CHAPTER FOUR

Eyewitness Recall and Testimony

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THE *RASHOMON* DILEMMA: THE COMPLEXITY OF EYEWITNESS RECALL

In Akira Kurosawa's classic film *Rashomon*, four eyewitnesses recount different versions of an event involving a man's murder and the rape of his wife. The four highly discrepant recollections of the same event suggest that not only are many details forgotten, but that much of the information that is "remembered" may be distorted or fabricated, or is at the very least, inherently subjective. The film highlights the intricacies of eyewitness recall and testimony in real-life situations, forcefully conveying the fact that memory does not operate like a video recorder. Identifying the factors and memory processes that may account for such discrepancies between different recollections of the same event poses an important challenge for memory researchers. It also raises difficult questions concerning "truth" and "accuracy."

What causes one person's recollection to differ from another's and from the observed event? Following the classic work of Ebbinghaus (1895/1964), the traditional experimental approach in memory research has focused almost exclusively on memory *quantity*; that is, on the amount of information that is retained or can be reproduced (Koriat & Goldsmith, 1996a, 1996b). This line of research has identified various factors that determine the strength of the memory "trace," thereby affecting the amount of event-related information that is remembered. First, people's original encoding of events may vary as a result of differences in such factors as perceptual conditions (e.g., lighting, vantage point, quality of the physical stimuli), the distinctiveness and importance of the event, the amount of attention allocated, and the degree of elaboration. Second, in terms of storage, different witnesses may suffer differential weakening of memory representations with the passage of time, and differential amounts of interference from newly encoded memories, resulting in varying degrees of forgetting of the original details. Finally, the strength of retrieval cues and the degree of match between their properties and those encoded may also affect the quantity of information that is recollected.

A separate body of research that focuses on memory distortions rather than on mere forgetting has identified many ways in which memory can go wrong (see Koriat, Goldsmith, & Pansky, 2000; Schacter, 1999). This focus, catalyzed in part by the recent wave of naturalistic, "everyday memory" research, has disclosed an unparalleled preoccupation with the *accuracy* of memory—that is, with the extent to which memory can be trusted. For example: To what extent can we trust the memory of a courtroom witness? How authentic is a person's memory of a childhood traumatic event that is "recovered" years later in the course of psychotherapy? These questions are concerned with the accuracy of what one remembers rather than the amount.

Much of the contemporary research on memory accuracy and distortion owes its inspiration to the seminal work of Bartlett (1932), who viewed remembering as a dynamic, goal-directed "effort after meaning." Bartlett's reconstructive approach, gaining impetus from Neisser (1967), holds that what is remembered is not simply a reproduction of the original input but, rather, an active construction or reconstruction based on inference and interpretation processes that are guided by each person's general knowledge and expectations about the world (i.e., schemas; for reviews, see Alba & Hasher, 1983; Brewer & Nakamura, 1984; Roediger, 1996). These processes are applied to that input—first, when the information is initially encoded, and then again when the stored information is later retrieved. For example, when recalling which objects were present in an office that they have briefly visited, people tend to recall objects that are normally found in such an office, including typical objects that were *not* present in that particular office (Brewer & Treyens, 1981). Such schema-based intrusions reflect a confusion between what we expect and what we actually experience. Thus, people's individual perspectives, goals, and motivations have been found to bias their memory reports, even when they believe that they are recollecting what "really" happened (e.g., Bahrick, Hall, & Berger, 1996; Tversky & Marsh, 2000).

Finally, memory performance has been shown to depend not only on the information that people retrieve or reconstruct, but also on "metamemory" processes used in the strategic regulation of memory reporting. In this context, *metamemory* refers to what people know about their own memories and how that knowledge is put to use in regulating what they report. To illustrate, consider a witness in the *Rashomon* film attempting to tell "the whole truth and nothing but the truth" about the target event. To fulfill that goal, witnesses must try to distinguish between correct and incorrect information that comes to mind and report only (and all of) the correct information. However, the metamemory processes of these witnesses may fail in one of two opposite ways. First, they may omit or "forget" event information, not because the information fails to come to mind but because they judge that the retrieved information is in fact "not correct." Worse still, perhaps, they may report incorrect information, falsely judging it to be correct.

Assessing the Quality of an Eyewitness Recollection

How can we determine the quality of a witness's recollection? Without an external criterion against which we can compare the eyewitness accounts, this determination is virtually impossible to make. Indeed, in the case of the *Rashomon* story, we cannot determine which of the different accounts is better because the details of the original event are not known to us (of course, this is true of most real-world eyewitness situations as well). But suppose we had been given access to the initial event: How would we evaluate the quality of one account compared to another?

In attempting to answer this question, we must distinguish between two different properties of memory: its quantity and its accuracy (see Koriat & Goldsmith, 1996a, 1996b). As mentioned before, these two properties have received rather different emphases in contemporary approaches to memory: On the one hand, traditional memory research has been guided by a storehouse conception (Roediger, 1980), evaluating memory primarily in terms of the number of (stored) items that can be recovered. On the other hand, the more recent wave of naturalistic, "everyday memory" research (see Cohen, 1989; Neisser, 1978) has inclined more toward a correspondence conception (Bartlett, 1932; Koriat & Goldsmith, 1996a, 1996b), in which there is a greater concern for the accuracy or faithfulness of memory in representing past events. Here the focus is on the extent to which memory reports can be relied upon to provide accurate information. Indeed, we would not expect an eyewitness in *Rashomon* to remember everything that had taken place. We do, however, want to be able to depend on the correctness of the information that he or she does report.

In the context of the storehouse metaphor, percent recall and percent recognition have been useful as standard all-purpose measures of memory quantity. These measures have been used to investigate a multitude of questions about memory, to derive "forgetting curves," and to examine the general effects of such variables as study time, divided attention, level of processing, and so forth.

It is more difficult to derive all-purpose measures of memory correspondence that would allow a similar study of factors affecting the overall faithfulness of memory (Koriat & Goldsmith, 1996a, 1996b; Koriat et al., 2000). In the context of traditional item-based assessment, overall measures of memory quantity and accuracy can be derived from the input-bound and output-bound proportion correct, respectively. The input-bound quantity measure (e.g., percent recall) traditionally used to tap the amount of studied information that can be recovered, reflects the likelihood that each input item is correctly recalled or recognized. The output-bound accuracy measure (e.g., percent of recalled items that is correct), in contrast, reflects the likelihood that each reported item is, in fact, correct. Hence, it uniquely evaluates the dependability of memory—the extent to which remembered information can be trusted to be correct. Suppose, for example, that the information in a crime scene could be segmented into 20 items. An eyewitness manages to recall 10 of these items and recalls two additional items that were not part of the original scene. This witness's input-bound quantity is 10/20 = 50%, whereas her output-bound accuracy is much higher: 10/12 = 83%. Essentially, whereas the input-bound measure holds the person responsible for what he or she fails to report, the output-bound measure holds the person accountable only for what he or she does report.

Note that when memory is tested through a forced-report procedure, memory quantity and accuracy measures are necessarily equivalent, because the likelihood of remembering each input item (quantity) is equal to the likelihood that each reported item is correct (accuracy). Accuracy and quantity measures can differ substantially, however, under free-report conditions, in which subjects are implicitly or explicitly given the option either to volunteer a piece of information or to abstain. Most everyday situations are of this sort. In the laboratory, the most typical example is the standard free-recall task, in which reporting is essentially controlled by the participant. Because the number of volunteered answers is generally smaller than the number of input items, the output-bound (accuracy) and input-bound (quantity) memory measures can vary substantially.

THE STRATEGIC REGULATION OF MEMORY REPORTING

Koriat and Goldsmith (1994, 1996c; Goldsmith & Koriat, 1999; Goldsmith, Koriat, & Weinberg-Eliezer, 2002) have developed a theoretical framework that specifies the critical role of metacognitive monitoring and control processes in strategically regulating memory performance. Our work is based on the assumption that in recounting past events, people do not simply report everything that comes to mind, but attempt to control their memory reporting in accordance with a variety of personal and situational goals, whether these involve aiding a criminal investigation or impressing their friends. Thus, people make strategic choices about which aspects of the event to relate and which to ignore, what perspective to adopt, what degree of generality or detail to use, and so forth. Such strategic control has been shown to have a substantial impact on the quality of memory reports.

Our framework focuses on two types of control by which rememberers can enhance the accuracy of what they report in real-life situations. The first, *report option*, involves choosing either to volunteer or to withhold particular items of information (i.e., to respond "I don't know" or "I don't remember";

Koriat & Goldsmith, 1994, 1996c; Koriat, Goldsmith, Schneider, & Nakash-Dura, 2001). The second type of control, *control over grain size*, involves choosing the level of detail (precision) or generality (coarseness) at which to report remembered information (Goldsmith & Koriat, 1999; Goldsmith, Koriat, & Pansky, in press; Goldsmith et al., 2002).

Figure 4.1 depicts a rough scheme for conceptualizing and distinguishing various basic components that underlie overt memory (recall) performance. Within this framework, the encoding, representation, and retrieval/reconstruction of information at different grain levels (e.g., gist vs. details) contribute the raw materials from which memory reports are ultimately produced, and the quality of this contribution, of course, substantially constrains the quality of the final product. Nevertheless, both the accuracy and the informativeness of what people report from memory also depend on strategic regulatory processes that operate in the service of personal and situational goals. These processes intervene in converting the retained information into actual memory responses (cf. conversion processes in Tulving, 1983). Thus, between the retrieval (or reconstruction) of information, on the one hand, and overt memory performance, on the other hand, lie metacognitive processes of monitoring and control. The monitoring mechanism subjectively assesses the correctness and informativeness of potential memory responses, whereas the control mechanism determines whether or not to volunteer the best available candi-

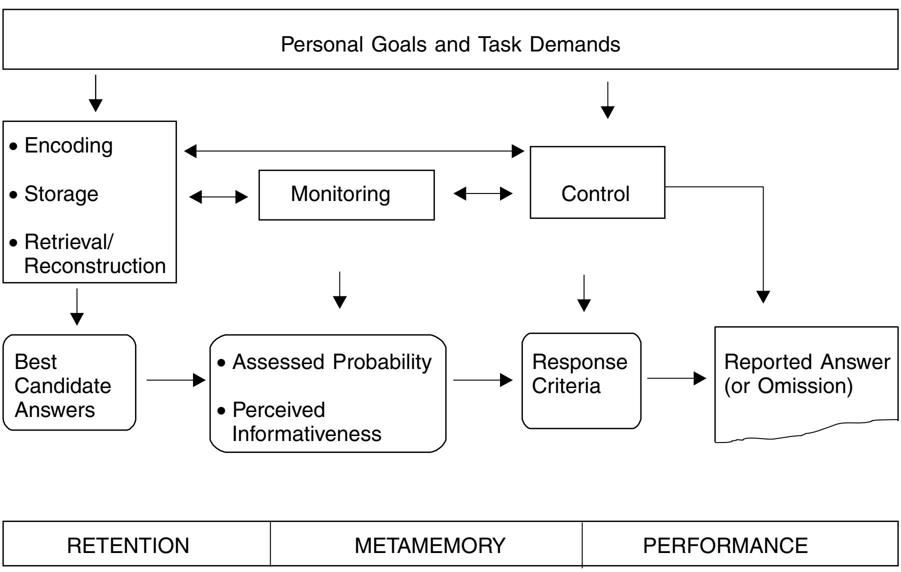

FIGURE 4.1. A scheme for conceptualizing and distinguishing cognitive and metacognitive components underlying recall memory performance, focusing on the strategic regulation of report option and grain size. Adapted from Goldsmith, Koriat, and Weinberg-Eliezer (2002).

date answer. The control mechanism operates by setting a report criterion on the monitoring output: A specific answer will be volunteered only if its assessed probability of being correct passes the criterion. Otherwise, either a more coarsely grained answer will be provided (control of grain size) or the answer will be withheld entirely (control of report option). The report criterion is set on the basis of implicit or explicit payoffs; that is, the gain for providing correct information relative to the cost of providing incorrect information.

The scheme is certainly oversimplified, and there is more overlap, undoubtedly, between the memory, monitoring, and control processes than is apparent in the figure (cf. Norman & Schacter, 1996). Nonetheless, for heuristic and organizational purposes, we separately address the three components of retention, monitoring, and control, noting how each of these is affected by various factors that determine both the quantity and accuracy of the information reported from memory. Our review of the literature is not confined to eyewitness research but also (primarily) includes an examination of theoretically oriented experimental studies, as they pertain to issues of memory quantity and memory accuracy.

