The Integrated Nature of Metamemory and Memory

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Introduction

Memory has been of interest to scholars and laypeople alike for over 2,000 years. In a rather gruesome example from antiquity, Cicero tells the story of Simonides (557–468 BC), who discovered the method of loci, which is a powerful mental mnemonic for enhancing one's memory. Simonides was at a banquet of a nobleman, Scopas. To honor him, Simonides sang a poem, but to Scopas's chagrin, the poem also honored two young men, Castor and Pollux. Being upset, Scopas told Simonides that he was to receive only half his wage. Simonides was later called from the banquet, and legend has it that the banquet room collapsed, and all those inside were crushed. To help bereaved families identify the victims, Simonides reportedly was able to name everyone according to the place where they sat at the table, which gave him the idea that order brings strength to our memories and that to employ this ability people "should choose localities, then form mental images of things they wanted to store in their memory, and place these in the localities" (Cicero, 2001).

This example highlights an early discovery that has had important applied implications for improving the functioning of memory (see, e.g., Yates, 1997). Memory theory was soon to follow. Aristotle (385–322 BC) claimed that memory arises from three processes: Events are associated (1) through their relative similarity or (2) relative dissimilarity and (3) when they co-occur together in space and time. Although Aristotle did not have sophisticated methodologies to develop or test his theory, these processes are strikingly reminiscent of modern theories of memory based on distinctiveness (e.g., Hunt & Worthen, 2006).

Metamemory versus Memory

Metamemory refers to people's knowledge of, monitoring of, and control of their own learning and memory processes. In the present chapter, we use the term *metamemory* or *metamemorial processes* to refer to any of these components of metamemory. The history of metamemory as a topic of experimental inquiry is very brief, relative to the history of memory research and theorizing. The first empirical work traces to Joseph Hart's research on feeling-of-knowing (FOK) judgments, reported in 1965, and the term metamemory was not even coined until 1970, when John Flavell introduced it.

The short experimental history of metamemory research notwithstanding, metamemory per se was evident as early as Simonides' tale and Aristotle's theory of memory. Using a mnemonic like the method of loci itself is a metacognitive act because individuals are using the mnemonic to control — and in this case, to improve — their memories, and Aristotle's distinction between having passive memories for a past event, versus attempting to recollect the past, has metacognitive implications as well. As Robinson (1989) explained in his treatise on *Aristotle's Psychology*:

> With recollection … the process is initiated by the actor and entails a knowing, striving, *conscious* [italics original] being. It is the active nature of this search that distinguishes recollection from memory, and it is for this reason that Aristotle considers recollection to involve an inferential process. (pp. 71, 73)

For Aristotle, recollection involved an investigation of the mind — or self-observation and reflection — that relied on inferential processes, and although many animals evidently have memories, according to Aristotle, "None, we venture to say, except man, shares in the faculty of recollection" (Robinson, 1989, p. 71). Whether nonhuman animals have metamemories is perhaps one of the most debated topics in the field today and is relevant to the evolution of metamemory (Terrace & Metcalfe, 2005). As argued by Metcalfe (this volume), current evidence suggests that Aristotle was largely correct, although some nonhuman primates and other animals may possess preliminary forms of memory monitoring.

Metamemory and the Cognitive Renaissance

Even before metamemory was considered a subfield of cognition, early and groundbreaking work in cognitive psychology during the cognitive renaissance of the late 1950s and early 1960s included processes that are quintessentially metamemorial. Miller, Galanter, and Pribram (1960), for example, in their classic book, *Plans and the Structure of Behavior*, postulated a test-operate-test-exit (TOTE) unit, which was to supplant behaviorists' stimulus–response reflex arc as the fundamental unit of analysis of controlled behavior (see Figure 1). In brief, while controlling behavior, individuals presumably develop plans to achieve a certain goal and then test their current progress against that goal. If this test reveals a discrepancy between the current state and goal, the individual continues to operate (or work toward) achieving the sought-after goal. If no discrepancy remains, then the individual would terminate that particular goal-oriented behavior. This TOTE mechanism has been foundational to many theories and frameworks of metamemory, which assume that monitoring (analogous to "the tests" in TOTE) is used to control (analogous to "operate") memory in service of a learning goal (for a review, see Son & Kornell, this volume).

As a second example, consider Atkinson and Shiffrin's (1968) landmark article on memory. They proposed that external stimuli, if attended to, are transferred from a sensory store to a short-term memory. At that point, an individual could rely on a number of *control processes* to maintain the information in the short-term store or to transform the information. If one were trying to associate two words in a pair (e.g., dog–spoon), for example, one could elect to repeat the words over and over to

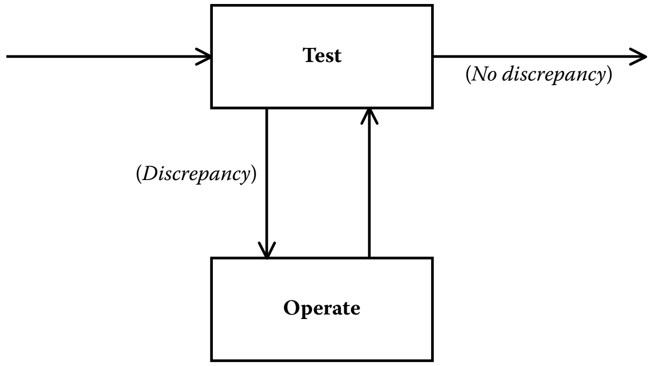

Figure 1 The test-operate-test-exit mechanism. (Adapted from G. A. Miller, E. Galanter, & K. H. Pribram, *Plans and the Structure of Behavior*, Holt, New York, 1960.)

oneself (a form of maintenance rehearsal) or one could develop an image of a dog swimming in a large spoon (a form of elaborative rehearsal). In either case, one is taking an active part in learning by manipulating the contents of one's short-term store. Thus, metamemory processes take center stage even in one of the first modern — and computational — theories of memory. It is important to emphasize, however, that although metamemory processes were implicated in these and other early theories of memory and cognition, most research on memory in the late 1960s and 1970s focused almost exclusively on memory qua memory, such as exploring the structure of the short-term store or the longevity of long-term memories.

