11 Metacognition research: an interim report

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Recent years have witnessed a trend toward the establishment of metacognition as a field of investigation in its own right that pulls together researchers from a variety of areas. These areas include memory research, developmental psychology, judgment and decision-making, neuropsychology, reasoning and problem solving, social psychology, forensic psychology, educational testing, and consciousness. The few edited volumes that have appeared in recent years on metacognition illustrate the tendency of researchers from disparate areas of investigation to bring their research under the common umbrella of metacognition. This volume is also a witness to this tendency, which I expect to intensify in the years to come.

In this overview chapter, I will begin by pointing out the basic assumptions that seem to underlie much of the experimental work on metacognition. I will then outline several lines of research on metacognition, and show how the chapters in this volume actually reflect the converging influence of these different lines of research. In the main part of the chapter I will focus on the basic issues in metacognition, pointing out some of the contributions of the research reported in this book to the emerging unified field of metacognition.

Basic assumptions

Metacognition, narrowly defined, concerns people's cognitions and feelings about their cognitive states and cognitive processes. However, the term metacognition has been also used more broadly to refer to cognitions about cognition in general, as well as self-regulation processes that take cognitive processes as their object (see Schneider and Lockl, this volume).

Underlying much of the work on metacognition is a view of the person as an organism that actively monitors and regulates their cognitive processes towards the achievement of particular goals. Such a view has been dominant in social psychology ever since Heider's (1958) influential

Appeared in *Applied Metacognition* (2002). Timothy J. Perfect, & Bennett L. Schwartz (Eds.), Cambridge: Cambridge University Press.

work, but has played a less prominent role in traditional information-processing models, in which cognition is sometimes conceived more like a medium through which information flows. The monitoring-and-control model that has been promoted by Nelson and his associates (Nelson, 1996; Nelson and Narens, 1990; see Son and Schwartz, this volume) assumes that in addition to an object level that is responsible for the processing of information, there exists a metalevel that monitors object-level processes, and regulates information processing and behavior accordingly. Thus, for example, during the study of new material, the degree of learning of different pieces of information is continuously monitored, and further learning resources are allocated until the learner's goal has been achieved.

The monitoring-and-control framework embodies two important metatheoretical assumptions (see Koriat, 2000). The first concerns the role of subjective experience. The assumption is that subjective beliefs and feelings play a supervisory, metalevel function. Phenomenal experience is relegated a critical role in the dynamics of the cognitive system: although many cognitive processes occur automatically and sometimes unconsciously, the assumption is that people generally monitor their on-going mental processes, and the output of that monitoring is embodied in the form of subjective, phenomenal experience.

The second assumption concerns the causal role played by conscious, subjective experience. One of the reasons for the increased interest in metacognition lies in the belief that subjective experience is not a mere epiphenomenon, but actually affects and guides controlled cognitive processes and behavior (Son and Schwartz, this volume). Hence the interest in subjective reports is not only because such reports may mirror mental processes (as is generally the case when introspective reports are obtained). Rather, it is because subjective beliefs and feelings are assumed to play a *causal* role in affecting the regulation of cognitive processes and behavior (Koriat, 2000; Nelson, 1996).

The emphasis on subjective experience among students of metacognition coincides with the general emphasis on consciousness in models of memory (e.g. Tulving, 1985). The idea that different memory systems are associated with different types of consciousness implies that the subjective states of consciousness that accompany remembering represent an integral part of cognitive processes, and their assessment provides valuable cues regarding the nature of these processes. Indeed, some of the theoretical frameworks that have dominated the study of memory in recent years place a heavy emphasis on the quality of the subjective experience that accompanies remembering (Gardiner and Richardson-Klavehn, 2000; Jacoby and Kelley, 1987; Mitchell and Johnson, 2000; see Mazzoni and

Kirsch, this volume). The contributions of these theoretical frameworks should be integrated into the study of metacognition.

In sum, underlying metacognitive research is a view of the person as an active agent who has at their disposal an arsenal of cognitive strategies and devices that can be flexibly applied in order to reach certain goals. The choice of such strategies as well as their online regulation is based on the subjective monitoring of these processes.

Research traditions in metacognition

Historically, there have been several lines of research on metacognition, each with its own emphasis. The most systematic research has been conducted within two hitherto disparate areas - developmental psychology and cognitive psychology (see Koriat and Shitzer-Reichert, in press; Schneider and Lockl, this volume; Son and Schwartz, this volume). Each of these two traditions has contributed different experimental paradigms and different theoretical perspectives. In addition, research on various facets of metacognition has been conducted within other areas of psychology, such as judgment and decision-making, social psychology, and neuropsychology. I shall focus first on the developmental and cognitive research traditions, attempting to bring to the fore their different emphases.

The developmental and cognitive research traditions have much in common in terms of their basic assumption about the critical contribution of metacognition to cognitive performance. However, they differ in their methodological style and in their research goals. In the context of developmental psychology (see Schneider and Lockl, this volume), research on metacognition has been stimulated primarily by the work of Flavell and his associates (e.g. Flavell, 1971). Flavell emphasized the role that metacognitive skills play in the development of memory functioning in children, and proposed a conceptual framework that is much more extended than that which underlies cognitive-based research on metacognition (but see Mazzoni and Kirsch, this volume). The assumption that developmental changes in memory performance may reflect in part the development of metacognitive knowledge and metacognitive skills, has generated a great deal of research that attempts to specify the components of metacognitive abilities, their development with age, and their possible contribution to learning and memory performance. Developmental research has focused more on between-individual and between-group variation in different aspects of metacognitive knowledge, abilities, and strategies, rather than on the processes underlying metacognitive monitoring and control per se.