THREE COMPONENTS CONTRIBUTING TO MEMORY PERFORMANCE: RETENTION, MONITORING, AND CONTROL

Retention

In terms of the scheme presented in Figure 4.1, most memory research has focused on elements contained in the left-hand box, investigating processes of encoding, storage, and retrieval that are generally considered to concern retention or memory, per se. These studies have employed a wide range of paradigms that vary in the degree to which they pertain to real-life situations. In some cases, the target stimuli are presented in naturalistic settings; more often, they are embedded in a filmed or narrated event; most often, perhaps, they are presented in a list.

A very productive list-learning paradigm that has been used extensively in recent years is the Deese–Roediger–McDermott (DRM) paradigm (see Roediger & McDermott, 1995). In the first phase of this paradigm, participants are presented with to-be-remembered lists of words (e.g., *THREAD*, *PIN*, *EYE*, *SEW*) that are associated with a common, critical theme word (e.g., *NEEDLE*) that is *not* presented. Typically, in the consequent memory test, participants tend to falsely recall and/or recognize the critical lures (theme words) as having been presented in the study list (for a review, see Roediger, McDermott, & Robinson, 1998). Manipulations involving this paradigm have yielded a wealth of findings on both true and false recall, some of which are reported below.

Contributions to Memory Quantity and Accuracy

Memory quantity and accuracy often go hand in hand (e.g., Roediger, Watson, McDermott, & Gallo, 2001). For example, both measures are impaired by divided attention at encoding (e.g., Kelley & Sahakyan, 2003) and by longer retention intervals (Belli, Windschitl, McCarthy, & Winfrey, 1992; Hanawalt & Demarest, 1939; Hirt, McDonald, & Erickson, 1995). In general, the weaker the memory trace, the more memory is prone to reconstructive processes that may lead to distortion (e.g., Hanawalt & Demarest, 1939; for a review, see Brewer & Nakamura, 1984).

On the other hand, there are factors that enhance quantity but impair accuracy at the same time (e.g., Goff & Roediger, 1998; Toglia, Neuschatz, & Goodwin, 1999). For example, using the DRM paradigm, Toglia et al. (1999) demonstrated a "more is less" effect by which deep processing at encoding increased the recall of true items (i.e., quantity) but also increased false recall, resulting in less accurate recall overall. Similarly, the act of imagining both true and false events has been found to increase the tendency to recall these events, thereby increasing quantity but decreasing accuracy (e.g., Goff & Roediger, 1998), and the recall of both true and false childhood events has been found to increase with repeated interviewing (e.g., Hyman & Pentland, 1996). Such findings support the idea that under certain conditions, "ironically, the techniques that are effective in aiding recall are the very ones that can distort memory" (Pennebaker & Memon, 1996, p. 383).

Consequently, in assessing the contribution of various factors to memory performance, it is important to consider separately the effects on memory quantity and on memory accuracy. Unfortunately, the necessary data are not always reported. Because most research does not separate retention from other influences on performance, we too initially treat memory quantity and accuracy performance as reflecting (primarily) retention. In later sections, we discuss how metacognitive monitoring and control processes may add to, or interact with, the level of retention in determining memory performance. Again, mainly for heuristic convenience, our examination of the factors that influence retention is partitioned according to three overlapping and interacting stages: (1) the initial encoding of information, (2) the storage or maintenance of information over time, and (3) the retrieval or reconstruction of the stored information.

Factors Affecting Retention: Encoding Factors

The Perceptual Quality of the Target Event

Not surprisingly, factors that improve the perceptual quality of the target event tend to improve its encoding, consequently improving event recall (for reviews, see Davies, 1993; Deffenbacher, 1991). For example, Shapiro and Penrod's (1986) meta-analysis of eight eyewitness lineup studies indicates that shorter exposure durations result in lower correct face identification rates and higher false identification rates. Thus, both quantity and accuracy measures are affected (see also Read, Lindsay, & Nicholls, 1998). Other studies have shown that eyewitness memory varies as a function of illumination conditions, with better memory quantity occurring in daylight and early evening viewing than in nighttime viewing (Yarmey, 1986). Thus, all else equal, it appears that we should, in fact, tend to trust the account of the eyewitness who had the better view.

Distinctiveness: The Importance or Salience of the Event

Distinctiveness is a complex theoretical concept with many definitions (e.g., Hunt & McDaniel, 1993; Schmidt, 1991). Common to all of these is the general idea that distinctive encoding improves memory performance. In this section, we focus on one form of distinctiveness: the importance or salience of the target event. One of the most extensively studied phenomena in this context is "flashbulb memory," a term used to label vivid and detailed recollection of the circumstances in which people hear about an important, surprising, and emotionally arousing event (e.g., the Columbia space shuttle disaster, the destruction of the "Twin Towers" on September 11, 2001). Initially, it was suggested that flashbulb memories are more accurate and durable than ordinary memories (Brown & Kulik, 1977).

However, despite the relative vividness and elaborateness of flashbulb memories, their accuracy is less than compelling, with many observed inconsistencies between the details reported after long retention intervals and those reported initially (e.g., McCloskey, Wible, & Cohen, 1988; Neisser & Harsch, 1992; Schmolck, Buffalo, & Squire, 2000; Talarico & Rubin, 2003). Some of the variance in the quantity and accuracy of flashbulb memories appears to be due to differences in the personal importance of the target event (e.g., Conway et al., 1994; Rubin & Kozin, 1984). Indeed, several researchers have pointed out that "ordinary" memories are also relatively accurate and long-lasting when they relate to highly distinctive and personally significant events (e.g., McCloskey et al., 1988; Weaver, 1993). Thus, for instance, a soccer fan attending his or her first live match is more likely to recollect the details of a fight that broke out in the stands than a fan who has attended dozens of soccer matches (and perhaps witnessed many such fights).

Amount of Allocated Attention

The role of attention as the key to successful encoding was highlighted in the multistore or modal model of memory (Atkinson & Shiffrin, 1968). Conscious attention to the incoming information was considered a necessary condition for the encoding or transfer of that information into long-term memory. More recent proposals have emphasized the role of attention in facilitating strategic/effortful and deep semantic processing (e.g., Craik, Govoni, Naveh-

Benjamin, & Anderson, 1996; Hasher & Zacks, 1979; Naveh-Benjamin, Craik, Gavrilescu, & Anderson, 2000) and in the binding of various pieces of information or features into one cohesive event (Naveh-Benjamin, 2002).

Whatever the particular mechanisms involved, many studies support the idea that eyewitnesses whose attention is overloaded or distracted during the original event will later remember fewer details from that event and also remember them less accurately. For example, increasing the attentional load in the original scene, by increasing the number of perpetrators simultaneously present, has been found to reduce memory quantity (Clifford & Hollin, 1981), as has dividing attention by having participants perform a simultaneous distraction task (e.g., counting backward by 3; Craik et al., 1996; for a review, see Naveh-Benjamin, 2002). Divided attention at encoding has also been shown to impair memory accuracy (e.g., Kelley & Sahakyan, 2003; Naveh-Benjamin, 1987; Perez-Mata, Read, & Diges, 2002; Seamon et al., 2003). Thus, the evidence suggests that an eyewitness who was fully attending to the target event is likely to remember the event more completely and more accurately than an eyewitness whose attention was distracted or overloaded.

Incidental versus Intentional Encoding

Another attention-related factor that may affect memory performance is whether encoding is incidental or intentional (e.g., Lampinen, Copeland, & Neuschatz, 2001). In a typical memory experiment, subjects intentionally study the target stimuli or event for a subsequent memory test. By contrast, in most real-life memory situations, particularly those of forensic interest, the witnessed events were not intentionally memorized. Rather, they were experienced *incidentally* and later recollected when the need arose. Thus, on the face of it, it would seem that incidental encoding is a more ecologically valid approach for eyewitness research.

Do empirical studies indicate a difference in memory quantity and accuracy for incidental compared with intentional encoding? In an early accuracy-focused study, Herman, Lawless, and Marshall (1957), adapting a paradigm developed by Carmichael, Hogan, and Walter (1932), presented participants with ambiguous figures (e.g., a pair of circles with a small adjoining line) along with one of two alternate labels (*EYEGLASSES*, *DUMBELLS*). Participants who were told that they would be asked to reproduce the figures from memory (i.e., intentional learning) produced more accurate reproductions than those who were not (i.e., incidental learning). The reproduced drawings based on incidental learning were biased more by the semantic labels present at encoding, apparently because the intentional-learning participants paid more attention to the exact details of the figures.

More recent studies have shown that memory quantity performance is also superior following intentional rather than incidental learning (e.g., Lampinen et al., 2001; Migueles & Garcia-Bajos, 1999; Naveh-Benjamin, 2002; Pezdek, Whetstone, Reynolds, Askari, & Dougherty, 1989). Particularly interesting are findings suggesting that the binding of contextual information with item information is partly dependent on intentional encoding. Compared to intentional encoding, incidental encoding was found to yield inferior memory for spatial location (Naveh-Benjamin, 1987) and for the joint (bound) combinations of item and color (Chalfonte & Johnson, 1996). This disadvantage of incidental encoding (and divided attention, e.g., Reinitz, Morrissey, & Demb, 1994, Experiment 2) may be particularly harmful to witness memory because of the role of feature binding in attributing memories to their proper source (i.e., *source monitoring*; see section on monitoring).

Depth of Processing (Elaboration)

Other research, however, has shown that the processes that are applied to the originally presented stimuli are more influential on subsequent recollection than is the intent to learn (Bernstein, Beig, Siegenthaler, & Grady, 2002; Craik & Lockhart, 1972; Hyde & Jenkins, 1973). According to Craik and Lockhart's (1972) landmark levels-of-processing (LOP) approach, memory is a by-product of perceptual and cognitive processes that are applied to the incoming information: The more deeply or meaningfully the incoming information is processed, the better it is retained, regardless of the intention to learn (see Lockhart & Craik, 1990). In Craik and Tulving's (1975) classic study, for example, the proportion of words recognized under incidental learning was higher when the encoding task required semantic processing than when it merely required the processing of either phonemic or orthographic features. This pattern was virtually the same whether learning was intentional or incidental. Although the mechanisms underlying LOP effects are not completely clear, the beneficial effect of deep semantic processing is generally attributed to more *elaborative* encoding, which in turn yields greater distinctiveness or differentiation of the richly elaborated trace from other memory traces, and enhanced connectivity and integration of the target information with other stored information (see Craik, 2002).

Interestingly, whereas elaborative or deep semantic processing generally has a beneficial effect on memory quantity, it may, at the same time, impair memory accuracy. Relative to nonsemantic processing, semantic processing has been found not only to increase true memory for the target items but also false memory for semantically related stimuli that were not part of the target event (e.g., Barclay, Toglia, & Chevalier, 1984; Rhodes & Anastasi, 2000; Thapar & McDermott, 2001; Toglia et al., 1999; but see Read, 1996; Tussing & Greene, 1997). Perhaps, then, an eyewitness will remember more information regarding events that have been processed more deeply, yet be less able to distinguish between the witnessed information, per se, and related information generated or activated in the process of understanding the events. This pattern resembles the one that emerges as a result of constructive processing, discussed next.

Constructive Processes

In general, the effects of prior knowledge, expertise, and interest on recall can be both positive and negative (for reviews, see Alba & Hasher, 1983; Davies, 1993). On the one hand, the assimilation of newly acquired information into preexisting knowledge or schemas increases the likelihood that the information will be recalled later. For example, skilled chess players perform better than novices when reconstructing from memory the locations of chess pieces from a real game, but not when the locations are random (Chase & Simon, 1973; de Groot, 1965). Similarly, baseball experts have been found to recall more details than low-knowledge participants from a narrative depicting baseball scenes (Chiesi, Spilich, & Voss, 1979). Powers, Andriks, and Loftus (1979) found differential patterns of memory performance between males and females for certain event details, consistent with typical gender interests: Whereas overall memory performance was comparable for the two gender groups, males showed superior memory quantity and more resistance to suggestion for typical male-oriented details (e.g., details of the purse snatcher), and females showed superior memory for typical female-oriented details (e.g., the victim's clothing).

On the other hand, however, prior knowledge, schemas, and attitudes may often impair accuracy. For example, Bartlett's (1932) classic study demonstrated how background and social–cultural schemas can distort memory to conform to these schemas. In that study, British college students who recalled the Native American folktale "The War of the Ghosts" tended to distort names, phrases, and events to more familiar Western forms. Explanations were often added in the story recollections, in attempts to make sense of ambiguous or incomprehensible sequences of events in terms of Western schemas. Recently, Tuckey and Brewer (2003) showed that eyewitnesses use schemas to interpret ambiguous scenes. They found less correct recall (i.e., reduced quantity) and more schema-based intrusions (i.e., reduced accuracy) in the recall of a videotaped bank robbery containing ambiguous scenes than for the unambiguous version of the event.