The histories of thought and research on both memory and metamemory are quite extensive and go well beyond the scope of this introductory chapter (for further details on these histories, see Bower, 2000; Dunlosky & Metcalfe, in press). In the remainder of this chapter, we first discuss the rise of metamemory research and then argue that in many (if not all) situations, memory and metamemory are inextricably linked, to the point that understanding one may be a necessary, if not sufficient, condition for understanding the other. Our goal is to demonstrate and highlight how current research integrates memory and metamemory theories and phenomena.

Metamemory: Finding Its Identity

Consider the following classic quotation from Tulving and Madigan (1970):

> Why not start looking for ways of experimentally studying and incorporating into theories and models of memory one of the truly unique characteristics of human memory: its knowledge of its own knowledge. … We cannot help but feel that if there is ever going to be a genuine breakthrough in the psychological study of memory … it will, among other things, relate the knowledge stored in the individual's memory to his knowledge of that knowledge. (p. 477)

Why would Tulving and Madigan (1970) have to make this call for metamemory research, especially given the presence of metacognitive processes in early theories of memory? One answer to this question was provided by Nelson and Narens (1994) in their chapter, "Why Investigate Metacognition?" They argued that much of the early research on memory (1) overemphasized the human organism as nonreflective and, accordingly, (2) used methods to describe human memory that would short-circuit reflective control of learning and memory. Nelson and Narens (1994) discussed numerous examples to support these claims, one of which —having to do with Craik and Lockhart's (1972) levels-of-processing framework — seems particularly relevant and instructive. In Craik and Lockhart's framework, stored memory representations are essentially by-products of perception and comprehension. After watching the movie, *The Maltese Falcon*, for example, you may remember much of the plot but little of what the actors were wearing because you specifically attended to and comprehended the former and did not even perceive the latter. Note that the *intent* to remember in this account did not play a causal role in memory. That is, you would later remember the plot not because you had intended to do so but because you perceived and comprehended it.

For the levels-of-processing framework, it is quite evident that reflection about memory is not *directly* relevant to learning per se. Of course, intent to remember may indirectly influence memory because intent may increase the likelihood that we perceive and comprehend an event, yet intent itself is not proximally causal. In fact, to evaluate predictions from this framework (which claims that deeper, or more semantically oriented, levels of processing yield longer-lasting memories), researchers often employ incidental learning procedures to short-circuit any control processes that individuals might naturally use when attempting to learn new information. That is, experimental subjects were often not even informed that they would later be given a test of their memory and instead were given instructions to orient themselves to a particular level of processing.

In the history and development of memory theory, there is no doubt that the levels-of-processing framework has had a profound and important influence (see, e.g., Roediger & Gallo, 2001), and we would never argue that research within this and other traditions like it should not continue. Instead, we use the levels-of-processing example to illustrate that early memory research often deliberately downplayed metamemorial processes. The potential importance of self-reflection and control in learning was ignored; in fact, there was often an effort to minimize, via experimental controls and constraints, people's ability to rely on metamemorial processes. As noted by Nelson and Narens (1994), attempts to short-circuit people's control of learning is quite ironic given that doing so implicitly acknowledges that they will attempt to self-direct their learning to achieve task goals. That is, if people were not self-reflective and self-directed as they studied for an upcoming test, then why attempt to undermine such self-regulation?

The Influence of John Flavell

During the 1970s, other scientists, such as Ann Brown, Joseph Hart, Ellen Markman, and Henry Wellman, joined Tulving and Madigan in recognizing the importance of understanding the nature and influence of self-reflective processes — and people's knowledge about their memory and cognitive processes. Perhaps most influential among such early advocates was John Flavell. In his classic book, *The Developmental Psychology of Jean Piaget*, Flavell (1963) noted that Piaget and his colleagues argued that children's capability of having thoughts about thoughts were perhaps the crowning achievement of cognitive development (for further discussion, see Hacker, 1998). Flavell (1979) also, in a highly provocative *American Psychologist* article, "Metacognition and Cognitive Monitoring: A New Area of Cognitive-Developmental Inquiry," argued persuasively for the importance of understanding the role of metacognition in development, and he defined basic concepts and posed questions that ultimately helped define and promote the field. As but one example, Flavell (1979) asked, "How much good does cognitive monitoring actually do us in various type of cognitive enterprises?" (p. 910). Son and Kornell's review (this volume) of the field on study time allocation illustrates that definitive answers to this question have been elusive, although it appears that, at least under some conditions, memory monitoring can enhance the effectiveness of learning.

The Influence of Nelson and Narens's (1990) Unifying Framework

Certainly, by the late 1980s and early 1990s, metamemory research — and, more broadly, metacognitive research — had obtained an identity in the field. Even so, research on metamemory was often conducted in isolation, not only from research on memory, but also from other research on metamemory. There were pockets of interesting work, with some researchers, for example, focusing on how people judged their learning during study and other researchers focusing on how people judged their retrieval. Thus, metamemory was developing as a discipline in its own right, but metamemory research was itself fragmented.

In 1990, Nelson and Narens offered a framework for metamemory research that unified the field by illustrating how various metamemory judgments and control processes were interrelated. Their framework, which highlighted the temporal order during learning and retrieval of various judgments and control processes, is shown in Figure 2, and definitions of each of these metamemorial components are provided in Table 1. The framework allowed researchers to place their particular programs of research on a given judgment or control process within a larger perspective, and equally important, it stimulated questions — such as "Are specific judgments (e.g., judgment of learning, JOL) used in the control of learning?" and "Are the bases of the various metamemory judgments essentially the same?" — that led to additional research in the field. Basically, Nelson and Narens's framework unified the field by illustrating how research in one area of metamemory may be related to research in other areas.

