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Metacognitive Theories

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This paper proposes a framework for understanding people's theories about their own cognition. Metacognitive theories are defined broadly as systematic frameworks used to explain and direct cognition, metacognitive knowledge, and regulatory skills. We distinguish tacit, informal, and formal metacognitive theories and discuss critical differences among them using criteria borrowed from the developmental literature. We also consider the origin and development of these theories, as well as implications for educational research and practice.

KEY WORDS: metacognition; self-regulation; metacognitive theories; knowledge.

METACOGNITIVE THEORIES

Hardly anyone questions the reality or importance of metacognition. Yet among those who study it, there is considerable debate about the scope and meaning of the term and the nature and interrelations among the various types of metacognitive knowledge and processes that have proliferated in the psychological literature (Alexander, Schallert, and Hare, 1991). The purpose of this paper is to consider how individuals consolidate different kinds of metacognitive knowledge and regulatory skills into systematized cognitive frameworks that we refer to as *metacognitive theories.*

To do so, it is necessary to distinguish specific components of metacognitive knowledge (e.g., conditional knowledge) and metacognitive regulation (e.g., comprehension monitoring) from the systematic integration of these components (e.g., theoretical knowledge about variables affecting cognitive performance). The question of how individuals coordinate their

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knowledge about cognitive structures has received little attention from researchers (see King and Kitchener, 1994; Kitchener, 1983; Kuhn, 1989). We propose that individuals construct metacognitive theories for two reasons: (a) to systematize their metacognitive knowledge, and (b) to understand and plan their own cognitive activities within a formalized framework.

The first section of this paper reviews standard accounts of metacognition and how metacognitive knowledge and regulation affect cognitive performance. The second section provides a taxonomy of metacognitive theories that range from tacit models of cognition to formalized theoretical structures. The third section considers some of the ways that individuals construct metacognitive theories. The final section examines methodological and educational implications of the present analysis.

TRADITIONAL ACCOUNTS OF METACOGNITION

Most accounts of metacognition make a basic distinction between metacognitive knowledge (i.e., what one knows about cognition) and metacognitive control processes (i.e., how one uses that knowledge to regulate cognition). Brown (1987) and Baker (1991), for example, distinguish knowledge of cognition from regulation of cognition. In this section, we elaborate on the distinction between metacognitive knowledge and regulation and consider subprocesses involved in each.

Knowledge of Cognition

Knowledge of cognition refers to what individuals know about their own cognition or about cognition in general. It usually includes three different kinds of metacognitive awareness: declarative, procedural, and conditional knowledge (Brown, 1987; Jacobs and Paris, 1987). Declarative knowledge refers to knowing "about" things. Procedural knowledge refers to knowing "how" to do things. Conditional knowledge refers to knowing the "why" and "when" aspects of cognition.

Declarative Knowledge. Declarative knowledge includes knowledge about oneself as a learner and about what factors influence one's performance. For example, research investigating metamemory (i.e., knowledge about memorial processes) indicates that adults have more knowledge than children about the cognitive processes associated with memory (see Baker, 1989 for a review). Similarly, good learners appear to have more knowledge

about their own memory and are more likely than poor learners to use what they do know (Garner, 1987; Schneider and Pressley, 1989). In one illustrative study, Leal (1987) found that several subcomponents on a metamemory questionnaire were significantly related to course performance among college students, including estimated savings (i.e., estimates of how much was remembered from study episodes).

Procedural Knowledge. Procedural knowledge refers to knowledge about the execution of procedural skills. Individuals with a high degree of procedural knowledge use skills more automatically (Stanovich, 1990), are more likely to sequence strategies effectively (Pressley, Borkowski, and Schneider, 1987), and use qualitatively different strategies to solve problems (Glaser and Chi, 1988).

From an instructional standpoint, a number of studies report that helping younger students increase their procedural knowledge improves their on-line problem solving performance. King (1991), for example, compared groups of fifth-grade students in which individuals solved problems using a problem-solving prompt card or solved problems without it. Those who received explicit procedural training in how to use the prompt card solved more problems on a paper-and-pencil test than the control group. The explicit training group also performed better than the control group on a novel computer task.

Conditional Knowledge. Conditional knowledge refers to knowing when and why to apply various cognitive actions (Garner, 1990; Lorch, Lorch, and Klusewitz, 1993). It may be thought of as declarative knowledge about the relative utility of cognitive procedures. For example, Lorch *et al.* (1993) found that college students distinguished among the information-'processing demands of ten different types of reading situations. Students selected different strategies most appropriate for each situation in an effort to better regulate their learning. Students' beliefs about the relative severity of demands placed on their cognitive resources also differed across the 10 situations.