In contrast, the cognitive approach to metacognition has focused primarily on what developmental psychologists subsume under "procedural metamemory." That is, it tended to confine itself to the study of the processes and dynamics of metacognition, primarily in the context of memory processes. This line of research was influenced greatly by the classic work of Brown and McNeill (1966) on the tip-of-the-tongue (TOT) phenomenon, and by Hart's (1965) studies on the feeling of knowing (FOK). The focus of these pioneering investigations has been on the accuracy of partial knowledge and feelings of knowing when the retrieval of a memory target fails. Basic to their methodology is the focus on *within-individual* variation that can shed light on the working of metacognition. This focus is characteristic of a great deal of metacognition research in the context of cognitive psychology.

The difference in methodological styles between the developmental and cognitive approaches can be seen in the focus on cross-subject versus within-subject correlations (see Maki and McGuire, this volume). For example, in studying the memory-metamemory relationship, developmental psychologists typically focus on individual differences in measures of memory and metamemory, and base their conclusions on correlations across participants (e.g. Schneider and Pressley, 1997). It has been observed, for example, that such cross-individual correlations generally increase with age (see Schneider and Lockl, this volume). Cognitive students of metacognition, in contrast, typically focus on within-individual correlations, such as the correlation between FOK and recall or recognition memory (Schwartz and Metcalfe, 1994), between confidence and accuracy (Perfect, this volume), or between judgments of learning (JOL) and recall (Koriat, 1997).

The chapters in this book disclose a convergence between the two styles of research. For example, in the work reported in Hertzog (this volume) on metacognition and aging, some of the conclusions are based on the structure of inter-individual differences in memory and metamemory measures. Perfect's (this volume) research on the confidence-accuracy relationship was motivated primarily by findings involving cross-subject correlations. However, the research that he reported benefits greatly from the inclusion of measures of within-individual correlations. Maki and McGuire's chapter (this volume) also illustrates both methodologies: the accuracy of metacomprehension judgments can be evaluated by calculating the correlation between global measures of metacomprehension and actual test performance across subjects, or by calculating within-subject correlations between judgments made for several different texts with performance for these texts.

Further research still may be seen to represent a constructive merger between the two methodological approaches, focusing on inter-individual

differences in intra-individual measures. For example, some of the experiments reported by Schneider and Lockl (this volume) borrow procedures from cognitive psychology to study age differences in monitoring and self-regulation as they reveal themselves through within-individual correlations. A similar effort underlies some of the work on metacognition in the elderly (e.g. Connor, Dunlosky, and Hertzog, 1997), as well as the work reported by Maki and McGuire (this volume) relating meta-comprehension accuracy (as measured by within-subject correlations) to individual differences in verbal ability.

Apart from the developmental and cognitive traditions, several more restricted lines of research have also contributed to the study of metacognition. The first of these is within the area of decision-making. In fact, a great deal of the current work on metacognition can easily be classified under the rubric of judgment and decision-making (Koriat and Goldsmith, 1996b; see Mazzoni and Kirsch, this volume). At the same time, much of the extensive research initiated by Lichtenstein, Fischhoff, and Slovic (Keren, 1991; Lichtenstein, Fischhoff, and Phillips, 1982) on the calibration of subjective probabilities would certainly be classified as research on metacognition (e.g. Erev, Wallsten, and Budescu, 1994). Not only did that research contribute greatly to our understanding of the confidence-accuracy relationship, but it has also provided refined measures of that relationship that have since been applied to other metacognitive judgments (see Maki and McGuire, this volume); most important is the distinction between calibration (or bias) and resolution. In addition, the work on heuristics and biases of Tversky and Kahneman (see Kahneman, Slovic, and Tversky, 1982) has direct bearings on some of the central issues in metacognition such as the basis of metacognitive judgments (e.g. the availability heuristic, Tversky and Kahneman, 1973), or the reasons for illusions of knowing (e.g. hindsight and foresight biases; Fischhoff, 1982; Koriat and Bjork, 2001). The work by Gigerenzer and his group (e.g. Gigerenzer, Hoffrage, and Kleinbölting, 1991; Gigerenzer, Todd, and ABC Research Group, 1999) is also closely linked to issues discussed in metacognition.

A second line of research that is directly related to issues of metacognition is the current work on memory processes underlying memory accuracy and memory illusions (see Koriat, Goldsmith, and Pansky, 2000). This includes the work of Jacoby, Kelley, Whittlesea, and their associates on the subjective experience of remembering, and on illusions stemming from fluency misattributions (see Koriat et al., 2000). Jacoby's attributional view of memory embodies the idea that the very experience of remembering is the product of a metacognitive, attributional process. A similar assumption underlies Johnson's source-monitoring approach (see Mitchell and Johnson, 2000). This approach brings to the

fore a variety of phenomenal cues that are used in deciding whether an event actually occurred or was just imagined (see Carroll and Perfect, this volume; Mazzoni and Kirsch, this volume). Recent work on false memory has also brought into attention the criticality of metacognitive processes in overcoming and escaping a variety of memory errors (Roediger and McDermott, 2000). A good example is Schacter's recent work on the distinctiveness heuristic (e.g. Dodson and Schacter, 2002).