Nelson and Narens (1990) also offered a straightforward model of metamemory, which itself implied that metamemory and memory were by their very nature integrated. This model contains a metalevel representation and an object-level representation (Figure 3), which loosely corresponds to metamemory and memory, respectively. This model is discussed extensively by Van Overschelde (this volume), who notes that "in this model, information flows hierarchically, with the metalevel acquiring information from (i.e., monitoring) the object level, and the metalevel

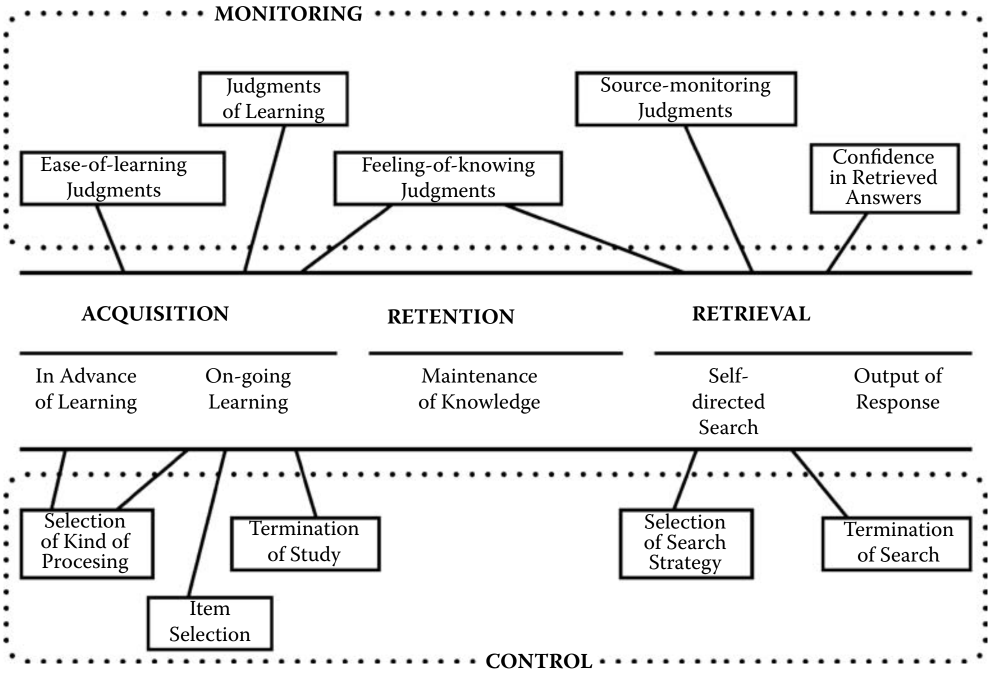

Figure 2 The Nelson and Narens (1990) framework. (Adapted by J. Dunlosky, M. Serra, and J. M. C. Baker, in F. Durso, R. S. Nickerson, S. T. Dumais, S. Lewandowsky, & T. J. Perfect, *Handbook of Applied Cognition,* 2nd ed., Wiley, New York, 2007.)

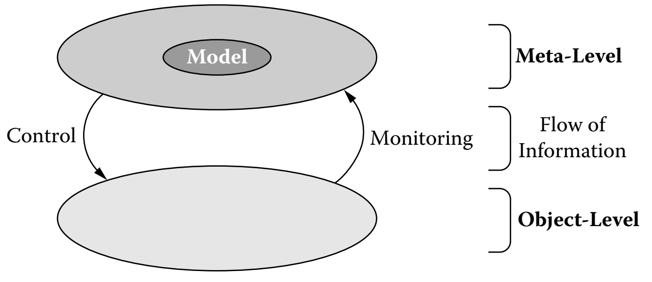

Figure 3 A framework relating metacognition (meta-level) and cognition (object-level) that gives rise to monitoring and control processes. (Adapted from Nelson and Narens, in G. H. Bower, *The Psychology of Learning and Motivation*, vol. 26 (pp. 125–173), Academic Press, New York, 1990.)

sending information to, and thereby changing (i.e., controlling), the object level" (p. 47). Van Overschelde also discusses a component of their model that had largely been neglected in research on metamemory. In particular, he expands on the idea that the metalevel itself contains a dynamic model of the underlying object level — which he calls the *meta-model* — that may play an essential role in people's decisions about how to control their learning and retrieval.

TABLE 1 Definitions of Metamemory Judgments and Control Processes

Term	Definition
	Metamemory Judgments
Ease-of-learning (EOL) judgments	Judgments of how easy to-be-studied items will be to learn
Judgments of learning (JOL)	Judgments of the likelihood of remembering recently studied items on an upcoming test
Feeling-of-knowing (FOK) judgments	Judgments of the likelihood of recognizing currently unrecallable answers on an upcoming test
Source-monitoring judgments	Judgments made during a criterion test pertaining to the source of a particular memory
Confidence in retrieved answers	Judgments of the likelihood that a response on a test is correct; often referred to as retrospective confidence (RC) judgments
	Control Processes
Selection of kind of processing	Selection of strategies to employ when attempting to commit an item to memory
Item selection	Decision about whether to study an item on an upcoming trial
Termination of study	Decision to stop studying an item currently being studied
Selection of search strategy	Selecting a particular strategy to produce a correct response during a test
Termination of search	Decisions to terminate searching for a response

Source: Adapted from J. Dunlosky, M. Serra, and J. M. C. Baker, in F. Durso, R. S. Nickerson, S. T. Dumais, S. Lewandowsky, & T. J. Perfect, *Handbook of Applied Cognition,* 2nd ed., Wiley, New York, 2007.

With respect to our main theme, Nelson and Narens's (1990) model in Figure 3 is notable in highlighting the symbiotic nature of metamemorial and memory processes: Metamemory itself involves monitoring an underlying memory system, but then metamemory processes in turn can act on the memory system. Put differently (and in rather general terms), memory influences metamemory, and metamemory influences memory (cf. Koriat, Ma'ayan, & Nussinson, 2006). Accordingly, they act together to decide the fate of learning, retrieval, and long-term retention.