Recent studies suggest that conditional knowledge continues developing at least through middle childhood. For instance, Miller (1985) found that although kindergarten students showed conditional knowledge about their own learning, they showed less knowledge than older children. Similarly, older children and adults appear better able than younger learners to selectively allocate their attention based on conditional task demands (see Reynolds, 1992 for a review). Comparing adults, Justice and Weaver-McDougall (1989) found a positive relationship between knowledge about the relative effectiveness of strategies (i.e., conditional knowledge) and strategy use (i.e., regulation of cognition).

Conclusion. Many studies support the claim that skilled learners possess declarative, procedural, and conditional knowledge about cognition. This knowledge usually improves performance. Many theorists believe that metacognitive knowledge appears early and continues to develop at least throughout adolescence (Brown, 1987; Garner and Alexander, 1989; Flavell, 1987). Adults tend to have more knowledge about their own cognition than do young children and are better able to describe that knowledge (Baker, 1989). However, a number of studies reveal that children as young as six can reflect with accuracy on their own cognition, especially when asked to do so in a familiar domain (see Flavell, 1992 for a review).

Metacognitive knowledge (i.e., knowledge of cognition) is not necessarily statable (but see Brown, 1987). Children routinely demonstrate and use knowledge about cognition without being able to express that knowledge (Karmiloff-Smith, 1992, Chap. 5; Montgomery, 1992). Even adults experience great difficulty providing explicit descriptions of their own expert cognition (Bereiter and Scardamalia, 1993; Chi, Glaser, and Farr, 1988). Although metacognitive knowledge need not be statable to be useful, conscious access to such information nevertheless may facilitate thinking and self-regulation.

Regulation of Cognition

Regulation of cognition refers to metacognitive activities that help control one's thinking or learning. Although a number of regulatory skills have been described in the literature, three essential skills are included in all accounts: planning, monitoring, and evaluation (Jacobs and Paris, 1987; Kluwe, 1987).

Planning. Planning involves the selection of appropriate strategies and the allocation of resources that affect performance. Examples include making predictions before reading, strategy sequencing, and allocating time or attention selectively before beginning a task (Miller, 1985).

An in-depth analysis of how good and poor writers plan their writing has been presented by Bereiter and Scardamalia (1987). One finding is that the ability to plan, and knowledge about this process, develops throughout childhood and adolescence, improving dramatically between the ages of 10 and 14. Older, more experienced writers engage in more global as opposed to local planning. In addition, more experienced writers are better able to plan effectively regardless of text "content," whereas poor writers are unable to do so. These findings are typical of the developmental sequence found when studying other types of regulatory metacognition (Baker, 1989; Garner and Alexander, 1989). Older, more experienced learners possess more knowledge about cognition and use that knowledge to regulate their learning *before* they undertake a task.

Monitoring. Monitoring refers to one's on-line awareness of comprehension and task performance. The ability to engage in periodic self-testing while learning is a good example. Research indicates that monitoring ability develops slowly and is quite poor in children and even adults (Glenberg, Sanocki, Epstein, and Morris, 1987; Pressley and Ghatala, 1990). However, several recent studies have found a link between metacognitive knowledge and monitoring accuracy. For example, Schraw (1994) found that adults' ability to estimate how well they would understand a passage prior to reading was related to monitoring accuracy on a post-reading comprehension test (see also Slife and Weaver, 1992).

Studies also suggest that monitoring ability improves with training and practice. For example, Delclos and Harrington (1991) examined fifth- and sixth-grader's ability to solve computer problems after assignment to one of three conditions. The first group received specific problem-solving training, the second received problem solving plus self-monitoring training, while the third received no training. The monitored problem solving group solved more of the difficult problems than either of the remaining groups and took less time to do so. The group receiving problem solving and monitoring training also solved complex problems faster than the control group.

Evaluation. Evaluation refers to appraising the products and regulatory processes of one's learning. Typical examples include re-evaluating one's goals and conclusions. A number of studies indicate that metacognitive knowledge and regulatory skills such as planning are related to evaluation (see Baker, 1989 for a summary). With respect to text revisions, for example, Bereiter and Scardamalia (1987) found that poor writers were less able than good writers to adopt the reader's perspective and had more difficulty "diagnosing" text problems and correcting them. These differences were attributed to the use of different mental models of writing. Good writers used what Bereiter and Scardamalia (1987, p. 12) referred to as the "knowledge-transforming" model. In contrast, poor writers used a "knowledge-telling" model.