Owens, Bower, and Black (1979) showed that providing participants with information regarding the motivation behind a character's actions biased later recall of the events to be more motive related. Attitudes have also been shown to bias memory. For example, Echabe and Paez-Rovira (1989) showed that memory for technical information about AIDS was distorted to support the rememberers' preexisting views regarding the causes of AIDS (i.e., a conservative-blaming or liberal approach). Following Hastorf and Cantril's (1954) classic experiment, Boon and Davies (1996) showed that football fans' perceptions of a football game (e.g., estimated number of infractions of each team, degree of roughness) were systematically distorted in favor of their preferred teams.

Clearly, many witnessed events in real life involve aspects that evoke prior knowledge, dispositions, and expectancies that can either enhance or impair later recall. The type of effect will generally depend on the strength of the preexisting schemas, the degree of match between these schemas and the target information, and on whether memory accuracy or memory quantity is of primary concern (see Fiske, 1993).

Factors Affecting Retention: Storage Factors

Although the manner in which a target event is encoded strongly influences the quality of subsequent recollection, events occurring after encoding are also critical. In this section, we relate several factors that may operate between the encoding of the target event and its subsequent retrieval, and examine their potential effects on the memory quantity and accuracy of that recollection.

Passage of Time (Retention Interval)

Perhaps no phenomenon is as intrinsic to the notion of memory as the forgetting of information over time. Following Ebbinghaus's (1895/1964) classic work on the forgetting curve, many studies have shown a gradual reduction in memory quantity with increasing retention interval (Schacter, 1999). Initially, forgetting was viewed as a spontaneous decay or weakening of memory traces: These traces were assumed to be strengthened through "usage" (i.e., retrieval) but to fade away with disuse (for a short review on strength theory, see Roediger & Meade, 2000). An alternative to this view was first put forward by McGeoch (1932), who proposed that it is not the passage of time, per se, that impairs memory quantity but rather interference from other material that accumulates during that time. Supporting this idea was Brown's (1923) finding that items that could not be recalled at one point in time could be recalled on subsequent memory tests without additional study. Thus, the memory traces of these items were not lost (i.e., unavailable) but merely inaccessible during particular retrieval attempts. Many experiments have since replicated this phenomenon, often termed *reminiscence* (for a recent review, see Roediger, McDermott, & Goff, 1997). It is experienced, for example, by witnesses who cannot recall certain information when questioned about it, but then spontaneously recall that information after the questioning is over. Similarly, temporary inaccessibility is also evident in the "tip-of-the-tongue" (TOT) phenomenon, in which a person has a strong feeling that he or she knows the answer to a question (e.g., "Who was the lead actor in [a certain] movie?") but is temporarily unable to retrieve it. Often, the sought-for information suddenly pops up at a later time (for a review, see Brown, 1991). Such insights eventually led to a fundamental change in the conception of forgetting, catalyzed by Tulving and Pearlstone's (1966) influential distinction between *availability* and *accessibility*, which holds that much more information is available in memory than is accessible at any moment. In fact, it is now commonly believed that the primary cause of forgetting is loss of access to stored information rather than loss of the information itself (Tulving, 1983).

Although the decrease in memory quantity over time is a very robust finding, interestingly, the findings regarding memory accuracy are quite mixed. Although some studies have observed a decrease in output-bound accuracy that parallels the decrease in memory quantity (e.g., Bahrick, Hall, & Dunlosky, 1993; Koriat et al., 2001), other studies have suggested that output-bound accuracy may be relatively stable across long retention intervals. For example, Ebbesen and Rienick (1998) found that the number of correct statements reported about a past event decreased dramatically over a 4-week period (15 after 1 day; 10.3 after 1 week; 5.5 after 4 weeks). At the same time, however, output-bound accuracy remained relatively stable (.89, .92, and .84, respectively). Similarly, McCauley and Fisher (1995), and Brock, Fisher, and Cutler (1999) found no reduction in output-bound accuracy from an immediate test (within 5 minutes) to a test given 1 or 2 weeks later. Even more impressive is the finding of Poole and White (1993): Accuracy rates for statements about a staged event remained constant over a 2-year period, averaging 95% after 1 week and 93% after 2 years! Such results led Ebbesen and Reinick (1998, p. 757) to note:

> It seems obvious that the key issue in the real world is not how many facts a witness can recall from all those available to recall but the accuracy of the facts that are recalled. . . . Thus, if the legal system is concerned with the accuracy of the information that witnesses supply rather than the amount of information that can be remembered, it seems reasonable to question whether the "generally accepted" expert opinion that the rapid drop and then leveling-off result [assumed to describe the time course of forgetting] is reliable enough to testify about in court.

The ability of rememberers to maintain a constant level of (output-bound) memory accuracy over time, despite a reduction in (input-bound) memory quantity, may be due to the operation of metacognitive monitoring and control processes used to regulate memory accuracy (see sections on monitoring and control, below). If so, however, why is accuracy sometimes stable, but in other cases declines over time? Ongoing work suggests that part of the answer may be found in differences in the control over memory reporting that participants are allowed and the perceived incentives for complete-versus-accurate reporting (Koriat & Goldsmith, 2004).

Hierarchical Storage

Certain types of information appear to be more likely than others to remain accessible over time. In particular, a large amount of work has shown that the general meaning or "gist" of encoded material remains more accessible than does more detailed information, such as the surface form or verbatim form of that material (e.g., Begg & Wickelgren, 1974; Kintsch, Welsch, Schmalhofer, & Zimny, 1990; Posner & Keele, 1970). Much of that research has examined gist-versus-verbatim memory of linguistic-textual information. For example, Kintsch et al. (1990) found differential forgetting rates for three different levels of textual information, with (1) surface information (i.e., verbatim memory) becoming inaccessible within 4 days, (2) memory for the semantic content (i.e., gist) declining at a slower rate, and (3) judgments based on situational memory (i.e., inferences from a relevant knowledge schema) showing highly stable memory quantity over time. Studies of story recall have also reported superior memory quantity over time for higher-level (thematic or superordinate) propositions than lower-level (subordinate) propositions, as well as diminished memory accuracy over time due to a large amount of intrusions (e.g., Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975). Similarly, in testing memory for university course content, Conway, Cohen, and Stanhope (1991) found little forgetting of general principles and concepts over a 12-year retention period, whereas memory of specific details had declined sharply.

A shallower rate of forgetting has also been observed for categorical than for item information. For example, Dorfman and Mandler (1994) presented participants with items from various categories (e.g., *SPARROW*). Item memory declined over a 1-week interval, so that participants failed to discriminate between items (e.g., *SPARROW*) and related distractors (e.g., *CANARY*). However, they were able to discriminate between same-category and different-category distractors, suggesting that category information remained accessible over time, despite the loss of item information. Recently, Pansky and Koriat (2004) have shown an advantage in accessibility over time for an intermediate hierarchical level—the basic level (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). They presented participants with a story containing target items, each of which could appear at one of three hierarchical levels: subordinate (e.g., *SPORTS CAR*), basic level (e.g., *CAR*), or superordinate (e.g., *VEHICLE*). Irrespective of the original level at which an item was presented, the participants tended to falsely recall it at the basic level. In other words, bidirectional shifts from both subordinate and superordinate levels were found, with the retained information converging at the basic level. The basic-level convergence effect was obtained at immediate testing, but it was especially pronounced following a 1-week retention interval, resulting in both reduced memory quantity (i.e., less correct recall) and reduced memory accuracy (i.e., more shifts to the basic level) over time. These results suggest that the basic level, which has been shown to be the cognitively optimal level for perception and categorization (e.g., Rosch et al., 1976), is also the preferred level for retaining episodic information over time.

The differential forgetting rates that occur at various hierarchical levels of information support the view that memory and forgetting are not all-or-nothing processes (e.g., Brainerd, Reyna, Howe, & Kingma, 1990). Rather, concepts and episodes may be represented in memory as bundles of features or attributes that are bound together to different degrees and are accessible or inaccessible with relative independence from one another (e.g., Brainerd et al., 1990; Chalfonte & Johnson, 1996; Lindsay & Johnson, 2000; Reyna & Titcomb, 1997). If so, when some of the features of an item are lost, or when the cohesion between these features weakens, item recall might fail and yet access to some individual features—those supporting recall or recognition at the categorical or gist level—may be preserved (see also Cowan, 1998; Koriat, Levy-Sadot, Edry, & de Marcas, 2003). Thus, particularly after a long time has passed since the witnessed event, it is much more likely that a witness's testimony will correctly reflect the gist or general characteristics of what occurred than the specific verbatim details (for a well-known example, see Neisser's [1981] analysis of John Dean's memory of conversations concerning the Watergate cover-up).

Interpolated Testing/Retelling

As discussed earlier, although the mere passage of time may affect the representation of events in memory, it is clear that more active processes also influence these representations. People frequently reflect upon what they saw or heard, recalling past events either to themselves or to others on different occasions following their occurrence. It has long been realized that the process of retrieving information does not merely test retention but also modifies the memory representation of that information and, consequently, its later retrieval (e.g., Bjork, 1975; Schooler, Foster, & Loftus, 1988). Early research focused mainly on the positive outcomes of retrieval "practice" on the subsequent recollection of the same information or event. Often referred to as the *testing effect*, an enhancement of memory quantity for recalled information following the interpolated testing of that information was demonstrated in word-list experiments (e.g., Allen, Mahler, & Estes, 1969; Carrier & Pashler, 1992; Wheeler, Ewers, & Buonanno, 2003), in eyewitness memory studies (Bornstein, Liebel, & Scarberry, 1998; Dent & Stephenson, 1979; Dunning & Stern, 1992; Eugenio, Buckhout, Kostes, & Ellison, 1982; Scrivner & Safer, 1988), and in autobiographical memory research (Linton, 1975). Some of these studies have shown that the benefit in memory quantity that results from interpolated recall of the target material exceeds that gained from additional study of the target materials (e.g., Carrier & Pashler, 1992; Cull, 2000; Kuo & Hirshman, 1996). In fact, memory testing was suggested as an effective inoculator against forgetting (e.g., Brainerd et al., 1990).

Nonetheless, interpolated reviewing of events can also have negative effects on recollection, some of which derive from the fact that such reviewing is usually selective. For example, Wenger, Thompson, and Bartling (1980) showed that the advantage of repeated testing over repeated study was reversed when the interpolated recall test was selective (i.e., only a few items were recalled). More recent research on a phenomenon known as retrieval-induced forgetting (RIF) has shown opposite effects on memory quantity for those items or pieces of information that were selected for review and those that were not: Whereas memory quantity for the reviewed items is enhanced, memory quantity for related, nonreviewed, items is reduced (see Anderson, Bjork, & Bjork, 1994; Levy & Anderson, 2002). RIF was first demonstrated for exemplars of semantic categories (Anderson et al., 1994), but has since been generalized to a wide range of stimuli and domains, such as visuospatial memory (Ciranni & Shimamura, 1999), action memory (Koutstaal, Schacter, Johnson, & Galluccio, 1999, Experiment 1), and social cognition (e.g., Dunn & Spellman, 2003; Macrae & MacLeod, 1999).

RIF is highly relevant to eyewitness memory. After viewing a typical crime scene, repeated questions relating to a subset of some of its details were found to increase memory quantity for the questioned details but to reduce memory quantity for details that were omitted from the interrogation (MacLeod, 2002; Shaw, Bjork, & Handal, 1995). In real life, witnesses to crimes are repeatedly questioned about the witnessed event by the police, legal representatives, family members, and others. These questions may often be limited to specific aspects of the incident, thus constituting selective retrieval tasks. Based on the RIF literature, those details that were not the subject of initial retrieval practice may be poorly recalled in a subsequent retrieval attempt (e.g., during a trial), resulting in an impairment in memory quantity for what might be critical aspects for a case (see Shaw et al., 1995).

Memory testing may also have negative consequences on memory accuracy. As previously reported, Bartlett (1932) found distortions in participants' recollections of the Native American folktale, "The War of the Ghosts." Testing the same participants repeatedly, following various retention intervals, he found both more forgetting (i.e., lower memory quantity) and more pronounced distortions (i.e., lower memory accuracy) over the repeated reproductions. Bergman and Roediger (1999) replicated these findings and also included a control group that was not tested immediately. Interestingly, delayed recall tests (after 1 week and after 6 months) revealed fewer distortions for the control participants than for those who were tested previously. Thus, immediate testing may preserve not only true memory but also false memory, resulting in enhanced memory quantity but reduced memory accuracy (see Bergman & Roediger, 1999; Brainerd & Reyna, 2002). These findings are consistent with findings obtained in the DRM paradigm, which showed an increase in false recall of the critical lure following prior recall of the list (e.g., McDermott, 1996; Payne, Elie, Blackwell, & Neuschatz, 1996).