The Integrated Nature of Metamemory and Memory

Given that self-reflective processes were often neglected in early research on memory, it may not be too surprising why Tulving and Madigan (1970) called for investigation of people's knowledge about their knowledge, or even why Nelson and Narens (1994) felt it necessary to ask (and then answer) the question, Why investigate metacognition? Such calls for research on metacognition are no longer necessary given that interest in metamemory — and more generally, in metacognition — has been growing steadily over the past several decades. Publications abound; specialized edited volumes have been appearing (e.g., Hacker, Dunlosky, & Graesser, 1998; Perfect & Schwartz, 2002;

Terrace & Metcalfe, 2005), and associations, such as the International Association for Metacognition (dept.kent.edu/psychology/iam.org) and the special interest group on Metacognition for the European Association for Research on Learning and Instruction, have been formed to support communication and collaboration among researchers. With such a focus on metamemory and metacognition, our aim here is partly to make sure the pendulum does not swing too far in the other direction, so that future researchers of metamemory will not need to raise the question, Why investigate memory in understanding metamemory?

In this *Handbook of Metamemory and Memory*, the charge to the contributors was to provide an overview of their particular area of research and to discuss recent evidence relevant to current directions for the field. The handbook chapters are biased somewhat toward emphasizing metamemory processes, in part because other excellent and comprehensive volumes have recently been dedicated to learning and memory (e.g., Naveh-Benjamin, Moscovitch, & Roediger, 2001; Tulving & Craik, 2000). In many instances, however, a by-product of this emphasis on cutting-edge research on metamemory has been a demonstration of the many ways that memory processes rely on, and are integrated with, metamemorial processes.

Is Metamemory a Necessary Component of All Memory?

Our basic argument is that attempting to study one construct (metamemory or memory) in isolation will likely fall short of completely understanding either because metamemory and memory are inextricably linked. This particular claim, however, is admittedly too strong because the mutual reliance between the constructs is likely asymmetrical. More specifically, understanding some forms of memory may not require a concurrent understanding of metamemory, whereas most metamemory research will likely benefit from knowledge about memory theory and phenomena. In the following sections, we briefly illustrate these ideas.

Even Aristotle realized that memory itself is present in nonhuman animals that do not have recollective — that is, reflective — capabilities. And although some recent research suggests, at least to some researchers, that even rats have the ability to monitor memory, Metcalfe (this volume) argues that the methods used in this research fall short of providing a convincing demonstration of rats' monitoring abilities. Thus, at least in some nonhuman species, metamemory is evidently not a necessary support for memory.

The first empirical research on human memory, published in 1885 by Hermann Ebbinghaus, relied on a method to investigate memory that allegedly sidestepped conscious awareness and perhaps the recruitment of metamemorial processes. In particular, Ebbinghaus developed nonsense syllables, consonant-vowel-consonant trigrams that do not form a word (e.g., VAL or DAX). He studied a given list of syllables during initial trials, and then, sometime later, he restudied that list. Among Ebbinghaus's multiple contributions to research on human memory was the development of a very sensitive empirical measure of retention, a *savings score*, defined as the percentage of the trials that were required to learn a given list to criteria that were saved on relearning. Thus, if relearning required the same number of trials as did original learning, there were no savings and, hence, complete forgetting of the list. As noted by MacLeod (this volume), Ebbinghaus's method "did not rely on conscious recollection at all: Savings can and does occur even when the subject has no recollection of the targeted item from the originally learned material" (p. 245). Thus, the savings score represents memory qua memory — no metamemory added.

In the decades following Ebbinghaus's pioneering research, the focus of research tended to be on explicit-memory tasks, that is, on tasks in which research participants were explicitly instructed to remember the past. In the 1980s, however, researchers turned their attention to implicit-memory tasks (e.g., Lewandowsky, Dunn, & Kirsner, 1989; Richardson-Klavehn & Bjork, 1988). As in Ebbinghaus realizing savings on relearning a list, even when he was unaware that the list was one he had learned earlier, implicit tests of memory do not require that people are aware that they are remembering a past event or being influenced by a past event. By definition, then, implicit memory is, at least in some cases, memory without metamemory.

Our conclusion may seem trivial to aficionados of memory because the answer to our question, Is metamemory a necessary component of all memory? most certainly is, No. The three related points we discuss next are much less trivial, and each echoes the subtle influences of metamemory on memory.

The first point is that even tests of implicit memory are often contaminated by people's explicit attempts to control their learning or explicitly recollect the past. Consider, for example, the nonsense syllables Ebbinghaus invented in an effort to study memory uncontaminated by earlier learning. Ebbinghaus (1885/1964) generated roughly 2,300 different, supposedly meaningless, syllables (e.g., VAL, MEV), but as Hothersall (1995) explained, Ebbinghaus was fluent in German, English, and French, making it virtually certain that many of his nonsense syllables were meaningful to him semantically. For VAL, for example, one can imagine him interpreting this alleged nonsense syllable as *valise*, the French word for "a small suitcase." In fact, researchers have subsequently generated meaningfulness norms for allegedly nonmeaningful nonsense syllables (e.g., Taylor, 1970). These observations suggest that even Ebbinghaus's savings score may have been tainted by strategic behavior.

The second point returns to more contemporary tests of implicit memory. MacLeod (this volume) explains that almost all tests of implicit memory are susceptible to intrusions of conscious memory. Thus, if we want to use implicit memory tasks to understand memory that is stripped of metamemory, we will need to devise techniques to minimize reflective processes while people perform them (for nine techniques to do so, see MacLeod, this volume). An intriguing observation is that adults usually attempt to be strategic — that is, choose to engage in various metamemorial processes — even during tasks that have been designed to isolate memory from metamemory. Thus, metamemorial processes may not be entirely ubiquitous in the use of our memories, but memory and metamemory processes are closely aligned, and people almost automatically turn to self-reflection, monitoring, and explicit control to achieve memory goals.

