

Memory Illusions

HENRY L. ROEDIGER III

Rice University

Memory illusions may be defined as cases in which a rememberer's report of a past event seriously deviates from the event's actual occurrence. This article introduces the special issue of the *Journal of Memory and Language* that is devoted to memory illusions by grounding their study in the context of perceptual illusions. Perceptual illusions have been investigated since the 1850s, whereas memory illusions have been systematically investigated only since the late 1960s or early 1970s (despite some pioneering research and writing before this time). I suggest possible reasons for this discrepancy in research activity, sketch a brief history of the study of memory illusions, and then consider the variety of memory illusions that are studied in contemporary psychology. The papers composing the special issue are introduced during this brief cataloging of memory illusions. Related areas of research are discussed in the concluding remarks. © 1996 Academic Press, Inc.

Illusions have fascinated philosophers, physicists, and psychologists throughout recorded history. Whenever our experience of events is shown to be at odds with the actual nature of the events, our curiosity is piqued. The word illusion is derived from the Latin word *illudere*, meaning to mock. Illusions mock our belief that what we perceive, remember, and know is in perfect accord with the state of the external world.

Despite long-standing interest in this topic, defining exactly what an illusion is can be a difficult exercise. When psychologists see the word *illusion*, it is usually modified by *visual*, *perceptual*, or *optical*. The term *memory illusion* is much less common. In a 1964 dictionary of psychology, Drever included the following entry under *Illusion*. "In the case of sense perception, 'a subjective perversion of the objective content,' or actual sense data; in the case of memory a subjective falsification by addition, omission, or substitution, in the

recall of a past experience." Even though both perceptual and memory illusions were mentioned in this definition, by 1964 there had been hundreds of studies of perceptual illusions but, even counting generously, there probably existed fewer than 30 publications directed specifically at memory errors, with the term *memory illusion* rarely arising at all. One exception occurred in Titchener's (1928) *Textbook of Psychology*, where he devoted a section to "Illusions of Recognition and Memory." He wrote that "Illusory memories and recognitions are of two kinds. We may remember or recognize something that is really, objectively, unfamiliar to us, and we may fail to recognize or remember something which once formed part of our common experience. Both types of illusion are quite common" (p. 424). Titchener discussed these matters for only one and a half pages and alluded to the existence of other memory illusions but did not describe them. The two illusions to which Titchener referred are usually called by their French names, *déjà vu* and *jamais vu*, and have been little studied experimentally, until lately when experimental analogs have been developed (as discussed below).¹

¹ It is clear from Titchener's examples that he did not mean that forgetting should be considered a memory illusion. Rather, the failure to recognize something quite familiar (such as a well-known word) was intended.

Preparation of this article was supported by Grant F49620-92-J-0437 from the Air Force Office of Scientific Research. The article benefited from comments by Marcia Johnson, Doug Nelson, Kathleen McDermott, Kerry Robinson, Dan Schacter, and Endel Tulving. I thank Kerry Robinson for help in preparing the manuscript. Correspondence should be addressed to the author at Department of Psychology, MS 25, Rice University, Houston, TX 77005-1892. E-mail: roeddy@rice.edu.

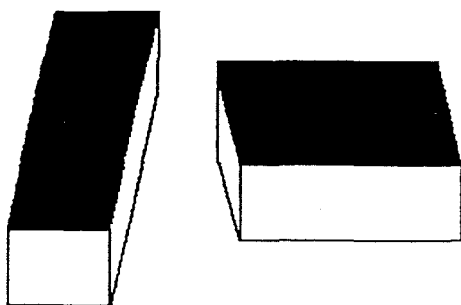


FIG. 1. A shape illusion. The shaded tops of the two figures appear quite different in shape, but are actually congruent. Reprinted by permission of Roger Shepard and Lawrence Erlbaum, Inc.

We may ask why, historically, this imbalance has existed between interest in perceptual illusions and in memory illusions. One answer probably lies in the immediacy of perceptual illusions relative to memory illusions. Shown in Fig. 1 is the remarkable shape illusion that Shepard (1981) created. The darkened parts (the tops of the figures) appear quite different in shape, but they are actually congruent. (Trace one on a sheet of paper and lay it over the other, if you need to be convinced.) Such a remarkable demonstration provides immediate and convincing evidence of a fascinating process at work, one worthy of serious and thoughtful study. Most visual illusions have just this quality. Even if memory illusions occur routinely in life—and I think they do—the evidence for their occurrence is quite different. Usually the events in question have long since disappeared from life's stage and we can believe that our memories are right, despite claims to the contrary that may be provided by others. If we simply look at the two shapes in Fig. 1, we are not aware of the illusion at all—one shape is simply perceived as quite different from the other. It is only if we are told to check that we can convince ourselves of the difference. This critical checking operation usually is not possible for remembered events.

The purpose of this essay is to introduce the special issue of the *Journal* on the topic of memory illusions. First I consider the topic of perceptual illusions, providing a brief his-

torical overview of their discovery and importance to the study of perception. Due to the longer history of serious scientific inquiry, a consideration of the topic of perceptual illusions seems an appropriate way to ground the study of memory illusions. I then turn to the topic of memory illusions and survey some of the major milestones in their study, as well. I provide a brief catalog of some of the main types of memory illusions that have been studied, and in the process I introduce the set of papers that constitute the special issue.

PERCEPTUAL ILLUSIONS

Illusions occur in all sense modalities, although those occurring in vision have been studied in greatest detail. The ancient Greeks were quite aware of visual illusions. The Parthenon was constructed to overcome two common visual illusions that would have caused it to look imperfect had steps not been taken in its design and construction to counteract their effects (see Coren & Girgus, 1978). Aristotle described the moon illusion—the fact that it looks larger at the horizon than when overhead—and also described the illusion of touch that still bears his name (Benedetti, 1985).

Closer to our own times, scientific interest in perceptual illusions began in the early 1800s and had exploded by the turn of the century. In 1832 Louis Albert Necker, a crystallographer, noted a curious effect he had discovered in gazing at crystals: Line drawings of crystals would spontaneously reverse in depth when an observer stared at them. This observation gave rise to the familiar Necker cube. In 1854, J. J. Oppel reported the curious observation that a certain distance of linear extent appeared longer if it were filled (say, with lines) than if it were unfilled. Coren and Girgus (1978) estimated that over 200 scientific papers appeared on perceptual illusions in the 50 years after publication of Oppel's (1854) paper. Many illusions identified during this period still bear the names of their discoverers: Zöllner, Müller-Lyer, Ponzo, Ebbinghaus, and so on. One important theoretical contribution from this era came from Hermann von Helmholtz, who offered a general approach to per-

ception still found in many theories today. As Coren and Girgus (1978, page 9) put it, "He proposed that, in general, perception in the adult observer is based on unconscious inferences that the mind makes about the pattern of stimulation in the nervous system. Since most stimulus arrays are ambiguous, the observer must interpret the sensory stimulation arriving in the brain in light of his knowledge of the environment. Thus perception is an inductive process wherein the observer uses his experience to interpret the patterns of excitation in his receptors." Helmholtz called this constructive process *unconscious inference* because when people create their perceptual world, they are unconsciously weaving together data from the senses with prior knowledge about the world. A classic example of unconscious inference occurs in depth perception, wherein the two-dimensional display on the retina gives rise to the experience of a three-dimensional world through the use of many cues that are combined without our awareness. The role of the active perceiver appears throughout the history of the study of perception (Neisser, 1968). Rather than the external world merely being projected onto the retina and faithfully transmitted to the brain, most perceptual theorists have emphasized that top-down, constructive processes help determine what we perceive. In *The Principles of Psychology*, William James described his general law of perception, which he believed was well substantiated: ". . . whilst part of what we perceive comes through our senses from the object before us, another (and it may be the larger part) always comes . . . from our own head" (1890, Vol. II, p. 108).