Other findings suggest that merely asking subjects about events that never occurred increases the probability that on a later occasion they will remember the event as having occurred (the "mere memory testing effect"; see Brainerd & Mojardin, 1998; Reyna, 1998). Boon and Davies (1988) presented participants with a series of slides depicting a subway, one of which depicted a white man pulling a knife on a black man. When recalling this slide, participants wrote accurate accounts of the scene. However, when the recall test was preceded by a recognition test that presented a racially prejudiced and false alternative (that it was the black man holding the knife), both recognition and subsequent recall were significantly distorted. Thus, merely presenting the false stereotype-consistent version in an interpolated recognition test impaired the accuracy of subsequent recall. Similarly, Fiedler, Walther, Armbruster, Fay, and Naumann (1996) demonstrated that merely considering false propositions increased the tendency to remember them later as true. In fact, even when these propositions were initially (correctly) rejected as false, they nonetheless intruded on subsequent memory reports, particularly following longer retention intervals between questioning and memory testing.

Other studies have shown that particular types of review or reflection are especially likely to impair memory accuracy (see Roediger et al., 1997). For example, Mather and Johnson (2003) found that following a review that focused on feelings and reactions to the target event, subsequent recall and recognition of event details were more prone to schema-based intrusions than following a review of the event details or no review at all. Tversky and Marsh (2000) demonstrated the influence of biased retellings of events on subsequent memory for these events. For example, in Experiment 3 of their study, participants were presented with a story of a murder that suggested two possible suspects. Afterward, participants in the biased retelling condition were asked to write a prosecuting summation accusing one of the suspects. In a subsequent recall test, participants in the biased retelling condition, but not those in a neutral retelling condition, recalled more incriminating items and made more incriminating errors for the suspect they wrote about than for the other suspect. Tversky and Marsh (2000) explain the role of the retelling perspective as a schema that guides the elaboration and reorganization of the event details, resulting in enhanced recall of both true and false information that is consistent with this schema.

To summarize, reflection on events, a frequent human activity, can enhance memory quantity for the reviewed details. At the same time, it may reduce memory quantity for those details that were not reviewed. Worse yet, any biases or schema-based intrusions that taint such a review may become even more pronounced in the subsequent recollection of the event, thus impairing memory accuracy. Although an attempt can be made to minimize selectivity and bias in review that is elicited by official questioning, clearly many opportunities for such review and reflection exist that are beyond the control of the legal system.

Misleading Postevent Information

If nonsuggestive review or reflection on an event can sometimes impair the quantity and accuracy of subsequent recollections, how much more impairment occurs when that review involves misleading suggestions. Classic studies by Elizabeth Loftus in the 1970s demonstrated the powerful effect of (mis)leading questions on memory of the target event (for a review, see Loftus, 1979). For example, Loftus and Palmer (1974) tested subjects' memory of a film depicting a car accident. They found that the question "How fast were the cars going when they *smashed* into each other?" yielded higher speed estimates than a more neutral question that used the verb *hit*. Furthermore, the "smashed" question later led more people to falsely claim that they had seen broken glass, resulting in reduced memory accuracy. Other studies have shown that simply using a definite article when questioning a person about an object that was not part of the original event (e.g., "Did you see *the* broken headlight?") rather than an indefinite article ("Did you see *a* broken headlight?") can bias witnesses into falsely remembering the specified object (e.g., Loftus, 1975; Loftus & Zanni, 1975; see also Fiedler et al., 1996). Apparently, false information presupposed in the formulation of a question is often accepted by the witness as true.

Subsequent work by Loftus and her colleagues highlighted the contaminating effect of less subtle forms of misleading postevent information on eyewitness testimony (e.g., Loftus, Miller, & Burns, 1978; see Gerrie, Garry, & Loftus, Chapter 7, this volume). This research stimulated a great number of subsequent studies that have replicated the basic finding that exposure to misleading information, presented after an event, can distort the memory for that event by what is known as the "misinformation effect."

In a prototypical misinformation experiment, participants who are exposed to an event are later misinformed about some details, then finally tested for their memory of the original details. For example, Loftus et al. (1978) presented participants with a film depicting a car accident and later asked them a series of questions about the events in the slides. Embedded in one of these questions was the misleading presupposition that the car stopped at a *yield* sign, although the film had shown a *stop* sign. In the final stage of the experiment, memory for the information seen in the film was tested using a two-alternative recognition test containing both the original and the misled item. The findings showed that participants who received the misleading question were less likely to report having seen the original stop sign and more likely to report having seen a yield sign than were the participants who received correct information (i.e., stop sign) or neutral information (i.e., intersection). Note that when using this testing procedure, a reduction in memory accuracy as a result of exposure to misinformation necessarily entails a corresponding reduction in memory quantity as well, because falsely selecting the misleading item comes at the expense of not selecting the original item. To better distinguish these effects, in this section we focus on studies that used a recall test or a yes/no recognition test, either of which allows an independent assessment of memory quantity and accuracy.

It is interesting that, in contrast to most of the factors we have reviewed so far, the introduction of misleading postevent information has been found to affect memory accuracy more strongly than memory quantity. Virtually all the studies have shown a decline in memory accuracy, evident in a larger tendency in the misled than in the control condition to falsely remember the misleading item as having appeared in the original event (henceforth, "suggestibility"). However, reduced memory quantity for the original item in the misled condition than in the control condition (henceforth, "memory impairment") has only been obtained under certain circumstances.

First, memory impairment appears to depend on the relative accessibility of the original memory representation. Once memory for the original information exceeds chance levels (see Belli, 1989; Frost, 2000), stronger memory impairment effects are more likely to be found for weaker representations of the original information (see Pezdek & Roe, 1995; Reyna & Titcomb, 1997; Titcomb & Reyna, 1995).

Second, it has been suggested that the postevent information must be believed to be redundant or the same as old information in order for memory impairment to occur (Windschitl, 1996). Consistent with this hypothesis, memory impairment was found on a recall test when the misleading items were more conceptually similar to the original items (i.e., belonged to the same category; e.g., Eakin, Schreiber, & Sergent-Marshall, 2003; Lindsay, 1990) but not when they were less conceptually similar (e.g., Zaragoza, McCloskey, & Jamis, 1987). A recent study (Pansky & Bar, 2004) specifically manipulated conceptual similarity and found memory impairment when the misleading information (e.g., *GOLD RING*) shared the same basic level with the original information (e.g., *SILVER RING*), but not when the misleading item belonged to a different basic level (e.g., *GOLD EARRING*).

There are several possible accounts for the joint reduction in memory accuracy and quantity that results from the introduction of misleading postevent information. Initially, these effects were attributed to a storage-based impairment by which the postevent information replaces or overwrites the stored memory traces for the original information, rendering the original traces unavailable for consequent retrieval (e.g., Loftus, 1979; Loftus & Loftus, 1980). However, subsequent studies have convincingly shown that the effects of misinformation can be temporary (e.g., Chandler, 1989, 1991; Christiaansen & Ochalek, 1983) or reduced by using retrieval manipulations (e.g., Bekerian & Bowers, 1983), suggesting that the postevent information does not impair the stored representation of the original information but rather impairs its accessibility relative to that of the misleading information (see also Eakin et al., 2003). Alternatively, moderate storage-based accounts have proposed a partial degradation hypothesis, according to which misleading suggestions weaken or disintegrate original memories (see Belli, Lindsay, Gales, & McCarthy, 1994; Belli & Loftus, 1996; Belli et al., 1992). A similar compromise between the storage-based and accessibility-based accounts has been suggested in terms of fuzzy-trace theory, in which memory impairment depends on the relative accessibility of verbatim and gist representations of the original information and the verbatim representation of the misleading information (see Brainerd & Reyna, 1998; Reyna & Titcomb, 1997; Titcomb & Reyna, 1995). Nonimpairment accounts of suggestibility (i.e., reduced accuracy) attribute it to (1) response biases or strategic effects that occur when no memory for the original event details exists (McCloskey & Zaragoza, 1985; Zaragoza & Koshmider, 1989), or to (2) an error in source monitoring that wrongly attributes the misled item to the original event (e.g., Johnson, Hashtroudi, & Lindsay, 1993; Lindsay & Johnson, 1989).

Memory Implantation

A more extreme case of misleading postevent information is the suggestion of entire episodes that did not occur, as induced in memory implantation studies (e.g., Hyman, Husband, & Billings, 1995; Loftus & Pickrell, 1995). Inspired by the heated debate over the authenticity of memories of childhood sexual abuse that are recovered in adulthood (often through psychotherapy), such studies are designed to test whether, and under which conditions, people can "remember" entire events that did not occur (see Gerrie et al., Chapter 7, this volume). In a typical experiment, young adults are asked to try to remember childhood events that were allegedly reported by a relative. These include several true events that had actually occurred in the participant's childhood and one false event that had not occurred (e.g., getting lost in a shopping mall). Studies using this procedure have shown that, under certain conditions, people can be induced to confidently and vividly recall entire events that did not occur in reality, and to provide a detailed account of them. Recollection of the false event, resulting in a reduction in memory accuracy, was found to be especially likely to occur following (1) repeated interviews or suggestions (Hyman et al., 1995; Hyman & Pentland, 1996; Wade, Garry, Read, & Lindsay, 2002), (2) instructions to imagine the false event (Hyman & Billings, 1998; Hyman & Pentland, 1996), and (3) when the false event is plausible (Pezdek, Finger, & Hodge, 1997).

On the basis of these findings and consistent with the source-monitoring framework (Johnson et al., 1993), Hyman and associates (Hyman, 1999; Hyman & Loftus, 1998) have suggested three interactive processes that underlie the implantation of false personal memories, each of which may be affected by situational demands. The first process is the acceptance of the plausibility of the suggested event. The second process is the creation of contextual information for the event, such as an image or a narrative, often by tying the false event with self-knowledge and other schematic knowledge that comes to mind. The final process is the commission of a source-monitoring error, in which the person wrongly attributes the created image to a past personal experience.

Factors Affecting Retention: Retrieval Factors

The encoding and storing of information is not sufficient for its subsequent recollection. Perhaps the first to put forward this idea was Semon (1921), who referred to a memory process he called "ecphory" as "the influences which awaken the mnemic trace or engram out of its latent state into one of manifested activity" (p. 12). However, this process, and the factors affecting it, only became the object of empirical study from the mid-1960s (see Roediger & Gallo, 2002; Roediger & Guynn, 1996; Tulving, 1983). Since then, numerous studies have shown that memory performance is highly dependent on the conditions of testing (e.g., Tulving & Pearlstone, 1966; Tulving & Thomson, 1973).

In addition to its theoretical importance, the study of retrieval factors has important practical implications because, compared to encoding factors and many storage factors, retrieval factors are more often under the control of the interviewer (e.g., see Wells, 1978, for a discussion of system, as opposed to estimator, variables). In our analysis of factors affecting retrieval, we separate those that play a role in forced reporting from metacognitive factors that play a role in free reporting (cf. the distinction between *ecphory* and *conversion* processes in Tulving, 1983; see subsequent sections on monitoring and control).

Retrieval Cues

Retrieval cues can be thought of as those aspects of the rememberer's physical and cognitive environment that drive the retrieval process (Tulving, 1983), whether they are explicitly presented as part of the memory query, self-generated, or simply part of the general retrieval context. All else equal, memory tests that provide more, or more effective, cues have generally been found to yield superior memory quantity than tests that provide fewer, or less effective, cues: Cued recall generally yields superior memory quantity than free recall (Lewis, 1971; Tulving & Pearlstone, 1966), and recognition testing generally yields superior memory quantity than cued recall (Brown, 1976). Additionally, providing more recall cues yields superior memory quantity than providing fewer recall cues (e.g., Mäntylä, 1986).