Conclusion. Researchers agree that regulatory competence improves performance in a number of ways, including better use of cognitive resources such as attention, better use of strategies, and a greater awareness of comprehension breakdowns. A number of studies report significant improvement in learning when regulatory skills and an understanding of how to use these skills are included as part of classroom instruction (Cross and Paris, 1988; Brown and Palincsar, 1989).

Brown (1987) has argued that regulatory processes — including planning, monitoring, and evaluation — may not be conscious or statable in many learning situations. One reason is that many of these processes are

highly automated, at least among adults. A second reason is that some of these processes have developed without any conscious reflection and therefore are difficult to report to others. A number of empirical studies support this assumption.

Research also indicates that knowledge of cognition and regulation of cognition are not independent of one another. Swanson (1990) reported statable knowledge of cognition was an important constraint on problem solving among fifth- and sixth-grade students. Schraw (1994) found that college students' judgments of their ability to monitor their reading comprehension were significantly related to their observed monitoring accuracy.

Despite these conclusions, researchers disagree on how individuals consolidate metacognitive knowledge and how knowledge about cognition is best characterized. In the next section, we propose a framework for addressing these questions. We argue that, although children as young as four possess metacognitive *knowledge,* individuals differ greatly in the nature and extent of their metacognitive *theories.*

CHARACTERISTICS AND TYPES OF METACOGNITIVE THEORIES

Metacognitive theories are theories that integrate one's knowledge about cognition and regulation of cognition. By "theory" we mean a relatively systematic structure of knowledge that can be used to explain and predict a broad range of empirical phenomena. By a "metacognitive theory" we mean a relatively systematic structure of knowledge that can be used to explain and predict a broad range of cognitive and metacognitive phenomena.

Within the specific domain of metacognition, theorists, and researchers have suggested that knowledge about cognition often is codified in some systematic framework. For example, the term metacognitive knowledge often is used to refer to a systematic body of knowledge about one's cognition. In some cases, individuals use this systematic knowledge to construct theories. Current research suggests that children as young as three or four appear to possess tacit theories of their own cognition (Flavell, Miller, and Miller, 1993; Karmiloff-Smith, 1992; Montgomery, 1992). These theories serve both social and cognitive functions (Flavell, 1992; Moore and Frye, 1991) and develop slowly at least through adolescence (Chandler, 1988; King and Kitchener, 1994). In this section, we (a) clarify the concept of *metacognitive theory,* (b) consider several general characteristics of metacognitive theories, and (c) distinguish among three different types of metacognitive theories.

Metacognitive Theories

By a *metacognitive theory* we mean a theory of cognition. Metacognitive theories are a subset of theories of mind in that the class of all theories of mind includes, but is not limited to, theories of cognition. Theories of mind address mental phenomena such as emotion, personality, and so forth (Astington, 1993; Flavell, 1992; Moore and Frye, 1991). Metacognitive theories are those theories of mind that focus on cognitive aspects of the mind.

In theorizing about cognition, individuals create and synthesize metacognitive knowledge. It is crucial, however, to distinguish (a) the structured knowledge that comprises a theory from (b) the phenomena the theory is about. All theories are cognitive in that they are structures of knowledge, but not all theories are about cognition. Metacognitive theories are theories about cognition. As such, they *comprise* metacognitive knowledge but they are not necessarily *about* such knowledge. Rather, theories about *meta*cognition would constitute *meta*-metacognitive knowledge. Such theories represent only a subset of metacognitive theories (see Bunge, 1972; Byrnes, 1992 for related discussions).

Characteristics of Metacognitive Theories

A variety of criteria have been suggested for distinguishing a theory from a nontheoretical body of knowledge. Our definition of the term suggests two primary characteristics of metacognitive theories that justify classifying them as a distinct and important subset of metacognitive knowledge. Specifically, metacognitive theories (a) integrate a wide range of metacognitive knowledge and experiences, and (b) permit explanation and prediction of cognitive behavior.

One primary characteristic of a metacognitive theory is that it allows an individual to integrate diverse aspects of metacognition within a single framework (cf. Kuhn, 1989). For example, research indicates that young children often find it difficult to use their knowledge about memory and learning strategies to regulate their cognition (Flavell *et al.*, 1993). One reason is that children have not integrated their metacognitive knowledge and regulatory skills within a unified conceptual framework. As a consequence, many of the skills at their disposal remain *inert* and difficult to apply beyond the context in which they were learned (cf. Kuhn, Schauble, and Garcia-Mila, 1992).