The topic of illusions plays a large role in these constructive views of perception (e.g., Gregory, 1970). Helmholtz (1881) wrote, "The study of what are called illusions of the sense is, however, a very prominent part of the psychology of the senses; for it is just those cases which are not in accordance with reality which are particularly instructive for discovering the laws of those processes by which normal perception originates." Helm-

holtz's theme in this quote reverberates to the present day through the writings of scholars studying perception, but it is not a uniform view. Kolers (1964, p. 98) noted that "Illusions have not always had a good standing among the investigators of perception. When perceptual illusions were introduced as a topic of study in the nineteenth century, the prevailing attitude about them was that they were mere parlor tricks—minor imperfections or errors" in the workings of perception. (Kolers went on to discredit this view.)

The study of illusions has occupied center stage in the study of perception since the turn of the century and has even given rise to entire theories that developed largely to explain their occurrence (e.g., the transactional approach to perception proposed in the late 1940s and early 1950s by Ames, Ittelson, and Kilpatrick and based on the remarkable demonstrations they produced (e.g., Ittelson, 1952; Ittelson & Kilpatrick, 1951). In 1978 Coren and Girgus estimated that over 1000 articles had been published on the topic of perceptual illusions. Now, 18 years later, hundreds more have appeared and whole books are devoted to special illusions, such as the edited volume by Hersenson (1989) on the moon illusion.

In the next section I turn to considering why illusions and errors have not, until lately, played a central role in research and theory about human memory. Before leaving the topic of perception, however, consider one more quote noting the importance of studying how systems fail in helping to understand how they normally operate. Gregory and Gombrich (1973) wrote that "Illusions are also tools for discovering processes in perception. In medicine, in engineering, and very frequently in biology, the abnormal and surprising lead to key ideas and facts for understanding the normal. So here we may expect abnormal perceptions (deviations from truth) to give insights and data for understanding normal (correct) perception" (p. 7). We may hope that studying illusion and error can play the same role in advancing our understanding of human memory. The study of perceptual illusions may need to become an integral part of the study

of memory illusions, as they both reveal constructive errors in the overall cognitive system. Later I consider some illusions that could be classified as either perceptual or memory illusions, illustrating that no firm boundaries exist between these phenomena.

MEMORY ILLUSIONS

Perceptual illusions reveal the constructive nature of perception: We can misperceive a stimulus while it appears before us under leisurely and optimal viewing conditions, as in Fig. 1. If perceiving is conceived as an active process, one full of inference and hence at least occasional error, then it is hardly surprising that remembering would be so considered, as well (Neisser, 1967, 1968). After all, if the cognitive system can err in misrepresenting objects when they are present before the eyes, the opportunities for error when a person later tries to recreate happenings of the past must be even greater.

The origins of formal memory research in Ebbinghaus's (1885/1964) great experiments probably helped keep early researchers from examining errors and illusions. Ebbinghaus learned and relearned his series of nonsense syllables and measured the savings during relearning. The relearning and savings method was ingenious and set the field off on a scientific and sure path, but like any method, it was better adapted to asking some questions than others. The method was generally unsuitable for investigating memory errors and illusions, despite the fact that Ebbinghaus had a keen interest in the topic of perceptual illusions. Nonetheless, one of Ebbinghaus's methodological contributions is critically important even for the study of memory illusions. As Schacter (1995) noted in this context, ". . . Ebbinghaus introduced a methodological innovation that has proved to be essential to evaluating whether a memory is true or false: he gained control over the input to the memory system. In earlier philosophical and clinical treatises on memory, discussion centered on introspective recollections of past experiences by the writers themselves or by patients whom they observed. The problem with

this sort of procedure is that the investigator typically has no reliable way to check the accuracy of a reported recollection" (p. 5). We may add that this difficulty—lack of control over the original events—plagues many modern treatments of the question of accuracy and inaccuracy in memory. *The experimentalist's credo* is that unless one can be sure as to the course of original events, one cannot make strong claims and statements about the accuracy or inaccuracy of later recollections.

There is a sense in which the study of memory errors is quite old. After all, every time subjects provide intrusions in recall tasks or make false alarms in recognition tests, these errors could be interpreted as memory illusions. However, in the history of experimental studies of memory, errors were rarely of interest in their own right. The emphasis has traditionally been on correct responding and errors were typically considered a methodological nuisance, reflecting guessing or criterion shifts. Errors were most commonly used to correct accurate recall or recognition for guessing and other biases, as in signal detection theory. Exceptions to this general methodological attitude concerning errors are described below, but it should be borne in mind that (at least until the 1970s), mainstream experimental psychologists were not usually interested in illusions of remembering that might be reflected in errors.

The first experiments showing the inaccuracy of memory were conducted with children by Binet (1900) in France and by Stern (1910) in Germany (see Ceci & Bruck, 1993). Both investigators exposed children to objects or events and later tested their memories with a series of misleading questions. The results of both studies revealed memory distortions in the children. At about this same time, Munsterberg (1908) reviewed evidence of the unreliability of eyewitness testimony in his book, *On the Witness Stand*.

In a totally different tradition, Freud (1895) began exploring memory distortions in the 1890s and continued to revise his statements on the subject throughout his life. His most famous idea was that of repression—the no-

tion that painful early memories are banished to an unconscious state where they may be revealed only indirectly, through dreams, slips, and symptoms of psychopathology. Erdelyi (1985, Chapter 5) describes the many changes in Freud's concept of repression, from people simply not wanting to think about bad events of their lives at one extreme (Erdelyi & Goldberg, 1979) to a deep and mysterious process of psychological banishment of memories to an unconscious state at the other. One corollary of the idea that memories of threatening experiences could be removed or banished to an unconscious state is that they could somehow reside in this state relatively intact and then be recalled (through therapy) at some later time in life. However, in his later writings Freud abandoned his earlier belief that childhood memories obtained during therapy should be treated as genuine and emphasized instead the processes of distortion that could occur during therapy. In 1910 he wrote that childhood memories are "... only elicited at a later age when childhood is already past; in the process they are altered and falsified, and are put in the service of later trends, so that generally speaking they cannot be distinguished from phantasies" (p. 83).