According to the well-known "encoding specificity principle" (Tulving, 1983), the effectiveness of retrieval cues in enhancing memory quantity depends on the degree of match between the features they provide and the encoded features (Thomson & Tulving, 1970; Tulving & Osler, 1968; Tulving & Thomson, 1973). There is a wealth of evidence supporting this principle. For example, Barclay, Bransford, Franks, McCarrell, and Nitsch (1974) presented participants with sentences containing target words (e.g., *PIANO*), in one of two possible contexts (e.g., "The man lifted the piano" or "The man tuned the piano"). On a subsequent recall test, the target word was more likely to be recalled when the recall cue was congruent with the context in which the word was presented initially (e.g., "something heavy" for the first sentence, and "something with a nice sound" for the second sentence) than when it was incongruent. Thus, cues that tap the features that were encoded are more effective cues in terms of memory quantity. Much less is known about the effect of encoding specificity on output-bound memory accuracy. In an adaptation of Thomson and Tulving's (1970) classic study, Higham (2002) found that strong-associate retrieval cues not presented in the study phase were inferior to weak-associate retrieval cues presented during study, both in terms of memory quantity (fewer correct recalls) and in terms of memory accuracy (more commission errors). However, in an adaptation of Tulving and Osler's (1968) study (comparing two sets of weak-associate cues), Rosenbluth-Mor (2001) found that presenting the same weak-associate cue both during retrieval and during study increased memory quantity compared to no retrieval cue, but did not improve memory accuracy. In contrast, presenting a different weak-associate retrieval cue than the one presented in the study phase impaired both memory quantity and memory accuracy compared to the neutral (no-cue) condition. This finding suggests that it is not the match between retrieval and study cues that enhances accuracy but, rather, the mismatch between these cues that impairs accuracy. It also suggests that we should be wary of providing external retrieval cues to witnesses when output-bound accuracy is of primary concern—there may be little to be gained (in terms of accuracy) from providing compatible cues and much to be lost by providing incompatible cues.

It has been proposed that encoding specificity, or trace–cue compatibility, is one (important) instance of a more general factor that promotes memory quantity: "cue distinctiveness" (Mäntylä & Nilsson, 1988; Nairne, 2002). In general, recall improves to the extent that the information that is provided by the cue is diagnostic of the target (for a review, see Schmidt, 1991). According to the "cue overload principle," the probability of recalling an item declines with the number of items associated with its retrieval cue (e.g., Watkins & Watkins, 1975). Thus, for example, an eyewitness may have difficulty accessing the details of a particular doctor's visit due to interference from many other visits with the same doctor. Also consistent with this principle is the "category size effect" (Roediger, 1973), in which the likelihood of remembering any particular category exemplar decreases as the size (number of exemplars) of the category increases. Thus, for example, all else equal, a witness recounting a meeting attended by six men and three women would be more likely to forget one of the men than one of the women. Nondistinctive retrieval cues may also impair memory accuracy, if they access competing alternatives more easily than they access the solicited information (e.g., Kato, 1985; Kelley & Sahakyan, 2003; cf. the potentially harmful effect of encoding–retrieval incompatibility, mentioned earlier).

Context Reinstatement

Effective retrieval cues can sometimes be tied to entire events rather than to particular items. For example, reinstatement of the physical study environment (e.g., the room) can provide effective retrieval cues that enhance memory quantity (Godden & Baddeley, 1975; Smith, Glenberg, & Bjork, 1978). This type of context reinstatement is frequently exploited by police authorities, who attempt to enhance the memory of eyewitnesses by having them return to the crime scene, or if this is not possible, by having the witness mentally imagine the original context (see Powell, Fisher, & Wright, Chapter 2, this volume). Similarly, reexperiencing the same state of mind or mood at retrieval that the person was in at encoding has also been found to enhance memory quantity, in what is known as "state-dependent retrieval" (e.g., Bower, 1981; Eich, 1980; Goodwin, Powell, Bremer, Hoine, & Stern, 1969). For example, participants who were intoxicated during the study session were better able to recall the studied information if they were also intoxicated in the test session than if they were not (Goodwin et al., 1969; for similar affects with marijuana, see Eich, Weingartner, Stillman, & Gillin, 1975).

However, subsequent research has shown that the beneficial effects of physical and mental reinstatement may be limited to situations in which more effective cues are unavailable (see Roediger & Guynn, 1996; Smith, 1988). Thus, physical aspects of the environment can serve as retrieval cues, but their effect is likely to be overshadowed if encoding strategies were rich enough for rememberers to supply their own, more effective retrieval cues (e.g., Eich, 1985; McDaniel, Anderson, Einstein, & O'Halloran, 1989). Similarly, state-dependent memory was found in free-recall tests but not in cued-recall tests (Eich, 1980, 1989), suggesting that the enhancing effect of the reinstatement of mental state is likely to be overshadowed if more powerful retrieval cues are available (e.g., category names).

Reconstructive Processes

In addition to the effects of constructive processes at the time of encoding, reviewed earlier, there is accumulating evidence that people's beliefs, knowledge, perspectives, and expectations at the time of retrieval also influence which information they retrieve from memory and how they interpret that information, affecting both memory quantity and memory accuracy (see Hirt, Lynn, Payne, Krackow, & McCrea, 1999). For example, Anderson and Pichert (1978) have shown that a person's perspective at retrieval (e.g., the perspective of a burglar vs. a potential home buyer) can enhance memory quantity for information that is relevant to that perspective (e.g., a rare coin collection for the burglar; a leaky roof for the home buyer) and an impairment of memory quantity for information that is irrelevant to that perspective (e.g., a leaky roof for the burglar; a rare coin collection for the home buyer). The authors interpreted their findings as suggesting that each retrieval perspective invoked a different schema that provided implicit cues for the recall of different information from the story.

Reconstructive processes operating at retrieval have also been shown to impair memory accuracy. Michael Ross and his colleagues (e.g., Conway & Ross, 1984; Ross, 1989) have shown that people's personal memories are biased by expectancies derived from implicit theories of stability and change. For example, people's belief that their attitudes are stable over time tends to bias recall of their earlier attitudes in the direction of greater consistency with their current attitudes (e.g., McFarland & Ross, 1987; Ross, McFarland, & Fletcher, 1981). On the other hand, people's expectancy that an attribute should change over time can also bias recall: Students led to believe in the effectiveness of a study skills course remembered their initial self-evaluated study skills as being lower and their subsequent test grades as being higher, than did students in a control condition (Conway & Ross, 1984; for similar results in a laboratory study, see Hirt, 1990). Bahrick et al. (1996) have demonstrated what appear to be motivational reconstructive errors. They tested college students for memory of their high school grades. Accuracy of recall declined monotonically with letter grade, ranging between 89% for A's and 29% for D's. The majority of the participants inflated their grades, resulting in an asymmetry of errors. These distortions were attributed to reconstructive inferences that biased recall in a positive, emotionally gratifying direction.

The research reviewed in this section and the earlier section on constructive encoding processes suggests that an eyewitness's knowledge, expectancies, and motivations can shape his or her memory of past events. Information that is consistent with schemas or implicit theories is selectively recalled or erroneously added, whereas inconsistent information is distorted to become more consistent. In fact, (re)constructive memory errors are so ubiquitous that some researchers have espoused a strong reconstructive view, arguing that reconstructive recall is the rule rather than the exception (e.g., Barclay, 1988; Neisser, 1984).

MONITORING

All of the stages of information processing reviewed in the previous sections (i.e., encoding, storage, retrieval) generally involve subjective monitoring (see, e.g., Barnes, Nelson, Dunlosky, Mazzoni, & Narens, 1999). In this section, we focus on processes of monitoring (and control) that operate during memory reporting. As we stated earlier, these processes mediate between retention and actual memory performance. Thus, for example, in order to tell "the whole truth and nothing but the truth," courtroom witnesses must differentiate between correct and incorrect information, volunteering the former but withholding the latter. Their ability to monitor their knowledge and to regulate their memory reporting accordingly will be critical in determining their memory performance. In fact, reporting inaccurate information reflects not only a failure of memory processes, per se, but also a failure of the monitoring process to "realize" that the information that comes to mind is faulty. Conversely, omission of event details from the memory report may result not only from failures in encoding, storing, or retrieving the solicited pieces of information, but, alternatively from a failure of the monitoring process to "realize" that certain accessible pieces of information are, in fact, correct. Hence, it is important to attempt to identify the contributions of memory monitoring to memory performance, as well as the factors that affect the accuracy of that monitoring.

Contributions to Memory Quantity and Accuracy

Many memory failures, which can reduce both quantity and accuracy, seem to stem from source-monitoring errors—that is, failures to attribute the retrieved information to its proper source (Johnson et al., 1993). For example, we may remember having called the doctor to cancel an appointment, but in fact we only thought about doing so. Reality monitoring—the ability to distinguish actual events from imaginings—is a special case of source monitoring. Source-monitoring errors can result in confusion in differentiating details of events that were experienced in one situation from those that pertain to another. A dramatic example is an incident that ironically involved a well-known memory researcher, Donald Thomson, who was wrongly identified by a rape victim as the rapist. Thomson's alibi both exonerated him immediately and helped explain the false accusation: He was giving a live television interview at the time of the rape. Apparently, the victim had been watching the interview just before she was raped, and she confused the memory of his image with that of the rapist. Thus, source-monitoring failures can often be more harmful than retrieval failures: Fragments of real experience are accurately and vividly recalled but mistakenly attributed to the wrong person, location, or time, resulting in false memory.

According to the source-monitoring framework (for a review, see Mitchell & Johnson, 2000), in discriminating the origin of information, participants usually engage a rapid heuristic process that takes advantage of the fact that mental experiences from different sources (e.g., perception vs. imagination) typically differ on various dimensions (e.g., visual clarity and contextual details). Thus, for example, memories of witnessed events tend to include more vivid sensory, temporal, and spatial information than imagined events. However, in some cases, representations of imagined events might be highly detailed and perceptually vivid, whereas representations of perceived events may be poor in perceptual detail, resulting in source confusions. The source-monitoring framework also posits a more strategic, deliberative process that is engaged under special circumstances (e.g., when trying to recall the particular conversation in which an incriminating statement was heard) and involves the retrieval of additional information and the application of conscious reasoning processes.

A number of factors have been found to promote source-monitoring errors that lead to memory distortions (see Mitchell & Johnson, 2000). These include, among others, a high degree of perceptual or semantic similarity between sources (e.g., Lindsay, Johnson, & Kwon, 1991) and the use of less thorough evaluative processes (e.g., Dodson & Johnson, 1993). Source-monitoring errors may explain many false-memory phenomena. For example, suggestibility to misleading postevent information (see earlier section) has often been attributed, in part at least, to deficient source monitoring, by which the postevent misinformation is wrongly attributed to the witnessed event (see Lindsay, 1994; Mitchell & Johnson, 2000). Consistent with this approach, suggestibility was reduced when the two sources (i.e., the witnessed event and the misleading post-event information) were more discriminable (e.g., Lindsay, 1990), and when the test format led rememberers to consider more detailed information (e.g., Lindsay & Johnson, 1989; Zaragoza & Koshmider, 1989; Zaragoza & Lane, 1994).

A more extreme case of faulty reality monitoring has been proposed to underlie memory implantation, which causes a person to remember an entire childhood episode that did not occur but was merely suggested (e.g., Hyman, 1999; Hyman & Loftus, 1998; and see earlier section). Memory implantation is particularly likely to occur if a person is encouraged to engage in mental imagery of the suggested event (Garry, Manning, Loftus, & Sherman, 1996; Hyman & Pentland, 1996), perhaps creating vivid visual images that are later difficult to distinguish from real memories, and are consequently misattributed to reality.

Closely related to the source-monitoring framework is the attributional approach to memory (e.g., Jacoby, Kelley, & Dywan, 1989; for a recent review, see Kelley & Rhodes, 2002). According to this approach, the subjective experience of familiarity does not derive directly from the retrieval of a memory trace but from the unconscious attribution of fluent processing to the past (e.g., Jacoby & Dallas, 1981; Johnston, Dark, & Jacoby, 1985). Fluent processing of a stimulus is enhanced by its previous presentation, and when such fluency is attributed to the past, it gives rise to a veridical memory. However, fluent processing can also be produced by other factors. In that case, an illusion of familiarity may ensue if such fluency is misattributed to the past. For example, Whittlesea (1993) manipulated fluency by priming the target words with predictive or nonpredictive sentences before they appeared in the recognition test. Words primed with predictive sentences were more likely to be falsely recognized than nonprimed words, presumably due to the higher conceptual fluency. Fluency can also be enhanced by perceptual manipulations: Showing a brief preview of a test word immediately prior to presenting the word in full view for a recognition memory test increases the likelihood that new (as well as old) words will be judged "old" (Jacoby & Whitehouse, 1989). The tendency to judge both unpresented and presented items as old is also greater with increased visual clarity (Whittlesea, Jacoby, & Girard, 1990) and auditory clarity (Goldinger, Kleider, & Shelley, 1999) of the test words. Within the context of Whittlesea's (2002, 2004) Selective Construction and Preservation of Experience (SCAPE) framework, remembering is based not only on the actual properties of the stimuli but also on the relationship between these stimuli and the rememberer's expectations. For example, if a novel stimulus violates the person's expectations in a surprising way that is not obvious to him or her (e.g., surprising fluency), a perception of discrepancy may ensue, creating an illusion of familiarity (e.g., Whittlesea & Williams, 2001a, 2001b). However, if the source of the expectation violation is obvious to the person, the same stimulus can elicit a perception of incongruity that can sometimes assist the rememberer in correctly and confidently rejecting this stimulus as not having been presented before (Whittlesea, 2002).