A third line of research comes from social psychology (see Yzerbyt, Tories, and Dardenne, 1998). It goes without saying that many discussions in social cognition are about metacognitive processes. These include discussions of self-perception theory (Bem, 1972), attribution research (e.g. Jones et al., 1972; Ross, 1977) and dual-process theories (Chaiken and Trope, 1999). Of most interest to metacognitive researchers are the recent developments involving the role of subjective experience in social cognition. A rich body of research by Bless, Schwartz, Strack, Wänke, and others (see Bless and Forgas, 2000) has considered the informational value of cognitive and affective feelings, the effects of ease of retrieval and how these effects are modulated by mood, the contrast between informational and experiential factors that affect behavior, the judgmental adjustments that people make after recognizing that their judgments have been biased by contaminating influences, and many other issues with direct bearing on those discussed in this volume (see, for example, Mazzoni and Kirsch, this volume).

Finally, a fourth line of research is work in cognitive neuropsychology that attempts to specify possible correlates of "executive functions" such as those subsumed under metamemory (e.g. Burgess and Shallice, 1996). The general assumption is that impaired metacognitive processes are related to frontal-lobe damage (see Hertzog, this volume; Moulin, this volume).

As can be seen from this sketchy review, there is still much to be done in terms of pulling together the various threads of metacognitive research into a unified field. This volume, with its focus on applications, is a step in that direction. I shall now outline some of the major issues in metacognition as they are addressed in this volume: the bases of metacognitive judgments; the accuracy of these judgments and the factors that affect it; and the monitoring-based regulation of performance.

The monitoring of one's own knowledge

Much of the cognitive research on metacognition has concerned the monitoring of one's own knowledge, primarily the bases of monitoring and its accuracy. Let us begin by considering the basis of metacognitive

judgments. Koriat and Levy-Sadot (1999) distinguished between experience-based and information-based metacognitive judgments. The former rely directly on a sheer feeling of knowing. For example, a person in the TOT state "feels" that the elusive name or word is about to emerge into consciousness (see Schwartz, 2001; Son and Schwartz, this volume). Similarly, a person who falls prey to unconscious plagiarism often experiences a firm conviction that the borrowed ideas are his / her own (Carroll and Perfect, this volume). Information-based or theory-based metacognitive judgments, in contrast, involve an explicit deduction from a variety of beliefs and memories. Such beliefs and memories clearly underlie many metacognitive predictions, perhaps giving rise to "judgments" of knowing rather than to "feelings" of knowing (Koriat, 1993).

Beliefs about memory

In this section we consider metacognitive beliefs, that is, beliefs about cognitive processes in general, including one's own. Such beliefs reflect one's "naive theory" about cognition, and may be explicit or implicit (see Mazzoni and Kirsch, this volume). The beliefs that people hold about cognition have received much more extended treatment by developmental psychologists than by cognitive researchers (see Schneider and Lockl, this volume). Flavell's conceptualization, for example, places a heavy emphasis on metacognitive knowledge, that is, on what children explicitly know about cognitive functioning and limitations. Metacognitive knowledge includes beliefs about one's own memory, its strengths and weaknesses, about the conditions and variables that affect memory performance, and about different encoding and retrieval strategies and their effects on learning and remembering. Since Flavell's pioneering work, there has been a wealth of research in developmental psychology on children's beliefs about such matters as the limitations of short-term memory, the contribution of different task variables and learning strategies to memory performance, and so forth (e.g. Kreutzer, Leonard, and Flavell, 1975). In addition, there has been a great deal of work on children's theory of mind, and that research also touches upon some of the issues discussed in the context of metacognition (see Holland Joyner and Kurtz-Costes, 1997; Schneider and Bjorklund, 1998). Clearly, one's general beliefs about memory and the variables that affect it should contribute to one's metacognitive judgments in any given situation.

Much less research has been invested in the study of metacognitive beliefs within the cognitive approach to metacognition. One reason for this neglect, perhaps, is that misconceptions about the working of memory are less prevalent among adults than among young children, and hence

differences in people's theories about memory are less likely to play a critical role among adults than among children. Nevertheless, there has been some acknowledgment of the contribution of beliefs to adults' metacognitive judgments as well.

A good example comes from Perfect's chapter (this volume). According to the proposal advanced in that chapter, the reason why people's monitoring is less accurate for eyewitness memory than for general information is that people have greater insight into their relative expertise in areas of general knowledge than in eyewitnessing. People simply do not know how good they are in eyewitnessing. Indeed, feedback about one's memory performance in an eyewitness memory task in comparison to other people increased the confidence-accuracy correlation substantially.

Mazzoni and Kirsch (this volume) provide a general framework in which metacognitive beliefs play a prominent role in autobiographical reports. They propose a distinction between autobiographical beliefs and autobiographical memory. A person may report an autobiographical event with great confidence on the basis of a simple inference rather than on the basis of a recollective experience. In fact, it is possible to increase people's beliefs about the occurrence of an event without creating any specific memory of it.