Second, metacognitive theories coordinate beliefs or postulates that allow individuals to predict, control, and explain their cognition, the cognition of others, or cognition in general (Flavell, 1992; Montgomery, 1992). Consider, for example, the Good Strategy User as described by Pressley *et al.* (1987). This individual understands that effective learning depends on activating relevant knowledge from memory, using automated procedures whenever possible, allocating one's resources in a planful way, using strategies selectively, and motivating oneself to learn the material at a deeper level of understanding. To the extent that such understanding is sufficiently coordinated to enhance control of one's learning, it constitutes a theory of what it means to be an effective learner.

Of course, the degree to which a metacognitive theory possesses each of these properties, and the degree to which an individual is aware of these properties, varies from person to person. We believe metacognitive theories change gradually over time given personal experience and self-reflection. In the next section, we describe three different metacognitive theories indicative of this change.

Types of Metacognitive Theories

We propose three different kinds of metacognitive theories: (a) tacit, (b) explicit but informal, and (c) explicit and formal. Henceforth, we refer to these as tacit, informal, and formal metacognitive theories.

Tacit Theories. Tacit theories are those acquired or constructed without any explicit awareness that one possesses a theory (McCutcheon, 1992). Consider the work of Dweck and Leggett (1988), who have argued that young children hold "implicit" theories about the nature of intelligence that, in turn, affect their behavior in the classroom. An *incremental theory* in this framework is one in which the child believes that intelligence is malleable and subject to change through other- or self-directed processes. Given the two criteria proposed above, one could argue that a child's implicit beliefs about intelligence constitute a theory because they allow the child to synthesize observations about the nature of intelligence and make predictions based on those observations. It is tacit in the sense that many children do not spontaneously report holding a "theory of intelligence" even though they systematically express beliefs consistent with such a theory.

Tacit theories about one's own cognition or about the epistemic nature of the world also affect the way adults perform (Sternberg and Caruso, 1985). McCutcheon (1992) describes how teachers' tacit theories affect their interactions with students and curricular choices. Kagan (1992) also reviews

a number of the ways in which beliefs and tacit theories affect teachers' decision making. One important finding is that tacit theories may be difficult to change even when individuals are encouraged explicitly to do so (see Guzzetti, Snyder, Glass, and Gamas, 1993 for a related review).

We view tacit metacognitive theories as gradually constructed, implicit organizational frameworks that systematize one's metacognitive knowledge. Some of the beliefs about cognition that form the core of one's metacognitive theory may be acquired from peers, teachers, or one's culture. In the realms of scientific and informal reasoning, Kuhn (1989, 1991) has referred to these as "reasoning scripts." Other aspects of one's metacognitive theory may be constructed tacitly based on personal experience or adaptations from others (Paris and Byrnes, 1989).

Perhaps the most salient aspect of a tacit metacognitive theory as opposed to an explicit one is that an individual is not readily aware of either the theory itself or evidence that supports or refutes it. Thus, tacit theories are not readily distinguished from, or tested against, relevant data (Kuhn, 1989; Moshman, 1979). To the extent that they remain tacit, metacognitive theories may be persistent even when they are false and maladaptive.

Informal Theories. Informal theories often are fragmentary in that individuals are aware of some of their beliefs and assumptions regarding a phenomenon, but have not yet constructed an explicit theoretical structure that integrates and justifies these beliefs. Informal theorists may have only a rudimentary awareness of their own metacognitive knowledge. Informal theories develop slowly and are affected by a number of social and personal influences on theorizing described later in this paper (Kuhn, 1989; Paris and Byrnes, 1989).

One important difference between tacit and informal theorists is that the latter possess some degree of explicit metacognition. It seems likely that simple informal theories begin as domain-specific entities (Kuhn *et al.*, 1992; Paris and Byrnes, 1989) and gradually are generalized to other domains. Increasing the depth and breadth of metacognitive theories over time may allow informal theorists to better understand and direct constructive processes (Flavell *et al.*, 1993; Montgomery, 1992). We view emerging recognition and control of constructive processes as an essential feature of informal metacognitive theories that is not found among tacit theorists. Awareness of the constructive nature of knowledge and theories is important because, without it, individuals are unable to strategically modify their theories, and as a consequence, should be less able to regulate their cognition and learning. With such an awareness, individuals can begin to (a) purposefully formalize informal aspects of their theory, and (b) evaluate the adequacy of their metacognitive theory as it becomes increasingly formalized.