Other heuristics have also been proposed as mechanisms that can be used to screen out false memories. For example, Strack and Bless (1994) showed that if an event is judged to be memorable (salient) but elicits no clear recollection, it can accurately and confidently be rejected as not having occurred via a metacognitive strategy (e.g., "If such a salient event had occurred, I certainly would have some recollection of it"). In their study, false alarms were found for nonsalient distractors (belonging to the same category as the majority of studied items) but not for salient distractors (belonging to different categories than the majority of studied items), and participants were more confident in their responses to salient than to nonsalient distractors.

A similar mechanism by which rememberers may avoid false memories is the distinctiveness heuristic (Dodson & Schacter, 2001, 2002; Schacter, Cendan, Dodson, & Clifford, 2001). This inferential mechanism takes the absence of memory for expected distinctive information as evidence that a target item was not previously experienced. For example, false recognition of semantically related lures was reduced when the studied words were accompanied by pictures (Schacter, Israel, & Racine, 1999) or when they were read aloud by the participants (Dodson & Schacter, 2001), compared to a word-only encoding condition. These findings were attributed to participants' metamemorial belief in the first two conditions: that if a word had, in fact, been presented in the study phase, they ought to remember the distinctive pictorial information (or having said the word aloud). Absence of memory for this distinctive information could be taken to indicate that an item was not previously encountered, thereby facilitating the rejection of nonpresented distractors.

Brainerd, Reyna, Wright, and Mojardin (2003) have suggested another mechanism whereby false events are edited out of memory. Recollection rejection is a mechanism that, either deliberately or not, suppresses the reporting of false but gist consistent information when verbatim traces of the target are available. Thus, even if a semantically related distractor (e.g., *PHOENIX*) seems familiar because its gist (Southwest U.S. city) is consistent with that of a studied item (e.g., *HOUSTON*), it may be rejected if its familiarity can be satisfactorily accounted for by the recollection of the verbatim representation of the target (e.g., "No, it wasn't *PHOENIX*, it was *HOUSTON* I heard").

Of course, common to all of these memory editing–rejection mechanisms is the risk that true events may also be screened out of eyewitness reports, resulting in the omission of information that may be vital (i.e., a reduction in memory quantity; see later section on control).

Factors Affecting Monitoring and Its Accuracy

How do witnesses monitor whether certain information that comes to mind is correct or incorrect? Research indicates that monitoring the correctness of the retrieved information is based on a number of inferential heuristics that are usually (but not always) valid (see Benjamin & Bjork, 1996; Koriat & Levy-Sadot, 1999). In what follows, we examine some of the clues that serve as a basis for metacognitive monitoring of the correctness of a piece of information that comes to mind. We assume that the output of this monitoring process is a subjective assessment of the likelihood that a particular answer is correct—an assessment process that can be tapped by confidence ratings.

Koriat and Levy-Sadot (1999) have proposed a dual-process framework for the analysis of metacognitive monitoring that distinguishes between *metacognitive feelings* that are based on nonanalytic inferences and *metacognitive judgments* that are based on analytic inferences. Analytic–inferential bases entail the conscious, deliberate utilization of specific beliefs and information to form an educated guess about various aspects of one's own knowledge. Nonanalytic bases, in contrast, entail the implicit application of global, general-purpose heuristics to reach a metacognitive judgment. We examine analytic cues and nonanalytic cues in turn.

Memory Content

One prominent analytic cue on which people surely base their confidence is the content of pertinent information retrieved from memory. Surprisingly, however, not much empirical work has been conducted on this topic. In an early study, Koriat, Lichtenstein, and Fischhoff (1980) presented participants with two alternative questions, requiring them to provide reasons for and against each of the alternatives before choosing an answer, and finally to rate their confidence in the chosen answer. Correlational analyses of the data suggested that their confidence depended on the amount and strength of the information retrieved from memory that supported the chosen answer. However, the results also indicated that the subjective assessment of correctness was biased by attempts to justify the decision: Once a decision was made, the evidence was reviewed to assess the likelihood that the answer was correct. This retrospective review tended to be biased by the decision already reached: It tended to focus on evidence that was consistent with that decision and to disregard evidence contradicting it, thereby resulting in overconfidence in the decision.

A similar view appears to underlie the theoretical framework proposed by Gigerenzer, Hoffrage, and Kleinbölting (1991). In this framework, confidence judgments represent the outcome of a well-structured inductive inference. For example, when people consider a question such as "Which city has more inhabitants, Heidelberg or Bonn?" they are completely (100%) confident in their answer only if they can retrieve the number of inhabitants in each city. Otherwise, they must form a probabilistic mental model (PMM) that puts the specific question into a larger context and enables its solution by inductive inference. The PMM contains a reference class ("all cities in Germany"), a target variable ("number of inhabitants"), and several probability cues with their respective cue validities (e.g., the perceived probability that one city has more inhabitants than the other, given that it, but not the other, has a soccer team in the German Bundesliga). People's answers, the researchers propose, are based on the relevant probability cues, and confidence in the answer is based on the respective cue validities.

In contrast to the view of confidence judgments as determined by information-based inferences, other work emphasizes the contribution of mnemonic-experiential cues such as perceptual fluency and retrieval fluency.

Perceptual Fluency

Busey, Tunnicliff, Loftus, and Loftus (2000) presented participants with a series of faces in five different luminance conditions and tested them in either a bright or a dim condition. A face that was studied under low luminance was recognized more poorly, but more confidently, under bright than under dim testing. Fluent perceptual processing of the faces in the bright testing condition may have inflated participants' confidence judgments. As mentioned earlier, perceptual fluency has been repeatedly found to enhance the tendency to "remember" both items that were part of the original event and those that were not (Goldinger et al., 1999; Jacoby & Whitehouse, 1989; Whittlesea et al., 1990). Thus, for example, presenting a suspect in enhanced viewing conditions in a lineup may increase the tendency for a positive identification accompanied by high confidence, whether or not he or she had committed the crime.

Retrieval Fluency

Retrieval fluency usually refers to the ease with which an item, idea, or contextual information comes to mind during an attempt to retrieve it. Nelson and Narens (1990) found that people expressed stronger confidence in the answers that they retrieved more quickly, whether those answers were correct or incorrect. Kelley and Lindsay (1993) demonstrated a similar effect of retrieval fluency on confidence and, ultimately, on memory accuracy. Participants were asked to answer general-information questions and to express their confidence in the correctness of their answers. Prior to this task, participants were asked to read a series of words, some of which were correct answers to the later questions, whereas others were plausible but incorrect answers to the questions. This prior exposure was found to increase the speed and probability with which the (primed) answers were provided in the recall test, and in parallel, to enhance the confidence in the correctness of these answers. Importantly, these effects were observed for both correct and incorrect answers. Postevent questioning, in which participants were asked to think about each of their responses on a memory test, was also found to increase subsequent confidence ratings for these responses, whether they were correct or incorrect (Shaw, 1996). The findings from these studies support the view that retrospective confidence is based on a simple heuristic: Answers that come to mind easily are more likely to be correct than those that take longer to retrieve. This heuristic is generally—but not always—valid.

Retrieval fluency may also underlie the imagination-inflation phenomenon: that is, the finding that the mere act of imagining a past event increases a person's confidence that the event actually happened in the past. Garry et al. (1996) pretested their participants on how confident they were that a number of childhood events had happened, asked them to imagine some of those events, and then gathered new confidence judgments. Imagination instructions inflated confidence that the event had occurred in childhood. Moreover, merely being asked about the event twice (on pretest and posttest) without imagining it led to an increase in subjective confidence, although not as large as the one produced by the act of imagination. A plausible account of these findings is that imagination of an event, and even the mere attempt to recall it, increases its retrieval fluency, which in turn contributes to the confidence that the event has occurred. Hastie, Landsman, and Loftus (1978) also found that repeated questioning about an imagined detail of a story increased confidence in that detail, and Turtle and Yuille (1994, Experiment 1) observed an increase in subjective confidence from one to two recall occasions (but see Ryan & Geiselman, 1991).

The metacognitive illusions outlined above support the view of monitoring as an error-prone heuristic process. Nonetheless, such monitoring illusions seem to be the exception rather than the rule. Although people are generally overconfident of the correctness of their answers (Keren, 1991; Lichtenstein, Fischhoff, & Phillips, 1982; McClelland & Bolger, 1994), by and large, they are successful in monitoring the correctness of their memories. Indeed, within-subject correlations between confidence and accuracy are typically moderate to high (e.g., Bornstein & Zickafoose, 1999; Kelley & Sahakyan, 2003; Koriat & Goldsmith 1996c). Thus, both the witnesses themselves and investigators, judges, and jurors are justified in placing more faith in details the witness is sure about than in details about which he or she is unsure (see also Roberts & Higham, 2002). This level of monitoring effectiveness, however, should be distinguished from the generally weak confidence–accuracy relation observed using between-subjects designs in eyewitness research (see Gruneberg & Sykes, 1993; Perfect, Watson, & Wagstaff, 1993). Based on this latter relation, there may be little or no justification for trusting the account of a confident witness more than the account of a witness with little or no confidence—although, quite naturally, both judges and jurors are prone to do so (e.g., Penrod & Cutler, 1995).

CONTROL

The preceding section presented evidence concerning the contribution of memory monitoring to memory performance—to some extent its quantity, but primarily its accuracy. However, the effect of monitoring on the amount and accuracy of reported information is realized via control: Whereas the monitoring mechanism provides an assessment of the source and ultimately the correctness of the information that comes to mind, it is the control mechanism that determines what to do with that assessment—for example, whether to provide an answer or to respond "I don't know."

Earlier, we used the *Rashomon* example to illustrate the great flexibility that people generally have in controlling their memory reporting, and the potential impact of such control on memory performance. Yet, in general, experimental psychologists have shied away from the systematic study of such control, treating it instead as a mere methodological nuisance (Nelson & Narens, 1994). Thus, in dealing with the "problem," the approach has been either to take control away from the rememberer, for instance, by using forced-report testing techniques (Erdelyi, 1996; Erdelyi & Becker, 1974), or to apply some sort of "correction" technique (Banks, 1970; Budescu & Bar-Hillel, 1993; Erdelyi, 1996).

There has been more intrinsic interest in the control of memory reporting in naturalistic memory research, perhaps because not only is such control ubiquitous in real-life remembering, but also because it clearly has a substantial impact on memory accuracy. For example, it is established wisdom in eyewitness research that witnesses should first be allowed to tell their story in their own words (i.e., in a free-narrative format) before being subjected to more directed questioning, and that even then, greater faith should be placed in the accuracy of the former type of testimony (e.g., Hilgard & Loftus, 1979; Neisser, 1988). This wisdom has been incorporated, for instance, into the Cognitive Interview technique (Fisher & Geiselman, 1992; see Powell, Fisher, & Wright, Chapter 2, this volume), and also into various government documents concerning the proper way to interview witnesses (see Memon & Stevenage, 1996). Nevertheless, the mechanisms and performance consequences of such control are far from clear (Goldsmith & Koriat, 1999; Memon & Higham, 1999).

As mentioned earlier, recall questioning offers rememberers at least two means by which they can enhance the accuracy of what they report. The first, report option, involves choosing either to volunteer or to withhold particular items of information (i.e., to respond "don't know" or "don't remember"). The second, control over grain size, involves choosing the level of detail (precision) or generality (coarseness) at which to report remembered information. Both of these are intrinsic aspects of real-life remembering. Thus, as we have argued previously (Goldsmith & Koriat, 1999; Koriat & Goldsmith, 1996c), rather than constituting a mere methodological nuisance that should be eliminated or corrected for, both report option and control over grain size constitute important topics of study in their own right, with underlying dynamics and performance consequences that deserve systematic investigation, particularly in the domain of eyewitness testimony.

Contributions to Memory Quantity and Memory Accuracy

Control of Report Option

The distinction between memory quantity and memory accuracy is particularly crucial with regard to the performance effects of personal control of memory reporting. This is because these effects are typically characterized by a quantity-accuracy trade-off (Klatzky & Erdelyi, 1985; Koriat & Goldsmith, 1996c): The accuracy of what one reports can be enhanced by the selective screening of one's answers, but this generally comes at the expense of a reduction in the quantity of correct information that is provided.