Two other types of distortions that Freud (1903) analyzed were paramnesias (or false recollections of forgotten events that took on subjective certainty), and screen memories (or cases when one memory substituted for another and screened it out of consciousness). Freud interpreted both in terms of defense mechanisms to protect against psychic threat and analyzed several cases that seemed to fit this mold. The difficulty with interpretation of screen memories, in particular, is that there is no rule to decide which may be the real memory and which the screen memory, except for ad hoc supposition (Schacter, 1995). Nonetheless, Freud (1903, p. 68) likened memories of early childhood to screen memories: "One is thus forced by various considerations to suspect that in the so-called earliest childhood memories we possess not the genuine memory-trace but a later revision of it, a revision which may have been subjected to the influ-

ences of a variety of psychical forces. Thus the 'childhood memories' of individuals come in general to acquire the significance of 'screen memories' and in so doing offer a remarkable analogy with the childhood memories that a nation preserves in its store of legends and myths." However, without the methodological stricture of the experimental school—knowledge of the original events and how they occurred—Freud's various discussions of whether childhood memories are accurate or inaccurate is based more on conjecture than on empirical evidence.

These two streams of study of memory illusions I have briefly described—one based on experimental methods and the other rooted in the psychoanalytic tradition—have guided discussion of memory errors to the present day. However, as previously noted, within academic psychology the main issues in memory research lay elsewhere. Researchers from early in the century worried about the course of forgetting and its causes (retroactive interference and retroactive inhibition), but rarely worried about error and illusion. There are two prominent exceptions to this generalization, however. The first is represented in the Gestalt tradition of memory research in which it was believed that memories changed over time in the directions that were in line with the Gestalt laws of organization. Briefly, people would remember events in a more organized fashion (the events would represent good patterns) when they were remembered at increasing intervals from the original event. For example, Wulf (1922) reported that visual forms were remembered as being more regular and symmetrical over time, and many other researchers conducted similar studies. The topic remained of sporadic interest in experimental psychology, but Riley's (1964) piercing review of the methodological difficulties and the inconsistencies in results in this area quelled continued interest. Most commentators have concluded more recently that nothing much was gained from this study (Baddeley, 1976; Schacter, 1995). However, as Loftus (1990) pointed out, Riley's (1964) analysis of research from the Gestalt tradition did em-

size the effect of verbalization on memory. The words that people used to label visual figures, for example, determined how they were later remembered (e.g., Carmichael, Hogan & Walters, 1932). The importance of verbalization on memory continues to be studied to the present day, as represented in the current issue in Melcher and Schooler's experiments on verbal overshadowing.

The second, and more important, contribution during the 1930s to the study of memory distortions was publication of Bartlett's (1932) great book, *Remembering: A Study in Experimental and Social Psychology*. Bartlett took it as axiomatic that remembering was imperfect and even argued that it would be unnatural for people to remember events verbatim. Before turning to remembering, he devoted a chapter to discussing constructive processes in perceiving. In one demonstration, he showed people a painting for a brief period of time and noted that their reports of what it contained were quite different and seemed to depend more on the background and proclivities of the observers than on the content of the painting. Further, when he exposed the painting repeatedly, but with quite brief exposures, his subjects would often cling to their earlier interpretations and fail to perceive the actual scenes portrayed, a finding presaging that of Bruner and Potter (1964) years later. Bartlett argued that both perceiving and remembering were constructive processes guided by schemas, or cognitive frameworks that people brought to the events and through which they interpreted them.

Bartlett's most famous experiments were those in which college students read and later recollected an Indian folktale, "The War of the Ghosts." In one type of experiment, which he called repeated reproduction, subjects recalled the story from memory on at least two occasions, without intervening study. Typically, Bartlett required a first recall 15 min after his subjects (Cambridge University students) had read the story twice. Then he tested them at various later points in time. His experimental methods were casual, to say the least, but he did at least control the input material

while violating most other strictures that careful experimentalists might prefer (Kintsch, 1995). His data were in the form of sample protocols produced by some of his subjects and showed numerous omissions, with the stories becoming shorter over time. More interestingly, the subjects made errors of commission in which they added material to make the story more rational and consistent. Supernatural elements dropped out and in general the students seemed to convert the story more to the form of an English fairytale, sometimes even tacking on a moral. Bartlett noted that this property of rationalization in the protocols brought the story in line with schemas with which the students were more familiar.

A few years before his death, Donald Broadbent (Bartlett's student) related to me an interesting story about rationalization in "The War of the Ghosts." Briefly, it did not start with Bartlett's subjects, but with Bartlett himself, when he created the materials. One of the most memorable parts of "The War of the Ghosts" occurs at the end, when an Indian falls down, something black comes from his mouth, and he dies. Bartlett's version put it this way: "Something black came out of his mouth." Broadbent told me that Bartlett had revised this part of the story, omitting an offensive phrase. Sure enough, in checking Franz Boas' (1901) original version, the sentence read "Something black came out of his mouth and blood came out of his anus." Broadbent opined that this version was too vivid for Bartlett to present to his refined Cambridge students! In fairness, Bartlett seems to have rewritten the entire story to make it flow better than Boas' original literal translation, but this is the only case where an important change of content occurred.

Bartlett's (1932) book, so important today in hindsight, actually seems to have had little impact on the questions experimental psychologists asked at the time, as reflected in the mainstream literature of the 1930s, 1940s, and 1950s. However, as noted below, the book received renewed attention in the late 1960s and early 1970s when Bartlett's approach to remembering gained renewed interest and fa-

vor. The legend of Bartlett's repeated reproduction experiments lives on today in most textbooks of psychology (introductory, cognitive, and memory texts alike). However, to my knowledge no one has successfully replicated his repeated reproduction experiments on materials like "The War of the Ghosts" when they used instructional sets requesting that people remember the story. Gauld and Stephenson (1967) found errors like Bartlett's when they told people to make up a story like the one they had heard, but not when they asked them to remember the story. Wheeler and Roediger (1992) gave subjects repeated tests on both "The War of the Ghosts" and on another prose passage and found that they actually recalled more on the second test than on the first, at least with short delays between tests. It seems odd that experimental observations could live on for so long in textbooks when the original methods were so casual and when no one has successfully replicated the work.² The probable reason lies in the fact that most observers thought Bartlett's (1932) basic story about memory rang true, regardless of his methods and results, and if so, that assessment still seems accurate today.

THE MODERN ERA

The information processing approach to cognition began in the 1950s as researchers carried concepts and methods from communications theory and electrical engineering into psychology. In the 1950s Donald Broadbent (1958) produced the first information flow diagrams and George Miller (1956a, 1956b) produced two papers that began a revolution in the study of human memory. One of Miller's key ideas was the concept of recoding, wherein information is received from the outside world in one form but is transformed and represented in a different way internally.

² Bartlett's (1932) serial reproduction experiments, in which one person reads and recalls a passage, the second person reads the first person's recollections and then recalls the information, etc., also induce systematic distortions. These experiments have been successfully replicated (e.g., Paul, 1959).