Mazzoni and Kirsch's distinction parallels the distinction between information-based and experience-based metacognitive judgments. It is also reminiscent of Reder's (1987, 1988; Cary and Reder, in press) distinction between two strategies for making fact verifications about a studied story - plausibility and direct retrieval. The propensity of using each of these strategies was assumed to shift with retention interval towards greater use of the plausibility strategy. Mazzoni and Kirsch, however, proposed that people first check for recollective experience that affirms the occurrence of the stated episodic event, but the beliefs about the plausibility of the event can also determine how much recollective evidence it takes to classify that event as a memory.

Carroll and Perfect (this volume) advance a similar argument with regard to the contribution of beliefs to unconscious plagiarism. If participants have no expertise in an area, they will not be likely to attribute to themselves an idea to which they have been exposed. For unconscious plagiarism to occur, participants must be convinced that it was plausible that they had generated the ideas. Indeed, inadvertent plagiarism was found to increase as expertise developed. Glenberg and Epstein (1987) also showed that judgments of comprehension are closely related to beliefs about what one ought to know, that is, to perceived expertise in the particular domain.

Other analyses by cognitive students of metacognition have also invoked metacognitive beliefs as determinants of one's judgments and

behavior. Several metacognitive biases have been assumed to result from people's misconceptions about the effects of various variables on memory performance. Such misconceptions include, for example, the belief that high-frequency words are better recognized than low-frequency words (Guttentag and Carroll, 1998), or that massed practice is more effective than spaced practice (Bjork, 1999). In Koriat's (1997) cue-utilization model of JOLs, a distinction was drawn between intrinsic and extrinsic cues that may contribute to JOLs, both of which may affect JOLs depending on one's beliefs. Intrinsic cues refer to inherent characteristics of the study materials (e.g. associative relatedness between paired associates). Extrinsic cues, on the other hand, pertain to the conditions of learning (e.g. number of presentations), or to the encoding operations applied by the learner (e.g. level of processing). Several results suggest that in making JOLs participants pay insufficient regard to the contribution of extrinsic factors relative to that of intrinsic factors (Koriat, Sheffer, and Ma'ayan, 2002; see also Carroll, Nelson, and Kirwan, 1997).

Global assessments of performance

The simplest measures of metacognitive monitoring are global or aggregate measures. For example, participants may be presented with a list of words and asked how many of them they are likely to recall. Of course, when global judgments are obtained before the study phase, participants' judgments should be heavily affected by their general beliefs about their own cognitive skills. When global judgments are obtained following the study phase, they might be affected in addition by feedback from one's encoding experience. Therefore we treat global metacognitive judgments as representing an intermediate category between theory-based and experience-based judgments. Maki and McGuire (this volume), however, note that global predictions and global postdictions of performance often yield different results in metacomprehension research.

Global metacognitive judgments are easy to obtain even with young children, and can be used to disclose over/underconfidence biases. Using such judgments, kindergarten children were found to be overly optimistic about their memory, believing that they would remember much of what they learn. Only during elementary school years do children become more realistic in their judgments. However, even young children's predictions tend to be accurate when the situation is familiar to them (see Schneider and Lockl, this volume). Schneider and Lockl note that it is not entirely clear that the inflated predictions of young children indeed reflect metacognitive deficiencies rather than motivational factors such as wishful thinking.

In several studies, participants were asked to make item-by-item JOLs during study, and in addition they were asked to provide a post-study aggregate judgment, that is, to estimate how many items they would recall. Similarly, after completing a forced-choice general-information questionnaire, participants have been asked to estimate how many items they had answered correctly. The general finding in these studies is that aggregate judgments typically yield an underconfidence bias even when the respective item-by-item judgments yield an overconfidence bias (Griffin and Tversky, 1992; Koriat et al., in press; Mazzoni and Nelson, 1995). It is interesting that children also display the pattern of stronger overconfidence bias in mean item-by-item JOLs than in aggregate judgments. The correlations, across subjects, between these two measures are rather low, suggesting that they may tap different aspects of monitoring (Schneider and Lockl, this volume).

In addition to global metacognitive judgments that are elicited in connection with a particular task, interest in practical aspects of memory has led to the development of self-report questionnaires about one's own memory functioning in general. These questionnaires, as discussed by Hertzog (this volume), have been used frequently with older adults, but also with brain-damaged patients. Self-reports about one's own memory are of interest in their own right, because they may have important implications for one's self-confidence and behavior. For example, as Hertzog describes, people's beliefs about the extent of memory decline in old age, and about the likelihood of contracting Alzheimer's disease are a major determinant of anxiety about aging. However, the accuracy of self-report measures is also of major interest. Moulin (this volume) refers specifically to the observation that Alzheimer's disease patients are generally unaware of their deficit, as evidenced by the discrepancy between their predicted and actual memory performance. Interestingly, as Moulin indicated, such discrepancies are not found when these patients predict other people's performance.

In sum, it is clear from this summary that metacognitive beliefs and theories as well as their effects have been mostly investigated in special populations such as young children, elderly adults, and brain-damaged patients.