Koriat and Goldsmith (1994, Experiment 1) conducted a study in which participants answered general-knowledge questions using either a recall or recognition test format. In addition, report option was orthogonally manipulated: Under forced-report instructions, the participants were required to answer every question, whereas under free-report instructions they were allowed to refrain from answering questions about which they were unsure. A payoff schedule provided all subjects with a common performance incentive, essentially rewarding them for each correct answer but penalizing them by an equal amount for each incorrect answer. Performance on all conditions was scored for both input-bound quantity and output-bound accuracy. The results indicated that, for both recall and recognition, participants were able to utilize the option of free report to increase their accuracy substantially compared to forced report, with only a negligible reduction in performance quantity (for similar findings, see Erdelyi, Finks, & Feigin-Pfau, 1989; Roediger & Payne, 1985; Roediger, Srinivas, & Waddill, 1989).

In addition, however, the accuracy of memory reporting was found to be under strategic control: In a high accuracy-incentive condition (Koriat & Goldsmith, 1994, Experiment 3) participants received the same monetary bonus for each correct answer, as in the first experiment, but forfeited all winnings if even a single incorrect answer was volunteered. These subjects achieved substantially better accuracy for both recall and recognition compared to subjects performing under the more moderate (1:1) penalty-to-bonus ratio. In fact, fully one-fourth of the high-incentive subjects succeeded in achieving 100% accuracy. Thus, the participants were able to adjust their memory accuracy in accordance with the operative level of accuracy incentive. Now, however, the improved accuracy was accompanied by a rather large reduction in quantity performance. That is, the participants traded quantity for accuracy in attempting to maximize their bonus in the high-incentive condition (for similar results, see Barnes et al., 1999; Kelley & Sahakyan, 2003; Koriat & Goldsmith, 1996c; Koriat et al., 2001).

In a subsequent study (Koriat & Goldsmith, 1996c), confidence judgments regarding the best answer that came to mind (assessed probability of correctness) were also elicited during a forced-report phase (report option manipulated within participants), shedding light on the monitoring and control mechanisms assumed to mediate the effects of report option and accuracy incentive on memory accuracy and quantity performance (see Figure 4.1, p. 97). First, participants were fairly successful in monitoring the correctness of their answers, and they appeared to base their decision to volunteer or withhold each answer almost entirely on their confidence (within-participant gamma correlations between confidence and volunteering averaged about .95!). Second, the participants' control policies were sensitive to the specific level of accuracy incentive: Participants who were given a high accuracy incentive (10:1 penalty-to-bonus ratio) were more selective in their reporting, adopting a stricter confidence criterion for volunteering an answer than those given a more moderate (1:1) incentive.

Importantly, the rate of the quantity–accuracy trade-off was shown to depend both on accuracy incentive and monitoring effectiveness. First, simulation analyses indicated that, under typical (moderate) levels of monitoring effectiveness, the rate of the trade-off tended to increase as the report criterion was raised, so that simply providing the option of free report should allow relatively large gains in accuracy to be achieved at relatively small quantity costs, compared to forced report, but additional gains in accuracy in response to higher accuracy incentives should involve disproportionately larger quantity costs. This pattern was confirmed by Koriat and Goldsmith's (1996c, Experiment 1) empirical results, and was shown to be consistent with the general pattern observed across several other studies (for a discussion, see Koriat & Goldsmith, 1996c).

The second factor affecting the rate of the trade-off is monitoring effectiveness: As monitoring effectiveness improves, the option of selective reporting allows larger increases in accuracy to be achieved at smaller costs in quantity. At the extreme, when monitoring resolution (i.e., discrimination between correct and incorrect answers) is perfect, the simple option of free report allows 100% accuracy to be achieved without any cost in quantity. On the other hand, when monitoring resolution is poor, selective reporting hardly improves accuracy at all, and the quantity cost of withholding answers is relatively high (see Koriat & Goldsmith, 1996c, Experiment 2, and simulation analyses).

The implications of this research in regard to the quantity and accuracy of eyewitness testimony can be gauged with respect to Figure 4.1 (p. 97). Above and beyond whatever can be done to improve the quality (i.e., quantity and accuracy) of the information that people retrieve (see earlier section on retention), people can further regulate the quality of what they report by the selective screening of candidate answers. Because monitoring one's answers is generally imperfect (see earlier section on monitoring), the enhancement of memory accuracy can be achieved only at the risk of reduced memory quantity. Thus, witnesses must weigh the relative incentives for providing more accurate versus more complete memory reports when deciding upon the most effective control policy for the situation at hand. This trade-off dynamic requires experimenters to take these incentives into account as well as the level of monitoring effectiveness, and to consider both accuracy and quantity in tandem when evaluating free-report memory performance (Klatzky & Erdelyi, 1985; Koriat & Goldsmith, 1996b, 1996c). In practical terms, it also means that investigators and other agents of the law-enforcement and judiciary systems should be able to manipulate witness's control policy—and, ultimately, the quality of their testimony—depending on whether they want to flesh out every possible lead or glean only information that is highly likely to be correct (see Fisher, 1995).

Control over Grain Size

The potential contributions of monitoring and control processes to memory quantity and accuracy are complicated even further when a second means of control is considered: control over the level of precision or "grain" of the information that is reported (e.g., reporting that the assailant's height was "5 feet, 11 inches" "around 6 feet," or "fairly tall"). Neisser (1988), in attempting to make sense of results indicating the superior accuracy of open-ended recall over forced-choice recognition testing, noted that unlike the recognition participants, the recall participants tended to provide answers at "a level of generality at which they were not mistaken" (p. 553). Furthermore Fisher (1996), in assessing participants' freely reported recollections of a filmed robbery, was surprised to find that the accuracy of people's reports after 40 days was no lower than on immediate testing, even though the same number of propositions was volunteered. The anomaly was resolved by considering the grain size of the reported information: Propositions volunteered after 40 days were as likely to be correct as those provided soon after the event (about 90% accuracy in both cases), but this equivalence was achieved by rememberers providing information that was more coarse (as rated by two independent judges) at the later testing than that contained in the earlier reports.

Goldsmith and Koriat (1999) and Goldsmith et al. (2002) proposed that both the mechanisms (monitoring and control) and the performance consequences of the control of grain size in memory reporting are similar to, though perhaps more complex than, those underlying the exercise of report option. Once again, consider a witness who would like to fulfill her vow to "tell the whole truth and nothing but the truth." How should she proceed? On the one hand, a very coarsely grained response (e.g., "between noon and midnight") will always be the wiser choice if accuracy (i.e., the probability of including the true value—telling nothing but the truth) is the sole consideration. However, such a response may not be very informative, falling short of the goal to tell the whole truth. On the other hand, although a very fine-grained answer (e.g., 6:22 P.M.) is much more informative, it is also much more likely to be wrong. Thus, the control over grain size would seem to involve an accuracy–informativeness trade-off similar to the accuracy–quantity trade-off observed with regard to the control of report option; here, too, witnesses will have to aim for a compromise between accuracy and informativeness in choosing a grain size for their answers (see also Yaniv & Foster, 1995, 1997).

Goldsmith et al. (2002) examined this idea in relation to the recall of quantitative semantic information, using a two-phase paradigm similar to the one used for report option (e.g., Koriat & Goldsmith, 1996c). In the first, forced-report phase, participants were presented with a set of 40 questions and required to answer each of them at two different grain levels, as specified by the experimenter. For example, "When did Boris Becker last win the Wimbledon men's tennis finals? (a) Provide a 3-year interval; (b) Provide a 10-year interval." In the second, free-choice phase, the participants were asked to go over their answers, and for each item, to indicate which of the two answers (i.e., which grain size) they would prefer to provide, assuming that they were "an expert witness testifying before a government committee." To shed light on the monitoring and control processes underlying the choice of grain size, in some experiments participants also provided confidence judgments, and accuracy–informativeness incentives were manipulated.

The results indicated that people trade off accuracy and informativeness in reporting information from memory. Participants tended to report coarse-grained answers when a more precise answer was likely to be wrong, thereby enhancing output-bound accuracy. Their choices of when to provide a fine-grained answer and when to report a coarse-grained answer were both systematic (dependent on confidence and incentives) and fairly efficient. Two models of the control process were compared: A "satisficing" model (cf. Simon, 1956), in which people report as finely grained (i.e., precise) an answer as possible, as long as its assessed probability of being correct passes some adjustable criterion, versus an "expected subjective utility" model, in which participants choose the grain size that they believe will maximize the utility of their answer in terms of both accuracy and informativeness. The results strongly supported the "satisficing" model, and this was so even when they were given differential monetary incentives for correct answers at the two grain sizes (Goldsmith et al., 2002, Experiment 3).

A similar pattern was observed in the regulation of memory grain size over time (Goldsmith et al., in press). In this study, Goldsmith et al.'s (2002) two-phase paradigm was adapted for use with episodic information contained in a short story read by the participants. Consistent with previous findings (e.g., Fisher, 1996), there was a tendency to report more coarse-grained answers at longer retention intervals (1 week vs. 1 day vs. immediate testing), and, again, the choice of grain size was sensitive both to participants' level of confidence and to the particular level of accuracy–informativeness incentive. However, control over grain size alone was not sufficient to prevent a reduction in output-bound accuracy over the 1-week interval. Perhaps when participants are allowed the freedom to choose a grain size for their answers *and* to withhold the answer entirely if necessary (as is the case, for instance, in open-ended free-narrative memory reporting), they will utilize this freedom to maintain a stable level of accuracy over time. Work in progress is examining this issue and other aspects of the joint control of grain size and report option in memory reporting.

Factors Affecting Control

Clearly, the most basic factor affecting the control of memory reporting is whether or not the rememberer is allowed to exercise such control. Under conditions of forced reporting, control over whether or not to provide an answer is taken away from the rememberer (e.g., Erdelyi, 1996), though in recall testing there may still be some limited control over grain size, and in recognition testing, the rememberer may have control over the placement of the yes/no (old/new) response criterion (not to be confused with the report criterion being addressed here; for discussions, see Higham, 2002; Koriat & Goldsmith, 1996a, 1996c). Conversely, under conditions of free report, control of grain size can be limited by using a recognition test format, or, in recall testing, by using word-list stimuli or other materials that require single-word answers (e.g., Koriat & Goldsmith, 1994, 1996c).

When control of report option or grain size is given to the rememberer, whether and how he or she will exercise that control is undoubtedly influenced by a constellation of factors, several of which are reviewed here.

Accuracy Motivation, Communication Factors, and Personal–Social Goals

Koriat and Goldsmith's (1994, 1996c) work, described earlier, highlights the importance of accuracy motivation: When people are more highly motivated to be accurate, they tend to employ a more conservative control policy (i.e., a higher report criterion). Conversely, when the quantity of information is stressed (e.g., "uninhibited retrieval" instructions in Bousfield & Rosner, 1970; Fisher, 1999), a more liberal policy is employed. Fisher (1999) explains that the use of uninhibited retrieval instructions in the Cognitive Interview is designed to elicit details edited out by witnesses in their spontaneous reporting, but which may be forensically important. He reports not only an increase in the number of correct propositions elicited with the Cognitive Interview, but also an increase in their average precision (i.e., the grain size of the responses). Interestingly, this improvement is not accompanied by a decrease in output-bound accuracy, suggesting that memory monitoring may be improved as well (perhaps by other components of the interview; see Memon & Higham, 1999). Other "communication" factors that are also utilized in standard interviewing techniques, such as rapport building and transfer of control from the interviewer to the witness (Memon & Stevenage, 1996), may also exert their effect via changes in report criteria.

Opposing concerns have generally been expressed with regard to the questioning of child witnesses; here increasing the output-bound accuracy of children's testimony has been emphasized (see Koriat et al., 2001). Findings from several studies suggest that children are particularly reluctant to say "I don't know" in response to memory questions (e.g., Cassel, Roebers, & Bjorklund, 1996; Mulder & Vrij, 1996; Roebers & Fernandez, 2002). Thus, children may be less able or less willing than adults to control their memory reporting on the basis of their subjective monitoring. One approach to correcting this problem is to explicitly instruct children in the "rules" of memory reporting. Mulder and Vrij (1996), for example, found that explicitly instructing children, ages 4–10, that "I don't know" is an acceptable answer significantly reduced the number of incorrect responses to misleading questions (i.e., questions about events that had not, in fact, occurred). Moston (1987) also found that such instructions induced children, ages 6–10, to make more "I don't know" responses, but in that study this instruction had no effect on the overall proportion of correct responses. On the other hand, Cassel et al. (1996) found that children (kindergartners, second graders, and fourth graders) exhibit a developmental trend and a greater tendency than adults to provide wrong answers to leading questions, even when they are reminded that they have the option to say "I don't know" (see also Roebers & Fernandez, 2002). Similarly, Koriat et al. (2001) found that although even 6- to 7-year-old children were able to utilize the option of free report to boost the accuracy of their reporting (increasing accuracy even further under a strong accuracy incentive), they were nevertheless less accurate in their reporting than 8- to 9-year-olds. This developmental trend could be due to monitoring effectiveness, report criterion, or both, and was found despite the use of explicit accuracy incentives.