One interesting example of how tacit theories develop into increasingly sophisticated informal theories comes from the literature on false beliefs (Moore and Frye, 1991). Research indicates that very young children simply do not question the truth and certainty of their own beliefs or those of others (Montgomery, 1992). One reason is that most children younger than four are unable to conceptualize false beliefs and therefore find it impossible to think of true (or false) beliefs as a subset of beliefs in general.

By the age of four, however, most children recognize that beliefs can be false and that it is thus reasonable to inquire about the truth or falsity of a claim as part of the reasoning process (Flavell *et al.*, 1993). At this age, children begin to develop what Flavell *et al.* refer to as *postulates* regarding the truth and certainty of a claim. Although initially tacit, such postulates over time may provide a basis for testing an increasingly explicit metacognitive theory. At the age of six, children also begin to develop an awareness that knowledge and understanding are constructed and that they have some degree of control over this process. Understanding the constructive nature of knowing may help children develop rudimentary informal theories of their own thinking (Montgomery, 1992), although such theories clearly continue to develop well into adolescence (Chandler, 1988; King and Kitchener, 1994).

One distinct advantage of an informal metacognitive theory compared to a tacit one is that it enables individuals to reflect purposefully and systematically on their performance and, in turn, to use this information to modify or redirect their future performance and thinking (Kuhn *et al.*, 1992). For example, Moshman (1990) argued that children who apply tacit logical rules experience more difficulty solving complex deductive reasoning problems than individuals who have explicit knowledge (i.e., an informal theory) concerning the nature and use of such rules. One explanation is that individuals adopting a "theory-driven" approach are better able to think about their performance and understand it as an integrated system of actions.

A second advantage of explicit theories is that individuals can begin to distinguish *formal* from *empirical* aspects, where the formal aspect refers to the structure and contents of the theory, and the empirical aspect refers to data that the theory attempts to explain (Hergenhahn and Olson, 1993). Making this distinction allows beginning informal theorists to evaluate formal aspects of their theory in light of disconfirming empirical evidence. In comparison, tacit theorists may abandon formal aspects of their theory on the basis of irrelevant evidence or ignore relevant, disconfirming evidence because it threatens the integrity of formal aspects of their theory.

A third advantage of explicit theories is that distinguishing the structure of one's metacognitive theory from evidence that supports or refutes it is a necessary step in the development of more sophisticated theories. For example, Reich, Oser, and Valentin (1994) have argued that knowledge about the knowing process develops in a predictable sequence in which individuals first become aware of changes in their beliefs, develop reasons for these changes, and finally attempt to explain these changes in terms of a lay theory of mind.

Formal Theories. Formal theories consist of highly systematized accounts of a phenomenon involving explicit theoretical structures such as those encountered in university classes in physics, music, or statistics. An example in the cognitive domain is Sternberg's (1986) triarchic theory of intelligence. No doubt formal theories about one's performance or anything else are rare outside the realm of one's immediate expertise, if they even occur there (Kuhn, 1989). McCutcheon (1992), for instance, reports that formal theories of pedagogy are rare even among skilled teachers. Schön (1987) makes a similar argument regarding other domains of expertise. Nevertheless, when they exist, formal theories may exert a profound impact on performance and on the understanding of performance.

Presently, it is unclear what constitutes a formal metacognitive theory of one's cognition. One possible example of a formal metacognitive theorist is the Good Strategy User as described by Pressley *et al.* (1987). The metacognitive knowledge of the Good Strategy User is not only integrated and explicit, but in some individuals (e.g., professional educators) may constitute a formalized theoretical structure involving a set of postulates that can be used to test and evaluate one's metacognitive knowledge.

In addition, it is likely that formal theorists possess some explicit awareness of the constructive nature of theorizing and engage in purposeful efforts to construct and modify metacognitive theories (Kuhn *et al.,* 1992; Paris and Byrnes, 1989). One potential advantage of a formal metacognitive theory is that it allows the individual to make informed choices about self-regulatory behaviors. Reich *et al.* (1994, p. 168) refer to individuals who make such choices as "producers of their own development."

In related work, Kuhn (1989) has described two skills that may be necessary for the construction of a formal theory. One is the ability to clearly distinguish and coordinate the formal and empirical aspects of a theory. Formal theorists understand that the formal and empirical aspects of a theory are conceptually independent of each other even though each can be used to evaluate the adequacy of the other.