"There are probably many ways to do this recoding, but probably the simplest is to group the input events, apply a new name to the group, and then to remember the new name rather than the input event" (1956b, page 93). Recoding is an active process of transformation and therefore the possibility of errors in recoding and later decoding may arise. Miller (1956a) wrote:

A . . . more general technique for organizing our experience into convenient units is provided by language. . . . When you witness a scene or hear a story that you want to remember, you try to translate it "into your own words," into the linguistic units that will fit into your own cognitive hierarchy. This highly schematic, verbalized abbreviation is remembered. Then when you try to recall you must decode. Since the fit of words to experience is seldom as tight as the fit of laws to data, the decoding process often goes astray. You supply details by secondary elaboration that are consistent with your coded memory. Often these details are wrong. (p. 132)

Miller (1956a, 1956b) paved the way to the information processing approach to remembering, which has largely guided research for the past 40 years. As Koriart and Goldsmith (in press) have noted, research conducted in this tradition has largely been devoted to issues of how much (how many units) could be remembered, and errors have been given rather short shrift. However, nothing within the information processing approach itself ordained this emphasis, as the quotes from Miller indicate; and some researchers did attend to error analyses. For example, Conrad (1964) studied errors of short-term memory and concluded that they had a phonological basis, whereas other researchers found semantic confusion errors in studies of long-term memory (e.g., Underwood, 1965). However, most researchers influenced by Miller (1956a, 1956b) studied how material was organized so as to be remembered better. For example, Tulving (1962, 1964) studied how subjects organized random word lists into subjective units in multitrial free recall so as better to remember the words. Glanzer and Clark (1963) developed the verbal loop hypothesis,

seeking to show that when people are faced with visual information, they recode it into a verbal description and that this description guides later recall.

Many different trends in the modern era launched psychologists on the road to studying errors and distortions of memory. I review some of the main trends in the field and, while doing so, show how articles in the current issue fit in.

Neisser's Cognitive Psychology

In 1967 Ulric Neisser published his great book, which gave an entire field its name and set many of the topics that were to be the center of attention in the new field: iconic memory, echoic memory, reading, imagining, and so on. Traditional memory research in the Ebbinghaus tradition was not much in evidence, but more importantly for present purposes, Neisser capped his book with a chapter on remembering and thinking that harked back to Bartlett's (1932) idea of remembering as a constructive process. Neisser emphasized the unity of cognitive processes and noted that perceiving, remembering, and thinking were all active and interdependent processes. It seems obvious that remembering depends on perceiving, but less so that higher cognitive processes usually studied as issues of problem solving and thinking are also involved in remembering, at least to the extent that remembering is conceived as a constructive activity.

Neisser's (1967) assumptions were stated clearly:

It is assumed that remembering and thinking are analogous to adaptive movement and to motor skill; they also resemble the synthetic processes of visual memory and speech perception. Stored information consists of traces of earlier constructive acts, organized in ways that correspond to the structure of those acts. However, the 'traces' are not dormant copies of earlier experiences, somehow aroused into consciousness from time to time. Stored information is never aroused, it is only used, just as stimulus information is used in the act of perception. (page 279)

Neisser (1967) developed the idea in the last sentence just quoted into the utilization

hypothesis of remembering (pages 284–286). Perceiving and remembering were seen to be amenable to similar interpretation: "The analogy being offered asserts only that the role which stored information plays in recall is like the role which stimulus information plays in perception" (page 285). In neither case can the information to be used directly enter consciousness or be reproduced in behavior in a literal manner; rather, constructive activity (top-down processing) operates on the information and the perceiver and rememberer become conscious only of the product of this constructive activity. Therefore, ". . . stored information is not revived, but simply used, in the constructive activity of recall" (page 289). Just as constructive activity can give rise to illusions in perceiving, the same is true in remembering.

Although it is not possible to pinpoint a cause and effect relationship with certainty, it seems likely that Neisser's famous book, and especially its final chapter, may have helped launch the renaissance of experiments in the 1970s that examined errors in prose retention in the Bartlett (1932) tradition.

Memory for Prose: The Influence of Schemas

In the early 1970s several groups of researchers began studying errors in prose retention that implicated the active role of the rememberer in bringing his or her knowledge to bear in recoding information. Bransford and Franks (1971) presented subjects sentences of varying complexity that created a coherent idea. Later they tested subjects' memories for sentences that had been presented, ones that had not been presented but were consistent with the complex idea, and ones that were unrelated to the idea. Subjects could easily reject the unrelated sentences, but they failed to distinguish between presented and not presented sentences so long as they were consistent with the overall idea. Subjects' confidence in recognition was directly related to the number of propositions in the test sentence that were consistent with the overall idea, regard-

less of whether they had actually been presented in the study phase.

In a later study, Bransford, Barclay, and Franks (1972) showed that people would falsely remember events as having occurred when the events had only been implied by prose passages but not actually stated (see too Johnson, Bransford, & Solomon, 1973). For example, subjects studied sentences such as "Three turtles rested on a floating log, and a fish swam beneath them." Later subjects were asked if the sentence "Three turtles rested on a floating log and a fish swam beneath it" had appeared in the passage and a large percentage said yes. Other research also shows that information implied, but not actually stated, is often remembered as if it had actually occurred (Brewer, 1977; Harris, 1974).

Much work in this tradition showed how what a person already knew, or the context in which information was presented, determined whether and how it would be remembered. Sulin and Dooling (1974) showed that subjects would falsely recognize a statement about a person if an appropriate schema had been invoked. For example, a week after reading a story about a troubled girl, subjects were more likely to recognize the sentence "She was deaf, dumb, and blind" if they had been told the story was about Helen Keller than if they had been told it was about Carol Harris. Many other experiments of similar form have demonstrated the power of schema (and scripts) in organizing incoming information, in line with Bartlett's (1932) and Miller's (1956b) ideas, cited above (see Bower, Black, & Turner, 1979; Owens, Bower, & Black, 1979; and Spiro, 1980, for some further examples and Alba & Hasher, 1983, and Brewer & Nakamura, 1984, for reviews).

Relatedness Effects

The experiments described in the previous section show that people will recognize sentences or passages as having occurred if they are similar in meaning to previously studied prose materials. Similar phenomena have been uncovered in other paradigms in which subjects study word lists and then are given recog-

nition tests composed in part of lures that bear various semantic relations to the studied words. Underwood (1965) gave subjects a continuous recognition test in which they decided if each presented word had been studied previously in the list. When subjects encountered a word that bore an associative relation to a previously studied word (e.g., to decide if *chair* had been previously presented, when in fact *table* had been), they were more likely to provide false alarms to the words (to *chair* in this example) than if there were no associative connection between the test word and prior words. Others replicated this effect (e.g., Anisfeld & Knapp, 1968; Paul, 1979), but it is sometimes rather small or even nonexistent (Gillund & Shiffrin, 1984). However, others have shown that the false recognition effect increases with the number of previously presented words that are semantically related to the test word or lure (Hall & Kozloff, 1973; Hintzman, 1988; Shiffrin, Huber, & Marinelli, 1995). Underwood (1965) interpreted the false recognition phenomenon in this paradigm as being caused by implicit associative responses during encoding; when studying *table*, *chair* might be aroused and therefore later recognized. With increasing numbers of related words, the chances of subjects producing the critical associates might be increased, thereby accounting for the more powerful effect observed in later studies.

The great bulk of the evidence about memory distortion relies on recognition paradigms, the primary measure in the studies described in this section and the previous one being false alarms. Studies examining false recall, either in the schema/prose tradition or the more standard word list tradition are much rarer, especially with the failures to replicate Bartlett's (1932) findings (but see Brewer, 1977; Hasher & Griffin, 1978; and Spiro, 1980, for exceptions in the prose tradition). Deese (1959) reported results of a paradigm that showed robust levels of false recall following presentation of word lists, at least for certain lists. Deese (1959) constructed his lists from word association norms by selecting words associated to one target word. For example,

hill, valley, climb, summit, and top are all related to *mountain*. Deese (1959) presented lists of 12 related words and then measured the intrusion of the critical nonpresented word from which the lists were derived, such as *mountain*. For some lists (ones in which there was a high probability of generating the critical nonpresented target from list members, as measured by free association norms), the level of intrusions, or false recalls, was quite high. Cramer (1965) reported similar observations, but neither study received widespread attention.