The third point is that, implicit memory aside, it is apparent that many forms of learning and retrieval *do* explicitly elicit metamemorial processes. Thus, even though metamemory may not be a necessary component of all memory, metamemorial processes arguably cannot be overlooked in any comprehensive theory of memory or in most specialized theories that focus on particular memory phenomena. As we discuss next, the chapters is this volume serve to emphasize that conclusion.

Contributions of a Metamemory Perspective to the Understanding of Memory Phenomena

Multiple chapters in the current volume showcase this potential contribution of metamemory for understanding phenomena that can be identified, mistakenly, as entirely “memory” phenomena. The following are examples:

Batchelder and Batchelder (this volume) explore source monitoring, which involves remembering the source of a particular memory. One may recall that someone said that “you probably shouldn’t eat grapefruit while taking your cholesterol medication,” but remembering *who* gave you this tidbit of information (your doctor, perhaps, or maybe your mother) is a different type of memory — namely, source memory. Importantly, optimizing source memory can enhance the quality of decision making. If, for example, you incorrectly remember your mother, rather than your doctor, warning you against eating your beloved grapefruit, then you may unwisely decide to have some for breakfast.

People, of course, often have faulty source memories. When they do, according to Batchelder and Batchelder (this volume), “They utilize metacognitive inferences derived from monitoring their own experimentally induced memory processes coupled with extra experimental experiences and beliefs” (p. 211). Their chapter provides an extensive exploration of these metacognitive inferences in source memory and how they can be actualized within multinomial models.

In a similar vein, Malmberg (this volume) demonstrates how metacognitive monitoring influences retrieval processes, which in turn affects performance on an associative memory task (cf. Reder & Schunn, 1996). Imagine studying a paired associate, such as turtle–board, and later being cued with “turtle” and asked to recall the correct response (in this case, “board”). This cued-recall task involves both retrieval processes and a global-matching process. The latter process serves to compute a familiarity response to the probe word (turtle); individuals presumably monitor this familiarity, which then drives the retrieval process itself. According to Malmberg (this volume), memory researchers have given relatively little attention to these familiarity processes in cued-recall tasks, partly because “familiarity alone is insufficient for successfully performing a recall task” (p. 266). He also provides new evidence that people’s monitoring of cue familiarity influences the duration of search during retrieval. Perhaps more intriguing, although such familiarity is used to control retrieval, it appears to be abandoned as a guide when familiarity itself is not attributed to memory strength.

Other examples of how metamemory informs theories of memory are provided by Perfect and Stark (this volume) and Mazzoni (this volume), who explore forms of false memory. Perfect and Stark, in “Tales from the Crypt … omnesia,” provides an impressive review of the extant literature on cryptomnesia, which refers to unconscious plagiarism — that is, inadvertently stating an idea is one’s own idea when in fact it is not. One issue Perfect and Stark raises is whether cryptomnesia that is produced in the laboratory is actually an error in output monitoring. If so, lab-based cryptomnesia may be more indicative of a monitoring deficit than a true underlying memory deficiency, and Perfect and Stark review evidence relevant to this intriguing possibility.

Mazzoni (this volume) explores how people come to believe that an entire event occurred to them when in fact it did not. She describes how people can be made to believe that a seemingly implausible event — for example, witnessing a demonic possession — actually occurred earlier in their lives. A variety of metamemorial processes may be involved in the development of such false memories, such as evaluations of event plausibility and whether memories are available that are believed to be related to that event. Thus, people may come to believe that they had even witnessed demonic possession given that it seems plausible to them and they believe that their childhood memories are relevant to such an unlikely event.

In summary, by considering the possible metamemorial processes that could contribute to memory errors and performance, the chapters by Batchelder and Batchelder, Malmberg, Perfect and Stark, and Mazzoni highlight the contribution of metamemory theory to advances in understanding memory.

Is Memory a Necessary Component of All Metamemory?

As we elaborate later in this chapter, the answer to this question is decidedly No, yet given the nature of metamemory, research in memory has also led to new insights into metamemory. In this section, we describe how both memory theories and memory phenomena have provided foundations for advances in metamemory research.

Joseph Hart's (1965) groundbreaking research on FOK judgments provides an instructive illustration. Hart asked this question: When people say they know an answer that they cannot recall, do they really know the answer? Put differently, do these feelings of knowing have any accuracy? Before Hart, William James eloquently described these tip-of-the tongue experiences in a manner that made them seem real and valid, but Hart asked, *are* they real — that is, do they really reflect the nature of one's underlying memory system? To reveal whether people's FOK judgments were accurate, Hart capitalized on the established memory phenomenon that people can often recognize sought-after targets that they cannot recall:

> To answer the question about the accuracy of FOK experiences it is necessary to find a research paradigm within which the experiences can be produced and their accuracy evaluated. Use was made of one of the best-established facts of verbal learning — recognition exceeds recall. People can almost always recognize more answers than they can produce. (pp. 208–209)

This simple memory phenomenon — that memories can be recognized even when they were not recalled — inspired Hart to develop the now-famous recall-judge-recognize (RJR) method, which is the genesis of many of the methods used today to explore the accuracy of metamemory judgments. In general, the RJR method involves asking people to *r*ecall the answer to questions, such as, "Who sang the hit song, 'Back on the Chain Gang?'" For questions they cannot answer, they then make an FOK *j*udgment by predicting the likelihood that they will *r*ecognize the correct answer. Given that some unrecalled answers would be recognized while others would not, Hart reasoned that participants should be able, if FOK judgments reflect genuine memories, to predict which answers they would and would not be able to correctly recognize on a later test. Using this method, Hart (1965) demonstrated that people's FOK judgments were accurate, which was quite surprising because, How can we know that a memory exists when we don't have access to it? In the present volume, Leonesio offers one answer to this question. To do so, he relies on the distinction, in current memory theorizing, between familiarity with an event and recollection of an event (e.g., Yonelinas, 2002). Based on the accuracy for FOK judgments for dream memories, Leonesio concludes that having recollection for some details of an event is critical to achieving above-chance FOK accuracy. In this case, memory theory and phenomena led to insight into the accuracy of metamemory judgments.