A second skill is the ability to evaluate and interpret the meaning of empirical evidence apart from the formal aspects of one's theory. Kuhn reports strong developmental changes in this regard in which children and some adolescents appear unable to evaluate the adequacy of empirical data. In contrast, professional scientists evaluate evidence with a far greater degree of accuracy. It appears likely that the ability to use evidence to test the formal aspects of a theory is a late developing skill associated with formal theorizing.

Summary. We have proposed three types of metacognitive theories and considered how each differs from the others. These theories form a naturally occurring hierarchy of knowledge about cognitive and metacognitive processes. At one end of this continuum are tacit theories, which provide limited guidance and explanatory power. These theories are characterized by loosely systematized knowledge and postulates that are not known consciously by the theorist. Informal theories are partially accessible to the theorist and presumably play a greater role in self-regulation. Formal theories provide an explicit framework for understanding and regulating one's cognition. Moreover, because their formal and empirical aspects are explicitly distinguished, they are more subject than informal theories to purposeful and rigorous evaluation.

Little has been said, however, about what personal and cultural factors influence the construction and development of metacognitive theories. The next section examines three important influences, including cultural learning, individual construction, and peer interactions. This section also describes experimental findings that are relevant to each of these three influences.

SOURCES OF METACOGNITIVE THEORIES

This section explores in more detail the origins of metacognitive theories. We consider three factors that we believe interact to bring about change: cultural learning, individual construction, and peer interaction.

Cultural Learning. One possibility is that metacognitive theories are internalized from one's culture via social learning. Socially shared conceptions about the nature of cognition are transmitted to children via informal experience and formal education. The most obvious sort of cultural learning is direct instruction in which students are taught to use a specified set of cognitive skills and are shown how to coordinate the use of these skills (see Pressley, Harris, and Marks, 1992).

One example of such an approach is the work of Paris and colleagues (Cross and Paris, 1988; Jacobs and Paris, 1987; Paris, Cross, and Lipson, 1984). In a series of studies, children were taught cognitive and metacognitive skills using the Informed Strategies for Learning (ISL) program which focused on increasing declarative, procedural, and conditional knowledge about the reading process. For example, students received modeled instruction, guided practice, and independent practice on specific reading strategies such as identifying main ideas. Students also were provided with regular feedback regarding their use of strategies. Last, the ISL program also sought to create higher levels of student involvement and awareness via the use of bulletin boards and periodic group discussions.

Cross and Paris (1988) reported significant gains between the third and fifth grades with respect to knowledge about cognition and regulation of cognition while reading. Knowledge of cognition, which was defined as an awareness of variables that influence thinking, was measured using a 15-question reading awareness interview as well as a strategy rating task in which students identified strategies that would be most helpful for learning new material in a particular situation. Regulation of cognition, which was defined as the ability to regulate one's learning, was measured by comparing pre- and post-test measures of error detection proficiency and changes in reading comprehension. Unlike the treatment group, significant changes did not occur among control subjects. Similar results have been reported by Kurtz and Borkowski (1987) and Palincsar and Brown (1984).

Notwithstanding these findings, it is unclear whether formal instruction using ISL or other direct instructional approaches leads to the development of informal or formal metacognitive theories among students. Moreover, if such theories do exist following direct instruction, they may be less useful to students than self-constructed theories. Future research should compare those who show evidence of a tacit, informal, or formal theory following instruction to those who do not show evidence of a theory.

Individual Construction. Much of what people know about cognition develops outside the realm of formal or informal instruction. We believe individuals spontaneously construct metacognitive theories for at least two reasons. One is to systematize their growing repertoire of cognitive skills and strategies as well as metacognitive knowledge about those strategies. A second reason is to come to grips with what it means to be an effective, strategic learner.

Individuals no doubt utilize a variety of strategies to construct metacognitive theories. In some cases, construction may involve what Flavell *et al.* (1993) refer to as *phenomenological bootstrapping* (see also Beckwith, 1991), in which children and adults project their cognitive experiences onto others and/or use these experiences as a basis for general reflection on the nature of cognition.

Other theorists also note the important role of private, reflective analysis of one's own cognition. Paris and Byrnes (1989) have suggested that self-directed reflection develops in young children as part of self-correction and takes on increasing importance as children grow older. Karmiloff-Smith (1992) takes a similar view, suggesting that reflection leads to the restructuring of one's knowledge in a manner that promotes an increasingly theoretical understanding of one's cognition. Both Paris and Byrnes (1989) and Karmiloff-Smith (1992) view theory building as initially domain-specific, followed by a gradual extension of one's theory to other domains.

