitive activities emerges. During middle childhood knowledge of cognitive activities becomes organized in terms of their input–output functions and their associated level of certainty (Schwanenflugel et al. 1994, 1998). According to Schwanenflugel and colleagues, the development of this organizational framework marks the appearance of a more general understanding of the mind as a constructive processor of information. Although some recognition of subjectivity can be seen in early childhood; for example, in young children's understanding of differences in beliefs, older children's increased awareness of constructive activities lays the groundwork for a more general confrontation with subjectivity. During adolescence the objectivity versus subjectivity of knowledge becomes a central issue of epistemological reflection.

I have proposed that occurrence knowledge, organizational knowledge, and epistemological thought form a developmental progression, but these levels of understanding do not constitute distinct stages. Instead, they may overlap each other, with one level beginning to emerge while the previous levels continue to develop. Moreover, these three levels of understanding may influence each other bidirectionally. For instance, accumulating occurrence knowledge may create an informational base that, by allowing comparison and analysis, facilitates the development of organizational knowledge. At the same time, organizational knowledge may help children acquire new knowledge about the occurrence of cognitive activities or help them refine, revise, or elaborate prior knowledge. Likewise, in middle and late childhood the development of organizational knowledge may be a step toward adolescent epistemological thought, but in turn epistemological reflection may result in new insights into both the organization of cognitive functioning and the occurrence of specific cognitive activities.

In addition to changes in the organization and abstractness of knowledge about cognition, there also may be changes in the explicitness of children's understanding. Schraw and Moshman (1995) identified three types of metacognitive theories: (a) tacit theories, (b) explicit informal theories, and (c) explicit formal theories. Tacit theories are held without any explicit awareness of possessing a theory. Tacit theories are implicit organizational frameworks that serve to organize knowledge and that may affect behavior and decision-making. Schraw and Moshman suggest that because an individual is not explicitly aware of either the theory or evidence that supports or refutes the theory, tacit theories are not easily distinguished from evidence or tested against data. Informal theories include some explicit knowledge, but are fragmentary, with individuals being aware of some of the assumptions that comprise the theory without having formed an explicit, integrated theoretical framework. Having at least some explicit awareness of their

assumptions enables individuals to distinguish the content of their theory from the data the theory attempts to explain. With this distinction, it becomes possible to evaluate and modify metacognitive theories. Explicit formal theories are highly systematic and explicit explanatory structures of the sort created by experts and taught in advanced academic settings. Schraw and Moshman note that explicit formal theories are rare and typically are limited to an individual's immediate area of expertise when they do occur. Therefore, it seems likely that most children and adults do not develop full explicit formal theories of cognitive functioning, but may achieve informal theories. More generally, Karmiloff-Smith (1996) has characterized development within cognitive domains as a process of constructing increasingly explicit representations, such that initially implicit procedures become objects of thought that can be compared and eventually accessed into consciousness.

These two developmental trends, the progression from occurrence knowledge to organizational knowledge and epistemological reflection, and the progression toward increasingly explicit knowledge, can be viewed as intertwined. Knowledge of the occurrence of particular cognitive events and activities may begin as case-specific, non-theoretical, and implicit. Over time this knowledge may become more general and explicit. As a result, children come to have concepts of cognitive activities, such as attention, memory, reasoning, the stream of consciousness, etc. Increased explicitness may facilitate the construction of organizational knowledge. At first organizational knowledge represents a tacit theory, but with increased explicitation may form the basis for an informal explicit theory. Because informal theories are amenable to evaluation and revision, possession of an informal theory of cognitive functioning would enable epistemological reflection and further theorizing.

2.3 Summary

Between preschool and adolescence, children progress from a basic understanding of mental states to understanding of some properties of cognitive activities such as attention, memory, and inference, and then to epistemological reflection on the nature of human knowledge. Kuhn (2000) suggests that young children's understanding of beliefs provides a foundation for further epistemological development. The present model distinguishes mental state reasoning and three aspects of conceptual knowledge of cognitive activities: Occurrence knowledge, organizational knowledge, and epistemological reflection. These three aspects of conceptual understanding may form a developmental progression, with occurrence knowledge providing a foundation for the development of organizational knowledge and in turn being further refined as organizational knowledge develops. Organizational knowledge represents implicit recognition of the mind as a systematic entity. This recognition of the mind as a system of subjective states and processes may facilitate thinking about the relation between the mind and external

reality, a core concern in the development of an epistemological framework. However, occurrence knowledge of cognitive activities, organizational knowledge, and epistemological reflection have been investigated separately. Developmental relations among mental state understanding, occurrence knowledge of cognitive activities, organizational knowledge of cognitive activities, and epistemological reflection remain to be determined empirically.

In this chapter I primarily have discussed descriptive research concerning age-related patterns in children's knowledge of cognitive functioning. Describing age-related changes is an important endeavor and one of my goals, but the patterns of change described here pose an explanatory question: How do such changes occur? That is, how do children learn about cognition? To address this question, I will consider possible sources of information about cognitive activity and also discuss possible learning mechanisms. Research concerning children's conceptual knowledge of cognitive activities has described age-related changes in children's understanding of cognitive functioning, but typically has not examined mechanisms of knowledge acquisition or modification. A more complete picture of development could be achieved by integrating studies of age-related changes in children's knowledge of cognitive activities with investigation of children's monitoring of phenomenological experience and children's participation in the social construction of knowledge about cognitive functioning. Research on the development of cognitive monitoring is reviewed next in [Chap. 4](#), followed by a discussion of social influences on children's understanding of mental functioning in [Chap. 5](#). Then in [Chap. 6](#) I attempt to integrate cognitive monitoring, social experience, and conceptual understanding of cognition, and I also consider learning processes that may contribute to the development of metacognitive knowledge.

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