More generally, virtually all theories about the accuracy of metamemory judgments are at least partly inspired by memory theory or phenomena. Notable examples in the field include Reder's use of the source of activation confusion (SAC) model of declarative memory to explore FOK decisions (e.g., Reder & Schunn, 1996); Metcalfe's (1993) use of the composite holographic associative model of memory to understand Korsakoff patients' deficits in FOK accuracy; Dougherty's (2001) use of a multiple-trace memory model to account for the accuracy of retrospective confidence judgments; and Sikström and Jönsson's (2005) application of a stochastic drift model of memory strength to explain the delayed JOL effect.

Memory Versus Metamemory: The Delayed Judgment-of-Learning Controversy

In the present volume, several other chapters also focus on the delayed JOL effect, which sparked controversy about the contribution of memory versus metamemory to the accuracy of JOLs. To comprehend the nature of the controversy, it is necessary to understand how the accuracy of JOLs (which are predictions of the likelihood of correctly remembering a recently studied item on an upcoming test) is estimated. Typically, experimental subjects study paired associates (e.g., turtle–board) and predict the likelihood of correctly recalling the target when later shown the cue (i.e., turtle– ?). The relative accuracy of JOLs is often computed by correlating each individual's JOLs to his or her own later recall performance, with higher correlations indicating better relative accuracy. The most commonly used correlation to estimate judgment accuracy has been the gamma coefficient, mainly because Nelson (1984) argued persuasively that this particular coefficient is the best available. Benjamin and Diaz (this volume) closely scrutinize gamma and other measures of relative accuracy. They provide a detailed argument and supporting analyses that a measure based on the application of signal-detection theory (d_a) can provide superior estimates of relative accuracy. In particular, they conclude that using d_a (or a transform of gamma) may be especially important when one desires to evaluate the differential effectiveness of a manipulation on relative accuracy.

Returning to the delayed JOL effect itself, the timing of the JOLs in relation to initial study matters: When JOLs are prompted by the stimulus of a pair (e.g., turtle– ?) and are made immediately after studying items, relative accuracy is quite poor, in the range of +.30. By contrast, when JOLs are delayed until after all items have been studied (e.g., a delay of a minute or more), relative accuracy is close to perfect (Nelson & Dunlosky, 1991). The first theories for the delayed JOL effect, which are considered in detail by Narens, Nelson, and Scheck (this volume) and by Spellman, Blumenthal, and Bjork (this volume), provide prime examples of how memory theory and phenomena are foundational to understanding metamemory. The monitoring-dual-memories (MDM) hypothesis was inspired by Atkinson and Shiffrin's (1968) model of memory. According to MDM, delayed JOL accuracy is excellent because memory monitoring is based on retrieval of information about a to-be-judged response from long-term memory (which would be predictive of eventual test performance), whereas immediate JOL accuracy suffers because noise about the to-be-judged item from short-term memory disrupts monitoring information stored in long-term memory. By contrast, the self-fulfilling prophecy (SFP) hypothesis was inspired by the memory phenomenon that success on a delayed retrieval test influences subsequent test performance. According to this hypothesis, delayed JOLs are accurate because people attempt to retrieve the correct answer when making the judgment at a delay, and it is this retrieval attempt that ensures high levels of accuracy (Spellman & Bjork, 1992).

Narens et al. (this volume) and Spellman et al. (this volume) offer new tools to evaluate these hypotheses. Narens et al. decompose the relative accuracy of JOLs into subcomponents that reflect the contribution of (1) monitoring processes relevant to the MDM hypothesis and (2) memory processes relevant to the SFP hypothesis. Based on this decomposition, the data modeled in their article were better explained by the SFP than the MDM hypothesis — the latter of which appeared to contribute minimally to relative accuracy under the conditions investigated. Even so, Narens et al. explain that experimental circumstances that yield the delayed JOL effect can be devised that could be explained best by the MDM hypothesis (as in Weaver, Terrell, Krug, & Kelemen, this volume) and others that could be explained best by the SFP hypothesis (as in their data set). Importantly, their analysis also demonstrates that changes in standard measures of relative accuracy (whether it be gamma or d_a) cannot be used to evaluate theories of the delayed JOL effect without further decomposition.

Spellman et al. (this volume) also consider the delayed JOL effect, and like Narens et al. (this volume), they use a new technique to explore the contribution of memory to the effect. In particular, Monte Carlo simulations were used to provide estimates of whether, and how much, changes in memory (due to making delayed JOLs) boost the relative accuracy of those JOLs. They discuss the underlying assumptions of the simulations and describe how the simulation can be used to explore the delayed JOL effect in particular and relative judgment accuracy in general. Their simulation, which supports the SFP hypothesis, is available on the Web and is user friendly. Thus, both Narens et al. and Spellman et al. offer new tools for the field that researchers can readily use to answer questions about the potential influence of memory on metamemory.

In a creative application of a memory phenomenon to explore metamemory, Weaver et al. (this volume) used flashbulb memories to explore explanations for the delayed JOL effect. Not only are they the first to demonstrate the delayed JOL effect involving "flashbulb memories," but their data also cannot readily be explained by the SFP hypothesis. Another intriguing issue raised in this chapter, and also pursued by Maki (this volume), is the degree to which a person has privileged access to his or her own memories. Put differently, when you predict your own performance on a memory task, do you really access your own personal memory, or is your prediction instead based on other factors (e.g., normative item difficulty) that anyone could potentially access? As concluded by Maki, “People do seem to have privileged access after they have answered a question … [People] showed less evidence for privileged access when they made predictions about future performance over text. Rather than accessing information about their own learning from text, participants may have used common intrinsic factors related to the difficulty of the texts” (p. 188). Thus, in both chapters, the evidence suggests that people do demonstrate at least some privileged access when they are evaluating the quality of their memories, but it is equally clear that privileged access is limited.