Roediger and McDermott (1995) revived Deese's (1959) paradigm, replicated the phenomenon of high levels of false recall following presentation of related word lists, and extended the findings in several directions. For example, they showed that false recognition of the target words (the false alarm rate) equaled the hit rate in some conditions and that the act of recall later enhanced both accurate and false recognition. Further, using Tulving's (1985) paradigm in which subjects were asked to judge whether they actually remembered the occurrence of words (rather than knowing that they occurred, but not specifically remembering the moment of presentation), subjects frequently *remembered* the words that were never presented.

Three papers in this issue use Roediger and McDermott's (1995) paradigm. McDermott replicates the basic phenomenon and adds significant new information. For example, she shows that multiple study and test opportunities cause the levels of false recall to decline, but that they are still substantial after five study/test trials. In addition, blocked presentation of words leads to higher levels of false recall than does random presentation and, over time, accurate recall declines, whereas false recall actually becomes somewhat greater.

Payne, Elie, Blackwell, and Neuschatz also replicate the basic phenomena reported by Roediger and McDermott (1995) while adding important new insights. For example, the false memory effect grew over repeated testing (under conditions, unlike those of McDermott, in which there were no additional study opportunities). In another experiment, words were

presented by two different speakers during study and subjects were asked on a later recognition test to make judgments about which speaker had said words that were recognized as old or studied. Payne et al. found that subjects were quite willing to indicate which of the two people had spoken words that had actually never been presented in either voice. The conclusion that they reached is similar to that derived from the *remember/know* judgments: subjects apparently experience the recollection of these events that never happened as quite real, as real as the recall of the word events that actually had occurred. "False memories" may be a misnomer, at least from the subjects' viewpoint, because the experience of recollecting the critical nonpresented words appears as real to the subjects as their recollections of the presented words.

Schacter, Verfaillie, and Pradere used the same paradigm to study development of false memories in amnesic patients. Interestingly, they found that patients were less susceptible to this memory illusion than were control subjects. They argued that this outcome indicates that development of false memories in this paradigm can be interpreted with the Reyna and Brainerd (1995) fuzzy trace theory (as did Payne et al., too). In particular, Schacter et al. interpreted the finding of less false recall and recognition in amnesic patients as indicating that the gist representations that normally support recollective processes are impaired in the patients, relative to normal controls.

The paradigms introduced by Deese (1959) and Underwood (1965) and their variations serve as tractable experimental manipulations for studying the development of false memories. As noted by Roediger and McDermott (1995), the robust levels of false recall and false recognition are remarkable, because they occur under conditions that often promote good verbatim (or reproductive) recall: simple word list materials, free recall tests that discourage guessing, short retention intervals, and the use of metamemory judgments (*remember/know* judgments, modality judgments) that direct subjects' attention to the bases of veridical judgment.

Effects of Interference and Misleading Information

Perhaps the most studied way of systematically distorting memory is presenting other events or information to interfere with retention of a critical target event of interest. Müller and Pilzecker (1900) first identified the role of interference in forgetting and it has been studied, in various traditions, ever since. The critical roles of both retroactive interference (McGeoch, 1932) and proactive interference (Underwood, 1957) in producing forgetting have long been recognized. Although error analyses played a role in the classic study of interference—for example, the curious pattern of intrusions as a function of trials of interpolated learning convinced Melton and Irwin (1940) that a Factor X (unlearning) needed to be added to response competition to explain forgetting—the primary interest of the times was not in how interfering information created memory distortions and illusions. Rather, the interest was in the forgetting of studied information.

At about the historic point when interference theory had peaked and a decline in research interest was occurring (usually dated from the Postman and Underwood (1973) paper), Loftus and Palmer (1974) introduced a paradigm that bore formal similarity to a retroactive interference paradigm, but that was used to ask different questions with different materials. They showed subjects a videotape of an automobile accident and later gave them a questionnaire in which a critical question was embedded: “About how fast were the two cars going when they ___ each other?” The verb was varied for different groups of subjects. For example, when *hit* was used, subjects estimated the speed at 34 miles per hour but when *smashed into* was used, the estimate grew to 41 miles per hour. More interestingly for present purposes, when subjects were later asked the question “Did you see broken glass?” 14% of those who had received the question with the verb *hit* answered yes, whereas 32% of those who had received *smashed* answered yes. No broken glass was

present in the scene, so these responses constituted errors. Loftus and Palmer (1974) argued that the question involving the powerful verb *smashed* caused subjects to recode the accident differently and consequently to be more likely later to remember broken glass where none existed.

The Loftus and Palmer (1974) paradigm eventually developed into what has come to be called the misinformation effect paradigm. In the standard case (e.g., Loftus, Miller, & Burns, 1978) subjects view a scene (for example, a traffic accident in which an automobile pulls into an intersection where there is a stop sign) and then later they are asked questions (or read a passage) that contain information about the original scene. Some subjects are told that the sign was a yield sign (the misinformation condition), whereas it is referred to in a neutral manner (a traffic sign) or not mentioned at all for subjects in the control condition. Typically, memory for the information in the original scene is worse when misinformation has been given relative to performance in the control condition, although the magnitude of the effect depends on many factors.

This paradigm has produced a huge amount of research (see Loftus, 1979a, 1993b, for reviews) showing how information coming after an event can shape and mold remembrance of the event. Interest centers both on forgetting of the original event and, more importantly for present purposes, on the case where subjects come to remember the suggested event as actually having occurred (Lindsay & Johnson, 1989; Weingardt, Toland, & Loftus, 1994).

Two papers in the special issue are devoted to this problem. Mitchell and Zaragoza examine the effects of repeating the misinformation on memory for the target event and for the misinformation itself. Repeating the misleading statements makes subjects less likely to recall the original events accurately. Roediger, Jacoby, and McDermott examine the effects of repeated testing on recall of events in this paradigm. In particular, they provided conditions in which subjects were encouraged to produce the misleading information on a first test, but then examined subjects 2 days

later under strict instructions to recall only events that they had actually witnessed during the first phase of the experiment, in the slides. Subjects who had provided the misinformation on the first test were still quite likely to do so again on the second test (relative to control groups). Further, subjects in this condition claimed to remember the actual occurrence of the suggested event, even though it had never happened. The misinformation paradigm introduced by Loftus continues to play a prominent role in studies of memory errors (see the edited volume by Ross, Read, and Toglia (1994) for recent reviews of these issues).

Verbal Overshadowing

A situation related to that of Loftus' paradigm was developed by Schooler and Engstler-Schooler (1990), which they called verbal overshadowing. Carmichael, Hogan, and Walter (1932) showed long ago that ambiguous visual stimuli were remembered in different ways depending on the verbal description given to the stimuli. Of course, in many situations verbalization can aid memory, and many studies have revealed positive effects of rehearsal and verbal elaboration. However, Schooler and Engstler-Schooler (1990) argued that verbalization may harm memory when the events to be remembered are difficult to capture in words. They have demonstrated this in a number of studies using stimuli from various domains. For example, when subjects viewed faces and had to describe them, memory for the faces was worse than when subjects did not describe the faces.