Online measures of metacognitive judgments

An important contribution of the cognitive approach to metacognitive judgments concerns the bases of online metacognitive judgments. As discussed by Son and Schwartz (this volume), earlier approaches assumed that metacognitive judgments are based on direct access to memory

traces. For example, Hart's (1965) conceptualization of FOK assumed a specialized internal monitor that directly detects the presence of the memory trace of the elusive target. A similar account has been proposed for JOLs: predictions of recall are based on direct read-out of the strength of the memory traces that are formed following study (Cohen, Sandler, and Keglevich, 1991). Some analyses of confidence judgments also implicitly assume that these judgments monitor the strength of memory traces.

In recent years, however, there has been a shift away from the trace-access view, although this view has not been entirely abandoned (see Metcalfe, 2000). More recent approaches assume that metacognitive feelings are based on the utilization of a variety of mnemonic cues. What these cues have in common is that they concern structural aspects of the processing of information rather than informational content (Koriat and Levy-Sadot, 1999). In the case of FOK judgments, the cues that have received some support are cue familiarity and accessibility (see Son and Schwartz, this volume). Recent findings suggest that these two cues contribute to FOK in a cascaded manner: whereas the effects of familiarity occur early, those of accessibility occur later, and only when cue familiarity is sufficiently high to drive the interrogation of memory for potential answers (Koriat and Levy-Sadot, 2001).

JOLs elicited during study have also been said to rely on fluency of processing (Begg et al., 1989; Benjamin and Bjork, 1996; Koriat, 1997), and in the case of delayed JOLs, perhaps on retrieval fluency as well (Nelson et al., 1998). Thus, delayed JOLs are substantially more accurate than immediate JOLs because they entail self-testing that provides feedback about retrieval fluency (see Dunlosky, Rawson, and McDonald, this volume). That is why the delayed-JOL advantage is most prominent for paired-associate learning when these JOLs are cued by the stimulus alone rather than by the entire cue-target pair.

Finally, subjective confidence in the correctness of retrieved information has also been claimed to rest on the ease with which information comes to mind (Kelley and Lindsay, 1993; Lindsay and Kelley, 1996).

Apart from perceptual and retrieval fluency, the source monitoring framework has brought to the fore a variety of phenomenal cues that are used to aid reality and source monitoring. Mazzoni and Kirsch (this volume) discuss the phenomenal quality of the content that comes to mind when a person is asked to decide whether a certain event occurred in their childhood. Such phenomenal characteristics as the vividness, richness, and amount of perceptual detail can help the person distinguish between memories and beliefs. In line with the work of Jacoby and Kelley (e.g. Jacoby and Kelley, 1987; Kelley and Jacoby, 2000), however,

they also acknowledge the importance of processing fluency as an important basis of the subjective experience of memory. Carroll and Perfect (this volume) also make use of the source monitoring framework for analyzing unconscious plagiarism as representing a misattribution of external to internal sources. From the source monitoring framework, it follows that when people are required to justify their plagiarized ideas, the quality of their memory descriptions should be more similar to that characteristic of imagining (or beliefs, in Mazzoni and Kirsch's terms) than to that of external events.

The issue of accuracy

Central among the issues addressed in the study of metacognition is the question of accuracy. Since Hart's pioneering studies on the validity of FOK judgments, there has been a great deal of work on the correspondence between subjective and objective measures of memory performance. That work coincides with, in fact predates, the remarkable wave of accuracy-oriented research in memory (Koriat et al., 2000). As Koriat and Goldsmith (1996a) argued, there has been a shift in the study of memory from a storehouse metaphor, toward a correspondence metaphor. The storehouse metaphor has led laboratory-based research to focus almost exclusively on memory quantity, that is, on the amount of information (e.g. number of items) that can be recalled or recognized under different conditions. The emerging correspondence metaphor, in contrast, underlies the interest in memory *accuracy*, that is, in the extent to which memory reports can be trusted to be true. This interest has been motivated by many real-life memory phenomena, such as the question of the reliability of eyewitness testimony, the authenticity of memories of childhood sexual abuse, the observations demonstrating the malleability of memory such as those pertaining to the effects of post-event misinformation or imagination inflation, and so forth (see Mazzoni and Kirsch, this volume).

Of course, focus on correspondence and accuracy, is characteristic of a great deal of metacognitive research. The Brown and McNeill (1966) study on TOT, for example, was not concerned with the amount of partial information that people can retrieve about an elusive name or word. Rather it was concerned with the accuracy of that information. Of course, when it comes to metacognitive judgments, the first question generally addressed is "How accurate are these judgments?" This concern is central to the application of metacognitive research, and indeed figures prominently in most of the chapters in this volume.

The validity of metacognitive beliefs

When it comes to theory-based metacognitive judgments, a critical determinant of accuracy is the validity of one's naive theories and beliefs about one's own memory, and the factors that affect memory performance. Developmental psychologists have provided a great deal of information about the validity of children's metacognitive beliefs at different ages (see Schneider and Lockl, this volume). Among adults too, it is clear that people's metacognitive judgments are affected by their assumptions about how memory performance varies with different factors such as the passage of time, item difficulty, number of study trials, encoding strategies, and so on (e.g. Begg et al., 1989; Mazzoni and Cornoldi, 1993). Mazzoni and Kirsch (this volume) discuss how one's metacognitive beliefs can affect the decision whether an autobiographical event occurred. For example, because people believe in infantile amnesia, the lack of memory from early childhood would not be taken necessarily as evidence for nonoccurrence. However, the validity of such deductions depends, of course, on the accuracy of one's theories. As noted earlier, some of the wrong beliefs that people hold (see Bjork, 1999; Simon and Bjork, 2001) can result in illusions of knowing.