Of course, in most cases the incentives for accuracy or quantity/informativeness are not explicit; rather, they are implicit in the personal–social context of remembering (Pasupathi, 2001). For example, picking up on social cues, people convey more detailed information to attentive than to inattentive listeners (Pasupathi, Stallworth, & Murdoch, 1998), and, in line with Grice's (1975) maxim of quantity, adjust the detail of their reporting to the perceived needs of the listener (Vandierendonck & Van Damme, 1988). Even young children have been shown to provide more details about experiences that were shared with the listener than about unshared experiences (Reese & Brown, 2000). Differential editing of memory reporting may be both quantitative and qualitative. For example, Hyman (1994) found that recalling a story to a peer yielded more opinions, evaluations, and world knowledge than did recalling it to an experimenter, which elicited a greater focus on story details and narrative structure. In many contexts, the goals of accuracy and completeness are subservient to other goals, such as goals to amuse, entertain, convince, and impress (e.g., Neisser, 1988; Sedikides, 1990; Tversky & Marsh, 2000; Wade & Clark, 1993; Winograd, 1994). Such insights have begun to be taken into account in the questioning of witnesses as well (Fisher, 1995, 1999).

Test Format

Test format refers to whether the rememberer produces his or her own answers (production or recall format) or must choose a response from a limited set provided by the questioner (selection or recognition format). This variable is also implicated in the belief that directed questioning or recognition testing can have contaminating effects on memory (e.g., Brown, Deffenbacher, & Sturgill, 1977; Gorenstein & Ellsworth, 1980; Lipton, 1977). Test format is also implicated in the "established wisdom" mentioned earlier, that witnesses should first be allowed to tell their story in their own words (i.e., in a free-narrative format) before being subjected to directed or recognition questioning, because of the harmful effects of the latter formats on memory accuracy (e.g., Hilgard & Loftus, 1979; Neisser, 1988). However, it is not clear to what extent the harmful effects of selection-format testing are mediated by memory contamination (e.g., due to misinformation contained in the question) or are due instead to a lowering of the report criterion. Both aspects are often implied in discussions in the literature (e.g., Hilgard & Loftus, 1979; Lipton, 1977).

Answering this question is made difficult by the general confounding of test format and report option that occurs in memory testing: In free-narrative and recall testing, people both produce their own answers (production format) and report only what they feel they actually remember (free report), whereas in directed questioning and recognition testing, people are not only confined to choosing between the alternatives presented by the interrogator (selection format), but are generally exposed to either implicit or explicit demands to answer each and every question (forced report). Conceivably, then, either variable could be responsible for the general superiority of production over selection testing in terms of memory accuracy (or, in fact, for the reverse pattern with regard to memory quantity; see Brown, 1976).

Koriat and Goldsmith (1994) called this confounded pattern the recall–recognition paradox. In order to unravel this paradox and separate the contributing effects of report option and test format, they conducted several experiments (described earlier) in which report option (free vs. forced), test format (recall vs. recognition) and memory property (accuracy vs. quantity) were orthogonally manipulated. That is, in addition to the standard tests of free recall and forced-choice recognition (five alternatives), two relatively uncommon procedures were added: forced recall (requiring subjects to respond to all questions) and free recognition (permitting subjects to skip items). The important result in this context is that report option, not test format, was found to be the critical variable affecting memory accuracy. In fact, under free-report conditions, test format had no effect at all on memory accuracy: Given equal opportunity to screen out wrong answers, the recall and recognition participants achieved virtually identical accuracy scores. Although these results were obtained using general-knowledge questions (see also Koriat & Goldsmith, 1996c), the same pattern was observed using a standard list-learning paradigm (Koriat & Goldsmith, 1994, Experiment 2) and using more naturalistic episodic stimuli (Koriat et al., 2001).

Based on their results, Koriat and Goldsmith (1994, 1996c) concluded that free selection may be a generally superior testing procedure to free production, because it elicits better quantity performance with no reduction in accuracy. This outcome, however, assumes that the option to withhold answers is emphasized by the questioner and clearly understood by the rememberer (see earlier discussion of communication factors). In many cases, there may be implicit pressures to respond to directed or recognition queries that cause witnesses to lower their report criterion, even though ostensibly they are given the option to respond "I don't know."

State of Mind

The witness's "state of mind" at the time of reporting may also affect the control of memory reporting. An interesting case is hypnosis, which is often used as a mnemonic enhancement technique (Pettinatti, 1988). Although memory testing under hypnosis has generally been shown to yield more correct recalls than without hypnosis, it yields more incorrect recalls as well (Dywan & Bowers, 1983), consistent with the idea that the effects of hypnosis are mediated by a lowering of the report criterion (Klatzky & Erdelyi, 1985). Indeed, when response selectivity is controlled by using a forced-recall procedure, the advantage of hypnosis compared to nonhypnotic retrieval is eliminated (Dinges et al., 1992; Whitehouse, Dinges, Orne, & Orne, 1988). It is not clear, however, whether the effect of hypnosis is simply a matter of inflating confidence in one's answers (Krass, Kinoshita, & McConkey, 1989), a lowering of the report criterion, or both. Interestingly, intoxication by alcohol does *not* appear to affect the control of memory reporting. Nelson et al. (1998; see also Nelson, McSpadden, Fromme, & Marlatt, 1986) found that although alcohol consumption impaired memory for lists of paired associates, compared to sober controls, confidence levels were reduced correspondingly, and there was no difference between the groups in the proportion of commission errors conditioned on recall failure (an indirect measure of output-bound accuracy). By contrast, other drugs such as marijuana (Darley, Tinklenberg, Roth, Vernon, & Kopelt, 1977) and lithium (Weingartner, Rudorfer, & Linnoila, 1985) do yield increased commission-error rates, suggesting that those drugs make people less conservative in withholding potential answers during retrieval.

Control Sensitivity

Other factors that affect control may do so by influencing the relationship between control and memory monitoring (what Koriat & Goldsmith, 1996c, termed "control sensitivity"). Koriat and Goldsmith (1996c) found an exceedingly high correlation between the decision to volunteer an answer and confidence in that answer (averaging about .95 for both recall and recognition!) with undergraduate participants. More recent work, however, has found lower correlations with elderly subjects (Pansky, Koriat, Goldsmith, & Pearlman-Avnion, 2002; but see Kelley and Sahakyan, 2003) and with clinical populations (Danion, Gokalsing, Robert, Massin-Krauss, & Bacon, 2001; Koren et al., 2004). Interestingly, relatively high correlations between control sensitivity and measures of executive functioning (e.g., rate of perseverance errors on the

Wisconsin card sorting task; Pansky et al., 2002) and measures of clinical awareness (Koren et al., 2004) were found, suggesting a link between control sensitivity and overall level of metacognitive and executive functioning. Conceivably, situational factors at retrieval, such as divided attention, time pressure, and drugs or intoxication might affect control sensitivity as well, though this possibility remains a topic for future research.

CONCLUSION: SOME METATHEORETICAL IMPLICATIONS FOR EYEWITNESS (MEMORY) RESEARCH

In this chapter, we have taken a somewhat unorthodox approach to the topic of eyewitness recall. First, we emphasized the basic distinction between two properties of memory—quantity and accuracy—and examined the factors affecting memory in terms of both properties. Second, we highlighted the contribution of metacognitive monitoring and control processes to memory performance and gave these contributions great weight in our presentation.

In assessing eyewitness recollections, the quantity of the target information that is recalled has received considerable attention in both traditional and eyewitness memory research. However, in real-life situations, and particularly in the courtroom, output-bound accuracy is no less important. In fact, errors made by eyewitnesses have been found to be the most common cause of the false conviction of innocent people (Huff, Rattner, & Sagarin, 1996).

As we have argued elsewhere (Koriat & Goldsmith, 1994, 1996b), the distinction between memory quantity and its accuracy is not just a distinction between two properties or measures of memory but, rather, is associated with two quite different approaches to the study of memory. Each approach has its own distinct focus, its unique paradigms and methodologies, and even its own underlying metaphor of memory (Koriat & Goldsmith, 1996b). Unfortunately, due to these differences in underlying conception and methodology, there has been relatively little cross-talk between researchers in the two approaches (Winograd, 1988), though recent years have brought some improvement (Koriat et al., 2000). One goal of the present chapter, then, is to bring findings from the two approaches together and attempt to integrate them into a common "coordinate system" (cf. Koriat & Goldsmith, 1994, Figure 1). Such integration would seem to be a necessary first step toward the development of a theoretical framework that could provide a comprehensive understanding of the different aspects of memory—including eyewitness memory—and engender a unified research approach. The benefits of such a framework would be immense. It would allow researchers, for instance, to apply the broad base of knowledge regarding the factors affecting memory quantity performance toward an understanding of memory accuracy performance, and vice versa.

Consider, for example, many of the classic memory principles and findings, such as levels of processing, encoding specificity, subjective organization, and so forth. What is the relevance of these principles for memory accuracy, which is so crucial in evaluating eyewitness testimony? Although some scattered studies have been conducted (some reviewed above), the general answer is that we simply do not know. In fact, accuracy was of such little concern in traditional, quantity-oriented memory research, that accuracy rates (false alarms or commission errors) were not even reported in many classic studies (see, e.g., Craik & Tulving, 1975; Thomson & Tulving, 1970; Tulving & Osler, 1968)!

The second unique feature of this chapter is the attention devoted to the metacognitive processes of monitoring and control at the reporting stage, as they mediate both memory quantity and accuracy. Actually, this feature is closely tied to the first. Although such processes certainly have an effect on memory quantity, they are particularly crucial in affecting memory accuracy, because output-bound memory accuracy is much more under the control of the rememberer than is input-bound memory quantity (Koriat & Goldsmith, 1996b, 1996c). In fact, these processes seem to be employed specifically in the service of enhancing memory accuracy, either by screening out incorrect answers (i.e., control of report option) or by "hedging" an answer by choosing a level of generality that makes it more likely to be correct (i.e., control of grain size). Nevertheless, because of the fundamental dynamic of the accuracy–quantity (or accuracy–informativeness) trade-off, the metacognitive regulation of memory reporting can have a substantial impact on both accuracy and quantity performance.

The joint consideration of cognitive and metacognitive components of memory performance has important theoretical and practical implications. On a theoretical level, this perspective implies that factors thought to affect retention might, in fact, exert their influence via an effect on monitoring or control (e.g., see Higham, 2002; Memon & Higham, 1999). In addition, differential effects on memory quantity and accuracy performance are to be expected when different underlying components are affected in different ways (e.g., the comparison of recall vs. recognition testing in Koriat & Goldsmith, 1996c). Teasing apart the separate contributions of retention, monitoring, and control to many other manipulations could be of great theoretical importance, and could also enhance the understanding of individual and group differences in memory performance (e.g., Kelley & Sahakyan, 2003; Koren et al., 2004; Koriat et al, 2001; Pansky et al., 2002; Roebers, 2002). At a practical level, methods for improving memory performance or safeguarding against error (e.g., in witness questioning techniques) could be targeted toward improving monitoring and control, in addition to the traditional focus on encoding and retrieval processes that improve retention.

Of course, the metacognitive regulatory processes that guide memory performance in real-life eyewitness situations are certainly more varied and complex than those addressed in this chapter, as are the goals and considerations of the witness in utilizing those processes. Providing a complete or accurate account of an event may not be the only or even primary aim of an eyewitness.

Therefore, the evaluation of memory performance in terms of memory quantity and memory accuracy may not always be appropriate—at least not from the witness's perspective. Memory does not operate in a vacuum, and hence memory performance, and the cognitive and metacognitive processes that mediate such performance, need to be analyzed in the context of the personal and social goals of the rememberer (e.g., Neisser, 1996; Pasupathi, 2001; Winograd, 1994). Taking this point seriously will require even more attention to the role of strategic regulatory processes as well as to the complexities involved in the evaluation of eyewitness memory performance.

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