In their article in this issue, Melcher and Schooler extend their verbal overshadowing paradigm to recognition of the taste of wine. Untrained wine drinkers were impaired in their recognition of wines when they engaged in verbalization during their initial tasting, relative to the case in which they participated in an unrelated verbal activity. Consistent with their predictions, this verbal overshadowing effect did not occur in trained wine drinkers who had considerable expertise in translating their tastes into words. We can expect to see many more experiments on the positive and

negative effects of verbalization on remembering. In line with Glanzer and Clark's (1963) verbal loop hypothesis, people remember the events as they described them to themselves, not as they actually happened.

Illusions of Reality Monitoring and Source Monitoring

In the 1970s Marcia Johnson and her colleagues began a program of research that has identified a variety of interesting and important facts about accuracy and inaccuracy of remembering. In the original work (e.g., Johnson, Taylor, & Raye, 1977; Johnson & Raye, 1981), interest was in how subjects distinguish between information derived from external sources (events that really happened) and those that were generated by sources internal to the person (such as events that were only generated or imagined), or, to use the question that formed the title of a related paper by Anderson (1984): "Did I do it or did I only imagine doing it?" Early experiments were concerned with estimating the frequency with which events were presented externally or were internally generated. For example, subjects show better relative frequency judgments for internally than externally produced events. More interestingly for present purposes, the more subjects imagined an event, the greater the impact on judgments of frequency that the event actually occurred (Johnson et al., 1977; Johnson & Raye, 1981). Subjects confused the imagined events with those that actually occurred in estimating their frequency, a failure to monitor real events accurately, or a failure of reality monitoring, as Johnson and Raye (1981) called it.

Johnson and Raye (1981) proposed that people distinguish between internal and external events in memory both by the types of information encoded and by decision rules used when tested. Encoded representations of external events are especially rich in perceptual information (sensory features or attributes) and contextual information (such as time and place of occurrence). On the other hand, encodings of internally generated events are assumed to include considerable informa-

tion about cognitive operations that were used to encode the event. People are assumed to use these differences in information when deciding on whether something "really happened" to them. However, confusions can arise in some cases, such as when an imagined event may have been vividly imaged in a particular time, at a particular location, and with considerable sensory detail.

Another critical aspect of Johnson's theory, as developed in later writings (e.g., Johnson, 1983, 1995) is the distinction between two general types of judgment processes (similar to those proposed by others; Atkinson & Juola, 1973; Jacoby & Dallas, 1981; Mandler, 1980). Briefly, subjects can use either a relatively quick, nondeliberative heuristic process in making judgments or they can use more systematic processes that are slower and more deliberate. The heuristic process is quick and dirty, used to make snap judgments and resulting in errors when the snap judgment leads to the conclusion (for example) that something actually happened when it only seems familiar because the person thought about it (or generated it internally). Systematic judgment processes bring other features to bear on the decision as to whether something actually happened and are therefore less likely to be error prone.

A large variety of evidence has been collected that supports Johnson's general approach, which has been broadened to a general source monitoring framework (Johnson, Hashtroudi, & Lindsay, 1993). Information can arise from many sources that vary in modality (auditory, visual, verbal, pictorial), time of occurrence, place of occurrence, and so on, rather than simply being external or internal. A primary type of data used to support the theory is confusion that subjects show among sources, leading to interesting illusions of memory. The source monitoring framework has assumed increased importance in the field, as researchers have interpreted other phenomena under its umbrella. For example, the impact of misleading postevent information can be conceived as a failure of source monitoring; subjects may remember the stop sign, which was only suggested by a question or from

reading about the accident, as actually having occurred at the original scene (Lindsay & Johnson, 1989; Zaragoza & Lane, 1994).

In the present issue, Johnson, Nolde, and DeLeonardis add important new information about the impact of subjects' emotional focus (either on themselves or on another person) on their abilities to accurately monitor the source of information. Johnson et al. asked people to focus either on how they personally felt about statements that were read to them or about how they thought the speakers of the statement felt when reading them. Although focusing on their own reactions to statements made people recognize the statements better on an old/new recognition test, this self-focus actually reduced their ability to monitor the source (to tell which of two people had spoken the statement). The difference in self versus other focus was eliminated, however, in an experiment when subjects were instructed to focus on how they felt about the speakers rather than (as in the studies described above) when subjects focused on how they thought the speakers felt about what they were saying, a finding in line with predictions made from the source monitoring framework.

The contribution by Hyman and Pentland in this issue also can be interpreted within Johnson's source monitoring framework. They use the technique of having people imagine events that may or may not have occurred during their childhoods and show that imagining the events sometimes induces people to believe that the events did happen. The events are, on the face of it, fairly improbable ones. This outcome agrees with others in showing the powerful role of imagination in creating false memories (Johnson, Foley, Suengas, & Raye, 1989; see too Garry, Manning, Loftus, & Sherman, in press). Imagining seems to involve brain mechanisms similar to those used in perceiving (e.g., Farah, 1989), so it is not surprising that imagining events can make people later remember that they had happened (even when they did not). However, the positive effects of imagery have usually been emphasized by psychologists interested in memory—how imagining studied events

makes them more memorable—so the role of imagery in undermining memory may at first glance seem surprising. However, Johnson's framework permits us to understand how imagery can both make studied events more likely to be correctly recalled, and imagined "nonevents" more likely to be falsely recalled. In the former case, imagining adds additional cognitive operations to the encoded event that serve to enhance later memory for the event's occurrence; in the latter case, the cognitive operations help make the "nonevent" appear real by specifying perceptual detail, which usually signifies an event that actually occurred (Johnson et al., 1989). Other illusions on the border between perceiving and remembering are considered below, in the next two sections.

Fluency Illusions: Misattributions of Memory

Jacoby, Kelley, and their colleagues have developed an attributional view of memory that is similar in some ways to Johnson's (1983) source monitoring approach (Jacoby, Kelley, & Dywan, 1989; Kelley & Jacoby, 1990). They borrow from attribution theory in social psychology, where (for example) emotional states are thought to arise from a particular combination of physiological arousal and appropriate cognitions induced by the situation (e.g., Schachter & Singer, 1962). Similarly, Jacoby, Kelley, and their colleagues conceive of remembering as a combination of fluent processing of an event with the mental set that attributes the fluency to past experience, or to remembering. As in Johnson's framework, Jacoby and Kelley distinguish different bases of judgment: a more intuitive, rapid, and nonanalytic basis on the one hand, and a more deliberate, reflective, and analytic basis on the other. For the experience of remembering there needs to be fluent processing of information (of it readily coming to mind) and an attribution of the fluency as arising from past experience.

Several interesting illusions support Jacoby and Kelley's attributional framework. First, past events may lead to fluent processing and

(if the subjects' attention is focused on performing some other task) this fluency may be misattributed to some other source besides the past events. For example, Jacoby, Allan, Collins, and Larwill (1988) tested subjects' judgments of the loudness of background noise in which words were embedded when some of the words had been previously heard and others had not. When subjects had previously heard the words, they judged the noise to be less loud than when nonstudied words were judged, despite the fact that the objective noise level was the same in the two cases. The facilitating effects of prior experience on hearing the words through noise were misattributed to differences in the noise levels rather than accurately attributed to memory for prior experience of the words.