No less important are one's beliefs about the strengths and weaknesses of one's own memory. Hertzog (this volume) noted that among the elderly, self-reports about one's own memory are only mildly correlated with actual performance on memory tests. Among the explanations that he examined is the possibility that such reports do not mirror one's actual memory efficacy. Rather, they reflect one's beliefs about the functioning of memory in general (see Nisbett and Wilson, 1977). Moulin (this volume) proposed a similar explanation for the inflated global recall predictions given by patients with Alzheimer's disease before they have an opportunity to study the material. He argues that these predictions are based on preconceptions, because the patients actually decreased their predictions substantially following the first study trial.

The accuracy of online measures of metacognitive judgments

When item-by-item metacognitive measures are obtained, an important distinction is between calibration (or bias; see Maki and McGuire, this volume) and resolution. Calibration generally refers to the overall correspondence between mean predicted and mean actual memory performance. Resolution, or relative accuracy, refers to the discrimination between recalled and not-recalled items (in the case of FOK and JOL), or

between correct and wrong answers (in the case of confidence judgments). It is generally estimated using a gamma correlation between judgments and performance across items (Nelson, 1984).

In order to obtain a valid measure of calibration, metacognitive judgments must be assessed using the same scale as that used to score performance. Not all of the studies on memory monitoring, however, have elicited metacognitive judgments in the form of assessed probabilities. This problem does not exist with regard to resolution.

As far as calibration is concerned, the results generally document an overconfidence bias in confidence judgments (see Lichtenstein et al., 1982). FOKs and JOLs, on the other hand, have generally been found to yield little overconfidence bias (Koriat, 1993, 1997).

As far as resolution is concerned, Son and Schwartz (this volume) note that by and large participants are generally accurate in their judgments. Nevertheless, there have been a number of reports in the literature that document strong dissociations between predicted and actual memory performance (e.g. Benjamin, Bjork, and Schwartz, 1998; Koriat, 1995; Simon and Bjork, 2001; see also Carroll and Perfect, this volume). What should be stressed is that these dissociations were deliberately generated by researchers as a vehicle for clarifying the mechanisms underlying metacognitive judgments, and do not mirror the ecological state of affairs.

The distinction between calibration and resolution, which is discussed in detail in Maki and McGuire's chapter, has important practical implications. In the case of JOLs, for example, calibration may affect a student's decision to continue studying for an exam or to stop, whereas resolution may guide the allocation of study time between different parts of the studied material. This distinction is also important for theoretical reasons: Koriat et al. (in press), for example, found that practice studying a list of paired associates improves resolution but impairs calibration (fostering increased underconfidence).

Variables that affect monitoring accuracy

What are the variables that increase or reduce monitoring accuracy? One factor that has been stressed is the degree of variability or homogeneity in the pool of items over which a within-person correlation is calculated. Koriat (1993) pointed out that changes in the characteristics of the items used can produce dramatic changes in the FOK-recall correlation. Perfect (this volume) made a similar point with regard to between-subject correlations: certain real-life factors may constraint the magnitude of the confidence-accuracy correlation by reducing inter-subject variability. For example,only eyewitnesses who have had a sufficient exposure to a crime

are called to testily in court. Also, in psychological experiments, considerations of experimental control necessarily result in reduced variability between different eyewitnesses. Thus, the conditions that enhance experimental control reduce the likelihood of obtaining a high confidence-accuracy correlation.

Maki and McGuire (this volume) also stressed that the resolution of metacomprehension judgments depends on the discriminability between the items included in the study. They also reviewed other factors that affect metacomprehension accuracy. For example, whereas shallow processing of text generally leads to overconfidence, deeper processing leads to better calibrated predictions and postdictions. This effect bears some similarity to the hard-easy effect documented in the decision-making literature: the overconfidence bias observed when people indicate their confidence in their answers is reduced as the difficulty of the questions decreases (see, for example, Gigerenzer et al., 1991; Juslin, Winman, and Olsson, 2000). In fact, easy items tend to produce a certain degree of underconfidence (e.g. Griffin and Tversky, 1992). Indeed, a similar effect was observed by Maki (1998) for metacomprehension. Consistent with the hard-easy effect, Maki also found overconfidence to be higher among students who did poorly on the test.

Other results reviewed by Maki and McGuire indicate that as far as the resolution of metacomprehension judgments is concerned, it is medium difficulty texts that seem to yield the best resolution. Resolution also benefited from deeper processing as well as from rereading the texts (Rawson, Dunlosky, and Thiede, 2000). This latter effect parallels the observation that practice studying a list of paired associates improves resolution (see Koriat et al., in press).

Individual differences in monitoring accuracy

Is there a general metacognitive ability? Do people differ reliably in monitoring effectiveness and regulation skills, and if so, to what extent are these differences generalized across different domains and tasks? Some of the work in which metacognition is treated as a skill (for example, in developmental studies) actually implies that metacognition is indeed a reliable dimension of individual differences.