The Cues That Support Metamemorial Judgments

Such limited privileged access can be readily accommodated by the metamemory framework from Koriat, Nussinson, Bless, and Shaked (this volume), who propose that people’s metamemorial judgments are based on two classes of cues: information-based cues or experienced-based cues. Information-based cues, such as the time spent studying or normative test difficulty, can influence a person’s judgments of memory. Given that other people also have access to these information-based cues, they may be responsible for the fact that one person can accurately judge another person’s learning. By contrast, experienced-based cues “involve a two-stage process (Koriat, 2000), first a process that gives rise to a sheer subjective feeling and second a process that uses that feeling as a basis for memory predictions” (Koriat et al., this volume, p. 118). These experience-based cues apparently reflect privileged access. The take-home message is that metamemory is often closely tied to an individual’s memory, so the two are closely linked, but metamemory judgments can also rely on information-based cues that do not recruit memories about the to-be-judged items. Thus, although memory is a necessary component of some forms of metamemory, certain metamemory judgments are not based on memory per se.

Contemporary Issues

A variety of contemporary issues covered in this volume also illustrate the integrated nature of memory and metamemory. Research on neuroscience explores the neurological substrates of both constructs and how one may function in the service of the other. For instance, Schwartz and Bacon (this volume) discuss pharmacological approaches for exploring the relations between metamemory and memory. Their review highlights how various drugs, such as benzodiazepines, can dissociate metamemory from memory. Their review of neuroimaging, neuropsychology, and pharmacological literatures converges on what has become the received view: Metacognitive monitoring relies on the prefrontal cortex (PFC) (see also Pannu & Kaszniak, 2005).

Shimamura (this volume) explores further the relations among the PFC, metamemory, and memory. According to Shimamura, a major role of metamemorial processes is to control information processing by suppressing, or inhibiting, unwanted information, which in turn improves the efficiency and success of information processing. More specifically, according to his dynamic filtering theory, the "PFC, with its extensive projections to and from many cortical regions, regulates posterior cortical circuits by way of a filtering or gating mechanism. By this view, object-level processors are distributed in posterior cortical regions and are controlled by metalevel processors in PFC regions. The PFC implements metacognitive control by dynamic filtering, that is, by the selection of appropriate signals and suppression of inappropriate signals" (pp. 374–375). Shimamura argues further that the PFC is segregated, and hence it should not be viewed as *the* central executive but more like a board of executives that act to control memory and cognition. Most relevant to our thesis here, both Shimamura (this volume) and Schwartz and Bacon (this volume) conjecture that, although the neural substrates underlying metamemory and memory are distinct, it is the coordinated interaction between these neural substrates that leads to efficient information processing.

The final set of chapters explores the developmental trajectory of metamemory in childhood as well as the relevance of metamemory to learning and student scholarship. These chapters herald the integrated nature of metamemory and memory because they focus directly on questions such as, When do children demonstrate the metamemorial ability to accurately evaluate their memories, and how can students use metamemorial processes to improve their learning of classroom materials? Concerning the first question, Schneider and Lockl (this volume) begin by describing the history of research on metacognition, focusing especially on issues relevant to child development. Their analysis of this history is impressive in that they lucidly illustrate the relationship between a metamemorial approach and a theory-of-mind approach to investigating memory development. After a thorough review of the literature on metamemory and child development, Schneider and Lockl conclude that "although monitoring accuracy tends to improve over the school years, even preschoolers show remarkable monitoring in learning situations they are familiar with. In contrast, the available evidence on the development of self-regulation skills shows that there are clear increases from middle childhood to adolescence" (p. 405).

Given that even preschoolers may have remarkable monitoring abilities, one might conjecture that students of all ages could readily use these abilities to improve their in-class performance. Although some students certainly rely on their monitoring of progress to guide their learning, the chapters by Carroll (this volume) and Hacker, Bol, and Keener (this volume) indicate that many challenges remain. Carroll describes a variety of situations in which even college students' judgments about their learning show poor relative accuracy. For instance, students' judgments do not appear to reflect the major benefits that overlearning can have on retention. Perhaps more important, however, Carroll emphasizes that such faulty judgment appears more prevalent when factors (e.g., overlearning vs. criterion learning) are manipulated between subjects than when manipulated within each subject. In the latter case, when students can experience and compare learning across levels of a factor, they are more likely to accurately judge the relative differences in memory across those factors.

Achieving high levels of relative accuracy is desirable, of course, but students' judgments of their learning often need to also show excellent absolute accuracy.

Unfortunately, Hacker et al. (this volume) document that laboratory-based research has repeatedly shown that students are typically quite overconfident in their learning. Such overconfidence can have detrimental effects on performance because a student who believes he or she has learned all the concepts in a chapter (when he or she really only knows 50%) will stop studying well before they are ready for an exam. Hacker et al.'s review of research conducted in classrooms yields even more sobering news: Poor students are overconfident in how well they have learned course materials, and various interventions involving feedback and practice do not improve their calibration. In such cases, the disconnect between metamemory and memory is serious and will contribute to poor performance, which is unfortunate given mandates to leave no child behind. Certainly, a major research agenda is to develop techniques that help students accurately evaluate their progress so that they can effectively and reliably obtain their learning goals.

Closing Remarks

The integrated nature of metamemory and memory is evident in the histories of both subfields of cognition and is showcased in the chapters in this volume. The main argument in this introductory chapter is that although one may investigate either construct alone, such isolationism runs a dire risk of providing an incomplete understanding of either. The chapters in this volume constitute not only a handbook of research on metamemory and memory, but also a demonstration of the importance of a dualistic, rather than isolationistic, approach to investigating metamemory and memory.