Jacoby and Whitehouse (1989) manipulated the ease with which words were perceived on a recognition test by preceding them with a briefly presented prime. Subjects judged the words that were primed as more familiar on a recognition test, presumably mistaking the fluency of processing for familiarity. Jacoby and Whitehouse proposed that such fluency may be the cause of *déjà vu* experiences (such as described by Titchener in the opening paragraphs). The enhanced fluency of an experience from a prior event that is not remembered may create a strange sense of familiarity, with no obvious source to which it should be attributed. Whittlesea, Jacoby, and Girard (1990) and Whittlesea (1993) reported illusions of immediate memory that were similarly caused by manipulations of perceptual fluency.

Two papers in the current issue draw on Jacoby and Kelley's attributional framework. Lindsay and Kelley show that enhanced fluency can drive know judgments in Tulving's (1985) remember/know paradigm. In their experiments, either easily solved word fragment cues, or ones that were difficult to solve, were presented as test cues following study of a word list. Subjects were told that the cues should remind them of list words and that they were to report the word and to judge whether they remembered details of its list presentation, or rather simply knew that it had been

on the list. Most studied words were represented by fragments appearing on the test, leading subjects to believe that the fragments were reliable retrieval cues for the list items. Lindsay and Kelley's primary interest was in judgments for a small group of words that had not been presented in the study phase. In this case, making the solution easy led subjects to report the word as having been presented, but to judge that they knew it had been on the list (but did not remember the details of its occurrence). This interesting illusion of knowing depends a bit on assumptions used to analyze know responses. In addition, recall that Roediger and McDermott (1995) reported that subjects would often provide *remember* responses for nonpresented items recognized in their paradigm. The differences between their results and those of Lindsay and Kelley may lie in the tests and the types of processing they engender. The Lindsay and Kelley paradigm capitalizes on perceptual (data-driven) factors in producing fluent output, with powerful cues; this sense of false familiarity arising from perceptual factors may lead to *know* judgments. The Roediger and McDermott (1995) subjects produced an erroneous memory conceptually related to other memories and judged them as being remembered (rather than known) most of the time. One hypothesis is that facile processing driven by perceptual fluency may lead to the illusion of knowing, whereas when material pops to mind that is conceptually related to other memories, it may give rise to the illusion of remembering. This speculation awaits further research (see Rajaram & Roediger, in press, for related observations).

In another set of studies, Kelley and Jacoby studied how memory of past events may interfere with making good subjective judgments. Writers are frequently unable to judge whether what they have written is comprehensible, and a frequently suggested strategy, once a paper is written, is to put it away for a few weeks before revising it. Presumably this advice capitalizes on the intuition that our judgment of the goodness of our writing will be better once we have forgotten what we wanted to say and why we wrote what we did; if we wait a while,

we can look at our writing more as someone just coming to it, without being quite so egocentric. Kelley and Jacoby studied these fascinating processes of judgment with an anagram solution task. When subjects had studied anagrams, they solved them faster on a later test (a *priming effect*), but they *misattributed* this ease to properties of the anagram rather than to their previous experience. Subjects' ordering of the general difficulty of the anagrams was different when the anagrams had been studied than when they had not; presumably, when subjects had studied solutions to the anagrams, they partly used fluency to determine the ease of arriving at the anagram's solution, or they relied more on nonanalytic bases of judgment. When anagrams had not been studied, subjects probably used more deliberate, rule-based judgments. Thus, somewhat paradoxically, experience within a domain may reduce one's ability to assess how others assess and comprehend the same information, a form of adult egocentrism (as Kelley and Jacoby call it) that doubtless afflicts us all. All college professors have had the experience of explaining an interesting point, with what they imagine to be great clarity, only to be confronted with the befuddled looks of most of the students in the class.

Illusions of Perception and Memory

The illusions arising from perceptual fluency discussed in the previous section document the intimate link between perceiving and remembering, which can be easily demonstrated either during the encoding or retrieval phase of memory experiments (as in the work of Jacoby and Kelley). Many illusions seem to lie on the border of perceiving and remembering. Consider the thought experiment of testing subjects' retention of the shapes in Fig. 1. If they were simply shown the figures with instructions to attend to the shaded space and then asked, a few moments later, which was wider and shorter, the one on the right or the one on the left, they would doubtless respond that it was the one on the right. They would of course be wrong, as the shaded portions are identical. Is this an illusion of perception? an

illusion of memory? or is it both? If the original event is wrongly perceived, then usually the resulting memory will be wrong too, unless some other factor corrects the false perception later (making memory for the event better, in a sense).

Another issue: Are sensory memories (iconic and echoic) veridical, or illusory, or both, in different aspects? Sensory memories are thought to be *quite faithful replicas of the original experience*, at least for their brief lifetimes. On the other hand, the perceiver/rememberer still experiences events as being perceived that have disappeared. So perhaps sensory memories have both veridical and illusory aspects. Like the questions above, this one about sensory memories is difficult to answer conclusively. Similarly, the illusory phenomenon known as the McCollough effect (McCollough, 1965) can last for days. (The McCollough effect is an illusion of color that is contingent on the particular orientation of adaptation and test lines.) Is it a phenomenon of erroneous perception, of memory, or both? These questions also illustrate again the difficulty of rigorously defining what an illusion is; such a definition has thus far eluded psychologists studying perceiving and it will probably be even more difficult to achieve for remembering.

Several other types of illusion are also difficult to classify as perceptual or as memorial and both labels likely apply. Part of the problem is that the operational procedures for studying perception and memory are often formally quite similar. In many experiments on perception of words or pictures, the stimuli are presented very briefly and subjects are asked to report what they saw (or heard) as soon as possible, or they are asked to make a rapid decision or judgment about the event. In many memory experiments words and pictures are shown and the subjects are asked, after some retention interval, to recall what occurred or to make a judgment about the presented events. Often the primary differences in the situations are (a) the duration of the original display, (b) the amount of time before a report or judgment is required, and (c) the nature of the query (what did you perceive? versus

what do you remember?). Obviously, the experimental situations blend into one another and it is impossible to say when perceiving is completed and remembering takes over in subjects' reports.

One memory illusion at the border between perceiving and remembering is the phenomenon of boundary extension, studied by Intraub and her collaborators. Observers view a picture and then later remember seeing more of the scene than was actually shown; it is as though the scene's boundaries have become extended when it is remembered. The effect occurs both in recall and recognition tests (Intraub & Richardson, 1989; Intraub, Bender & Mangels, 1992). In this issue, Intraub, Gottesman, Willey, and Zuk examine the effects of brevity of exposure on the phenomenon, as well as testing after very short delays. They found that the effect occurs even when exposure durations for the studied pictures are quite brief (250 or 333 ms) and when the retention interval is only 1 s. In conjunction with other evidence, they interpret the illusion as arising just after a picture is perceived. In particular, subjects interpret a picture in terms of a perceptual schema that contains information likely to exist just outside the actual picture. When the scene is comprehended, subjects remember information that did not actually exist in the picture, but only in their schema used to comprehend the picture. The error is clearly memorial, in one sense, because boundary extension does not occur while subjects are looking at the scene, so it is not a perceptual illusion in the usual sense. However, the Intraub et al. results show that the illusion develops very rapidly upon offset of the picture, presumably as it is still being interpreted. Therefore, the phenomenon falls at the boundary between perceiving and remembering.