This question has been addressed in several different contexts. Maki and McGuire (this volume), for example, examined this question with regard to metacomprehension. The results of several studies indicate that there may exist stable and general individual differences in the over/under confidence bias, but not in discrimination accuracy (resolution). The importance of individual differences in confidence judgments, that is, in

over/underconfidence bias, is brought to the fore by Perfect (this volume). Perfect notes a pattern that has been consistently observed across a number of studies: whereas there was only a weak between-subject correlation between memory performance in a general-information task and in an eyewitness memory task (0.21), the respective correlation between mean confidence judgments in the two tasks was quite high (0.52). These results suggest that the reliable individual differences that have been observed in a number of studies in over/underconfidence bias reflect mostly reliable individual differences in confidence judgments alone. The individual differences in confidence, however, were not totally independent of performance because they yielded a relatively high correlation with performance on the general-information task (0.53).

By and large, the search for stable individual differences in discrimination accuracy (resolution) has been rather disappointing (Weaver and Kelemen, in press; see Maki and McGuire, this volume). It is rather surprising that systematic effects have been observed between different age groups in various aspects of metacognitive performance, but no reliable differences seem to exist within each group. Note, however, that resolution measures of memory accuracy have not yielded systematic age differences either (Schneider and Lockl, this volume).

Improving monitoring accuracy

An important practical challenge for metacognitive research is to find ways to train metacognition and help reduce metacognitive illusions. The need to develop techniques for the training of metacognition has been emphasized by Schneider and Lockl, by Maki and McGuire, and by Dunlosky et al. (this volume). Schneider and Lockl reviewed several attempts to train metacognition in children, most of which involve instructing children to apply specific cognitive strategies for learning and remembering. The results indicate some benefit from training under certain circumstances. Koriat et al. (2001) succeeded in enhancing the accuracy of children's reports by using a payoff schedule that encouraged children to volunteer all and only correct reports about a slide show. This procedure was found to improve children's memory accuracy even when they were tested a year later.

Several attempts have been made to reduce the overconfidence bias that is typically found in confidence judgments. Some of these were based on the assumption that overconfidence derives from a confirmation bias - a tendency to justify the choice that has already been made (Koriat, Lichtenstein, and Fischhoff, 1980).

More work has been carried out on the improvement of JOLs. Research on JOLs has indicated two variables that enhance the JOL-recall correlation markedly. The first is practice studying the same list of items: several studies indicated that resolution increases systematically from one study-test cycle to the next (e.g. King, Zechmeister, and Shaughnessy, 1980; Koriat, 1997; Koriat et al., in press). The second is delaying JOLs until shortly after study (see Dunlosky et al., this volume). As noted earlier, Dunlosky et al. present a convincing case for the argument that the delay-JOL effect derives from the opportunity that it offers for self-testing. It is argued that self-test will help enhance accuracy to the extent that the feedback from it rests on the same processes as those underlying performance in the criterion test.

A recent study (Koriat and Shitzer-Reichert, in press) suggests that the benefit that accrues from practice and delayed JOLs may rest on the same mechanism: when both manipulations were combined, the benefit for JOL resolution was not better than that found for each of them separately.

Monitoring-based self-regulation

As noted earlier, the interest in metacognition derives in part from the assumption that metacognitive judgments affect the strategic regulation of cognitive processes and behavioral responses. Indeed, as Son and Schwartz (this volume) note, there has been increased interest among cognitive students in the investigation of how people apply their metacognitive knowledge to optimize performance.

The interest in metacognitive regulation has been quite prominent among developmental psychologists, who have studied a variety of encoding and retrieval strategies as they develop with age. Research has attempted to specify what children at different ages know about the potential benefits of using these strategies, and the extent to which they make use of them (see Bjorklund and Douglas, 1997). The general conclusion (see Schneider and Lockl, this volume) is that there is a general increase from middle childhood to adolescence in self-regulation skills, and that during the elementary school years effective self-regulation occurs only in highly constrained situations.

An important distinction made by developmental psychologists is between metacognitive beliefs about the value of using a particular strategy, and the ability to actually use that strategy. For example, as discussed in Schneider and Lockl (this volume), both younger and older children can distinguish between easier and harder items in a study list. However,

only the older children allocate more study time to the more difficult items (Dufresne and Kobasigawa, 1989). Thus, differences between younger and older children may sometimes lie not simply in the effectiveness of monitoring but in the ability to put the output of monitoring to use in the self-regulation of cognitive processes.

A seemingly reversed pattern is reported by Moulin (this volume) for patients with Alzheimer's disease: like control participants, they exhibited increased recall performance and reduced self-paced study time with repeated presentations of a list. However, unlike control participants, their JOLs showed no sensitivity to list repetition. Thus, regulation seems to demonstrate some sensitivity to repetition in the absence of a corresponding sensitivity in monitoring.

In comparison to the developmental approach to metacognition, only a restricted set of control processes has been investigated by cognitive psychologists (see Son and Schwartz, this volume). These include the selection of items for study or restudy during learning, and the time allocated to the study of different items in self-paced learning. The general finding is that learners choose the more difficult items for (re-)study unless the study goal is modest (e.g. to master six out of thirty items; Thiede and Dunlosky, 1999), in which case they choose the easier items. With regard to study time, more study time is allocated to the more difficult items, but the reverse is found when the overall amount of time available for study is too short relative to the difficulty of the material (Son and Metcalfe, 2000).