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References

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. Spence & J. Spence (Eds.), *The psychology of learning and motivation* (Vol. 2, pp. 90–197). New York: Academy Press.

Bower, G. (2000). A brief history of memory research. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 3–32). New York: Oxford Press.

Cicero, M. T. (2001). *On the ideal orator (de oratore)* (J. M. May & J. Wisse, Trans.). New York: Oxford University Press.

Craik, F.I.M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, *11*, 671–684.

Dougherty, M. R. P. (2001). Integration of the ecological and error models of overconfidence using a multiple-trace memory model. *Journal of Experimental Psychology: General, 130*, 579–599.

Dunlosky, J., & Metcalfe, J. (2008). *Metacognition: A textbook for cognitive, educational, life-span and applied psychology.* Thousand Oaks, CA: SAGE.

Dunlosky, J., Serra, M. J., & Baker, J. M. C. (2007). Metamemory applied. In F. Durso, R. S. Nickerson, S. T. Dumais, S. Lewandowsky, & T. J. Perfect (Eds.), *Handbook of applied cognition* (2nd ed.).

Ebbinghaus, H. (1964). *Memory: A contribution to experimental psychology*. New York: Dover. (Original work published 1885)

Flavell, J. H. (1963). *The developmental psychology of Jean Piaget*. New York: Van Nostrand.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*, 906–911.

Hacker, D. J. (1998). Definitions and empirical foundations. In D. J. Hacker, J. Dunlosky, & A. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 1–24). Hillsdale, NJ: Erlbaum.

Hacker, D. J., Dunlosky, J., & Graesser, A. (Eds.) (1998). *Metacognition in educational theory and practice*. Hillsdale, NJ: Erlbaum.

Hart, J. T. (1965). Memory and the feeling-of-knowing experience. *Journal of Educational Psychology, 56*, 208–216.

Hothersall, D. (1995). *History of psychology* (3rd ed.). New York: McGraw Hill.

Hunt. R. R., & Worthen, J. B. (Eds.). (2006). Distinctiveness and memory. New York: Oxford University Press.

Koriat, A. (2000). The feeling of knowing: Some metatheoretical implications for consciousness and control. *Consciousness and Cognition*, *9*, 149–171.

Koriat, A., Ma'ayan, H., & Nussinson, R. (2006). The intricate relationships between monitoring and control in metacognition: Lessons for the cause-and-effect relation between subjective experience and behavior. *Journal of Experimental Psychology: General, 135*, 36–69.

Lewandowsky, S., Dunn, J. C., & Kirsner, K. (Eds.). (1989). *Implicit memory: Theoretical issues*. Hillsdale, NJ: LEA.

Metcalfe, J. (1993). Novelty monitoring, metacognition, and control in a composite holographic associative recall model: Implications for Korsakoff amnesia. *Psychological Review, 100,* 3–22.

Miller, G. A., Galanter, E., & Pribram, K. H. (1960). *Plans and the structure of behavior*. New York: Holt.

Naveh-Benjamin, M., Moscovitch, M., & Roediger, H. L., III (Eds.). (2001). *Perspective on human memory and cognitive aging: Essays in honor of Fergus Craik*. New York: Psychology Press.

Nelson, T. O. (1984). A comparison of current measures of the accuracy of feeling-of-knowing predictions. *Psychological Bulletin, 95,* 109–133.

Nelson, T. O., & Dunlosky, J. (1991). When people's judgments of learning (JOLs) are extremely accurate at predicting subsequent recall: The "delayed-JOL effect." *Psychological Science, 2*, 267–270.

Nelson, T. O., & Narens, L. (1990). Metamemory: a theoretical framework and new findings. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 26, pp. 125–173). New York: Academic Press.

Nelson, T. O., & Narens, L. (1994). Why investigate metacognition? In J. Metcalfe, & A. J. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 1–26). Cambridge, MA: MIT Press.

Pannu, J. K., & Kaszniak, A. W. (2005). Metamemory experiments in neurological populations: A review. *Neuropsychological Review*, *15*, 105–130.

Perfect, T. J., & Schwartz, B. L. (Eds.). (2002). *Applied metacognition*. New York: Cambridge University Press.

Reder, L. M., & Schunn, C. D. (1996). Metacognition does not imply awareness: Strategy choice is governed by implicit learning and memory. In L. M. Reder (Ed.), *Implicit memory and metacognition* (pp. 79–122). Hillsdale, NJ: LEA.

Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. *Annual Review of Psychology, 39,* 475–543.

Robinson, D. N. (1989). *Aristotle's psychology.* New York: Columbia University Press.

Roediger, H. L., III, & Gallo, D. (2001). Levels of processing: Some unanswered questions. In M. Naveh-Benjamin, M. Moscovitch, & H. L. Roediger, III (Eds.), *Perspectives on human memory and cognitive aging. Essays in honor of Fergus Craik* (pp. 28–47). New York: Psychology Press.

Sikström, S., & Jönsson, F. (2005). A model for stochastic drift in memory strength to account for judgments of learning. *Psychological Review, 112*, 932–950.

Spellman, B. A., & Bjork, R. A. (1992). When predictions create reality: Judgments of learning may alter what they are intended to assess. *Psychological Science, 3*, 315–316.

Taylor, K. (1970). An information-theory measurement of CVC trigram meaningfulness. *Psychonomic Science, 21*, 101–103.

Terrace, H. S., & Metcalfe, J. (2005). (Eds.) The missing link in cognition: Origins of self-reflective consciousness. *New York: Oxford University Press.*

Tulving, E., & Craik, F. I. M. (2000). *The Oxford handbook of memory.* New York: Oxford Press.

Tulving, E., & Madigan, S. A. (1970). Memory and verbal learning. In P. H. Mussen & M. R. Rosenzweig (Eds.), *Annual review of psychology* (pp. 437–484). Palo Alto, CA: Annual Reviews.

Yates, F. A. (1997). *The art of memory.* London: Pimlico.

Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language, 46*, 441–517.