Peer Interaction. A third factor, and one we wish to highlight, is social interaction among peers (Youniss and Damon, 1992). By peers we mean individuals who are roughly at the same cognitive level in relevant aspects so that none can be considered an expert with cultural knowledge to be passed on to the others. Peer interaction involves a process of social construction that differs in part from both cultural transmission and individual construction (Brown and Palincsar, 1989; Pressley *et al.,* 1992), even though it also may be affected by cultural processes (Rogoff, 1990; Vygotsky, 1978). One way this occurs is when groups of individuals engage in *collective reasoning.* A recent review by Pontecorvo (1993) describes a number of advantages of collective and socially shared reasoning processes, but especially the role played by resolving group dissension.

One example of the effect of peer interaction is a recent study in which Geil and Moshman (1994) asked college students to solve Wason's (1966) four-card problem. This task requires a person to decide which of four cards needs to be examined further (i.e., turned over) in order to conclusively determine the truth or falsity of a given hypothesis. Success on this task requires the metatheoretical insight that all those cards — and only those cards — that could falsify the hypothesis must be turned over in order to reach a definitive conclusion. Geil and Moshman proposed that individuals working as a group would engage in more sophisticated hypothesis testing than individuals working alone.

Students were asked to solve the problem individually or in groups of five or six. Only 9% of students reached the correct solution in the individual condition, whereas 75% of the groups did so. In half of the groups, students were asked to solve the problem individually prior to group discussion. Of these individuals, 35 gave an incorrect answer before discussion and a correct answer afterward, whereas only two showed the reverse pattern. These results are consistent with the view that discussion of one's metacognitive conceptions with others may help clarify those conceptions and improve complex problem solving.

A cultural learning explanation of these results would suggest that students changed their responses because they internalized either the majority view or the view of one or more group members who were perceived as experts. The data contradict this explanation, however. The correct response was not initially the majority view, or even the most common view, in any of those groups in which individual problem solving preceded group discussion. In three of those groups, in fact, not a single individual initially selected the pattern of cards that showed understanding of the role of falsification in hypothesis testing. All three of these groups nonetheless were among those that ultimately agreed on the correct response.

It appears, then, that the falsification insight was actively constructed and/or applied in the course of the discussion rather than being imposed by the majority or by an expert. It is noteworthy in this respect that there was initial disagreement in all of the groups. One may speculate that this facilitated group interaction and that such interaction is at least as important as individual reflection in the construction of a metacognitive theory.

Conclusion. It seems plausible that cultural learning, individual construction, and peer interaction all play important roles in the emergence of metacognitive theories. Moreover, it is likely that their influence is interactive rather than simply additive. By interactive, we mean that improvements made via any of the three factors described above reciprocally affect the remaining factors. For example, the communication of specific information about cognition via direct instruction may enhance a student's ability to construct an informal or formal theory of his or her own cognition. Similarly, peer discussion and collective theorizing about cognition may enhance the effectiveness of direct instruction. In general, we believe that cultural learning, individual construction, and peer interaction *are not* mutually exclusive pathways to self-regulation, but are interrelated. An important direction for future research is to explore the interactive role of these factors in the emergence of metacognitive theories.

ISSUES OF RESEARCH AND PRACTICE

Assessment

Research and application with respect to metacognitive theories require means for characterizing such theories. One possible approach is to model a person's expertise, including his or her metacognitive theory about that expertise, using verbal report procedures (Ericsson and Oliver,

1988). While subject to criticism, under some circumstances the verbal report technique offers direct access to otherwise unobservable processes such as metacognition, mental models, and personal theories. We believe this method may be especially useful during preliminary investigations of metacognitive theories.

A second approach is to compare individuals on a task that can be performed more efficiently with a theory-in-action, by implementing a mental model of the task at hand, or when one possesses a formal metacognitive theory. For example, Karmiloff-Smith and Inhelder (1974–75), found that older children were more likely than younger children to construct a theory-in-action of a block balancing task and, in turn, to use evidence from their performance to confirm or disconfirm their theory. Verification of the theory led to improved performance. Similarly, Bereiter and Scardamalia (1987) proposed that the use of different mental models of writing led to differences in the quality of writing among older children and adults. One possibility would be to observe expert and novice teachers as they evaluate their students. These teachers would be expected to differ in two ways: (a) with respect to their explicit awareness of their own metacognitive theory, and (b) the extent to which they use their metacognitive theory to evaluate their students' cognition and performance.