As far as the retrieval phase is concerned, the primary dependent variable has been the amount of time searching for a solicited target before the person gives up (see Son and Schwartz, this volume). People search longer for an elusive memory target when they experience a high FOK or when they are in a TOT state (Gruneberg, Monks, and Sykes, 1977; Nelson, Gerler, and Narens, 1984; Schwartz, 2001). Search time is also affected by the person's goals, for example, speed versus accuracy (Barnes et al., 1999). Reder and her associates (Reder, 1987; Reder and Ritter, 1992) also investigated more refined strategic choices, such as the choice to retrieve versus infer an answer or retrieve versus calculate a solution to an arithmetic problem.

As far as retrospective confidence judgments are concerned, people have been found to bet money on the correctness of their answer when they were confident about it even when their confidence judgments had little validity (Fischhoff, Slovic, and Lichtenstein, 1977). Koriat and Goldsmith (1996b) used a task that attempts to simulate that of a person on a witness stand who is sworn to tell "the whole truth and nothing but the truth" (see Mazzon i and Kirsch, this volume). They found that

people generally enhance the accuracy of their reports by screening out pieces of information that they believe are likely to be wrong (i.e., answers endorsed with low confidence). Thus, under conditions that encourage memory accuracy, participants rely very heavily on their subjective confidence in the answer in deciding whether to volunteer or withhold it, and do so even when their confidence judgments have little validity. Children as young as eight years also rely on their confidence judgments in choosing which answers to report, thereby enhancing the accuracy of their reports in comparison to a situation in which they are forced to answer all questions (see Schneider and Lockl, this volume). Among adults, confidence judgments have also been found to affect the grain size of the memory report (e.g. reporting "the event took place in late afternoon" rather than "around 4:00-4:30 in the afternoon"). In general, people rely on their confidence judgments in choosing a level of generality for which their report is likely to be correct (Goldsmith, Koriat, and Weinberg-Eliezer, 2002). Of course, the degree of confidence that a person attaches to their report affects how much we (as well as judges) trust their report to be reliable (see Perfect, this volume).

Toward the application of metacognitive research

This brief overview illustrates the potential applications of metacognitive research in many different contexts. There have been several successful attempts to apply metacognitive theory and findings to real-life problems, but these attempts only scratch the surface of what is yet to be done. There is much to be accomplished in applying metacognitive theory to educational settings, and in incorporating monitoring and strategy instruction into the curriculum (Schneider and Lockl, this volume). The research on metacomprehension (Maki and McGuire, this volume) as well as that on JOLs (Dunlosky et al., this volume) illustrates some simple techniques by which the accuracy of one's metacognitive judgments can be markedly enhanced. On-the-job training programs have been shown to be susceptible to instilling an illusory sense of competence, and there are ways to avoid that (Bjork, 1999). Clearly, there are many ways in which metacognition research can be applied to optimize learning (Son and Schwartz, this volume). However, as some of the results suggest, effective monitoring skills and accurate metacognitive beliefs do not necessarily translate into effective self-regulation strategies (see Moulin, this volume; Schneider and Lockl, this volume).

Another area in which metacognition research has important implications is forensic psychology. There has been some acknowledgment on the part of the judicial system as well as law enforcement departments

of the critical contribution of psychological theory to the improvement of current practices. An important task for metacognitive researchers is to educate the public about the malleability of memory (Mazzoni and Kirsch, this volume; Carroll and Perfect, this volume) and about ways in which the accuracy of memory reports can be enhanced (e.g. Koriat and Goldsmith, 1996b). The findings regarding the diagnosticity of confidence judgments in eyewitness testimony (Perfect, this volume) have important implications for the court. So have the findings documenting an overconfidence bias. In fact, the increased interest in the reliability and accuracy of memory has generated increased awareness of the metacognitive processes underlying several memory biases, and several proposals have been advanced of how metacognitive strategies can be used to help avoid or correct such biases.

Communication in its various forms is another domain in which metacognitive research can make important contributions. In everyday life not only do we have to monitor our learning and comprehension (Maki and McGuire, this volume), but we also have to monitor those of others. For example, teachers must monitor the comprehension of their pupils. They must assess the relative difficulty of different topics and regulate the amount of time spent teaching each of them. In lecturing or communicating with others, we must have an accurate knowledge about what the other knows or believes, and must assess online their degree of comprehension (Koriat and Bjork, 2001). Such knowledge is especially valuable when one has to take the perspective of the other (Nickerson, 1999; Schneider and Lockl, this volume).

Finally, metacognitive research has important implications in dealing with special populations. The results accumulated so far on metacognition in the elderly suggest that as far as the standard laboratory tasks are concerned, monitoring resolution is generally spared in old age (Hertzog, this volume). However, compared to younger adults, older people have been found to rely more heavily on gist, familiarity, or plausibility than on exact retrieval or recollection. This may result in impaired monitoring and control processes in old age. Studies linking metacognitive skills to frontal functions also suggest that memory deficits observed in some brain-damaged individuals may stem from impaired monitoring and control (see Moulin, this volume). Thus, metacognitive research can help not only in the development of diagnostic tools, but also in devising methods that alleviate some of the memory problems encountered in special populations.

It would seem that the goal of applying metacognitive research to real-word issues would be best served by further development and refinement of theories of metacognition. This goal, in turn, can benefit greatly by

combining insights from the various lines of research and theorizing about metacognition.

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