A third approach is to use computer modeling techniques to approximate the structure of a metacognitive theory. For example, Goldsmith, Johnson, and Acton (1991) have generated multidimensional representations of complex structural knowledge within a domain using the Pathfinder system. Computer simulations in this case are based on empirical data collected from students who completed a semester-long course. Simulations also could be created based on theory-driven parameters rather than empirical data. This procedure is fairly routine among researchers attempting to construct expert systems and artificial intelligence.

It is important to note, however, that numerous measurement problems are endemic to the study of metacognition and especially metacognitive theories. Due to the complexity of the knowledge that must be assessed, problems related to reliability are inevitable. Assuming that metacognitive theories can be detected reliably, the problem of comparing one person's theory to another still exists. Although computer programs are available to make such comparisons (Goldsmith *et al.*, 1991), they are not without their critics. One of the greatest challenges for researchers will be to develop reliable methodologies for detecting and representing people's metacognitive theories.

Educational Implications

One criticism of traditional instruction is that it encourages passive rather than active learning and thus may lead to inert knowledge structures. Many recent instructional programs have sought to improve learning by encouraging students to be more active and constructive and by providing greater opportunities for peer interaction. For example, a number of programs designed to improve reading provide explicit and sustained strategy instruction in skills such as predicting and summarizing (Brown and Palincsar, 1989) and encourage discussions designed to increase metacognitive awareness about those strategies (Cross and Paris, 1988).

Although many of these programs are quite effective at improving strategy use, performance, and metacognitive awareness, few if any seek to promote what we refer to as metacognitive theories. Thus, although students may attempt spontaneously to systematize their skills and knowledge into a theory-like structure, there is little encouragement or assistance for such efforts. Lacking a theory, many students are unable to explain their cognitive performance or to plan effectively.

Kuhn (1989) has argued that children and adolescents have a great deal of difficulty engaging in scientific reasoning because they fail to understand how theories work; that is, they do not distinguish between the formal postulates of the theory and the data that are used to test those postulates. Many students, including those in college, may find it especially difficult to construct meaningful theories of their own cognition. Providing these students with metacognitive knowledge and regulatory skills is important, and many effective educational programs do so. However, many of these programs fall short of helping students (a) to understand the structure of theories, and (b) to use theories to systematize self-knowledge and apply that knowledge to self-regulation.

For this reason, we believe instructional programs should include three additional instructional components: (a) a rationale for the importance of metacognitive theorizing, (b) examples of informal and formal metacognitive theories, and (c) ways to construct metacognitive theories. Regarding the second point, one possibility is for teachers or mentors to explicitly model their own knowledge about their expertise and about how they regulate their expert performance. A rather different approach would be to use a formal instructional model such as Sternberg's (1986) triarchic theory.

One program that makes an attempt to accomplish these goals among younger students is the transactional strategy instruction model described in Pressley *et al.* (1992). In the transactional model, even young readers are encouraged to theorize to themselves (typically out loud) and to others about the reading process. Students also are shown how to construct text meanings and are encouraged to do so. One advantage of this program is that it promotes thinking about learning that draws on individual, cultural, and peer influences. Over time, transactional instruction may promote the kind of explicit theoretical understanding of one's learning that we have associated with informal and especially formal metacognitive theories.

There remains the question of when individuals are first "ready" to engage in metacognitive theorizing. Some educators may believe that metacognitive skills should be excluded from the curriculum until basic skills are mastered. An alternative view is that metacognitive awareness and metacognitive theorizing should parallel, or perhaps even precede, basic skills instruction.

The developmental research described earlier in this paper suggests that most children are able to theorize about their own cognition by the age of four (Flavell *et al.,* 1993; Montgomery, 1992) even though the depth and breadth of their theorizing continues to develop throughout their school careers (Chandler, 1988; Moore and Frye, 1991), into adolescence (Kuhn, 1989) and adulthood (Benack and Basseches, 1989; King and Kitchener, 1994). Children also appear to use simple constructed theories to regulate their performance (Karmiloff-Smith and Inhelder, 1974–75; cf. Moshman, 1979). These findings suggest that it is reasonable to place some degree of emphasis on metacognitive theorizing from the time a child enters school regardless of his or her skill level.

In conclusion, we believe that schools should actively promote metacognitive theorizing among all students. Research indicates that theorizing improves both performance and understanding of one's performance. Research further supports the claim that metacognitive theorizing can be facilitated by self-talk and peer interactions that focus on the *process* rather than the *product* of learning.

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