Another illusion falling at this boundary is representational momentum (Freyd & Finke, 1984). In the original experiments, subjects received three computer animated rectangles (called inducing stimuli) and then later had to judge whether a fourth stimulus, the probe or test stimulus, occurred in the same position as the last inducing stimulus. On some occasions

the three inducing stimuli implied rotation in either a clockwise or a counterclockwise direction. The interesting finding was that subjects were more likely to respond *same* to the probe stimulus if it was slightly forward of the final inducing stimulus in the direction of implied motion, as if the representation of the motion of the inducing stimuli had momentum and was carried forward (hence the name). The effect increased with the velocity of the implied motion and is not due to eye movements (see Hubbard, 1995, for a review). Again, it is difficult to classify this illusion as perceptual, mnemonic, or both.

A third and final case to be considered is that of illusory conjunctions in perceiving, a topic of study introduced by Treisman and Schmidt (1982). Subjects are presented quite briefly with stimuli that contain several features, such as letters that differ in color (e.g., a blue R, a red M, a green C, and so on). The interesting observation, now replicated many times, is that subjects will often report seeing objects that represent illusory conjunctions of features, such as a red R or a blue C in the above example. Because the displays are so rapid in this research, these errors have a perceptual feel, yet they occur at a short interval after the perceptual display has disappeared. However, as we see in the next section, illusory conjunctions also arise in remembering.

Illusory Conjunctions in Memory

Underwood and Zimmerman (1973) and Underwood, Kapelak, and Malmi (1976) introduced a way of studying illusory conjunctions in memory by presenting compound words for subjects to study (e.g., handstand, shotgun). Later subjects were tested for recognition of previously studied words, words that had one syllable in common with the studied words (handmaid) or, in the most interesting case, words in which both syllables had been previously studied (handgun, in this example). Subjects produced more false alarms to the conjunction test items like *handgun* than to either words with one syllable of overlap with the studied word or control words that were unrelated to the studied words. The effect was

rather small but Reinitz, Lammers, and Cochran (1992) and Reinitz, Morrissey, and Demb (1994) replicated it and showed similar results in encoding of faces (see too Solso & McCarthy, 1981). The interpretation of such illusory conjunctions in memory, as in perception, is that features may not be tightly bound together into unitized wholes. Rather, features are free-floating to some degree and, when two features are combined from different units, they may be falsely recognized.

Two papers in the current issue use the illusory conjunction paradigm to explore the roles of attention and consolidation in encoding. Interestingly, both sets of researchers also used a neuropsychological approach in which patients with memory disorders arising from brain damage were tested. Reinitz, Verfaellie, and Milberg compared amnesic patients to control subjects in the basic recognition paradigm in which subjects are tested with previously studied words, conjunction words (the two syllables have been presented, but in different words), feature words (one syllable has been studied and the other is new), or completely new words. Control subjects showed the pattern expected from prior experiments: The hit rate for studied words was much higher than the false alarm rate for conjunction words, and in turn this false alarm rate was higher than that for either feature words or new words. Amnesic patients showed a different pattern in that they were unable to discriminate between studied words and conjunction words. The patients seemed not to have formed a global representation of the words, because parts of the words could "float" and be erroneously joined together, leading to false alarm rates as high as the hit rates.

Kroll, Knight, Metcalfe, Wolf, and Tulving use a variant of the illusory conjunction paradigm on patients having left, right, or bilateral hippocampal damage. In a running recognition task in which subjects judged every presented word as old or new, items could represent either previously studied items, conjunction items, single feature items, or completely new items. They found that patients with left hippocampal damage classified more conjunc-

tion items as old (i.e., they produced more false alarms on these items) relative to normal subjects or those with right hippocampal damage. Kroll et al. interpreted these results, and those from a similar experiment involving pictures, as evidence for a binding process during consolidation of information occurring via the hippocampus.

The illusory conjunction paradigm using words, pictures, or faces may prove to be important in the study of false memories. It is also worth noting that both papers discussed here (and the one by Schacter et al. described previously) used memory-disordered patients to study memory illusions. Certain patients, especially those with damage to the frontal lobes and to the areas surrounding the hippocampus, display profound memory disorders. Although amnesic patients—those with damage in and around the hippocampus who are rendered incapable of consciously recollecting newly presented information—represent an interesting type of disorder, those patients with frontal damage who confabulate and claim to remember events that never happened may turn out to be just as interesting in the study of memory illusions (Johnson, 1991; Moscovitch, in press; Schacter, Curran, Galuccio, Milberg, & Bates, in press).

Hypnosis and Guessing Effects

The use of hypnosis in attempts to aid memory retrieval has a long and checkered history. The topic has been examined intensively for the past 20 to 30 years and there now seems general agreement that hypnosis does not serve as the key to unlock forgotten memories, as some had hoped (see Smith, 1983, and Lynn & Nash, 1994, for reviews and discussion). Relative to appropriate control groups, hypnotized subjects generally recall no more veridical information than do control subjects and, on the few occasions when they have been shown to do so (e.g., Dywan & Bowers, 1983), the increased recall comes only at the expense of an increase in errors, suggesting a general criterion shift.

Although hypnosis does not lead to enhanced accuracy of retrieval, there is mount-

ing evidence that hypnosis leads to illusory memories (e.g., Lynn & Nash, 1994; Whitehouse, Orne, Orne, & Dinges, 1991). Subjects under hypnosis are often encouraged to generate everything they can think of to free associate about the event they are trying to remember. Much of the information obtained under this state is erroneous, although some is correct (but no more than that retrieved by nonhypnotized control subjects given extra time). The difficulty comes later when subjects (back in their normal waking state) try to distinguish what actually happened in the target event from what they recalled during hypnosis. The available evidence shows that subjects who score high on hypnotic susceptibility scales often confuse events they retrieved under hypnosis with those that actually occurred and that they cannot even distinguish the memories they retrieved under hypnosis from those that they retrieved prior to the hypnotic session (Sheehan, 1988; Lynn and Nash, 1994; Whitehouse et al., 1991).

These findings of false memories induced by hypnosis bear many points of similarity with phenomena discussed previously. In a sense, hypnotized subjects are encouraged to provide their own misinformation about events during the hypnotic session and it may even be that such internally generated misinformation (in the form of guesses of what might have happened) could be even more powerful than externally presented misinformation in creating interference, although this hypothesis awaits experimental test. At the very least, subjects who are queried later seem to display reality monitoring and source monitoring confusions, not being able to tell what actually happened from descriptions that they produced while hypnotized. In addition, the Jacoby et al. (1989) attributional approach may help here, because as Schacter (1995) has noted, "The evidence suggests that hypnosis creates a retrieval environment in which people are more willing than usual to call a mental experience a 'memory,' and in which they express a great deal of confidence in both true and false memories" (p. 17).

Although most researchers attribute the illu-

sions created when subjects are hypnotized to the state of hypnosis per se, it may be that they are caused in part by the instructions during hypnosis that lead people to produce erroneous information. That is, it may well be that nonhypnotized subjects who are instructed to guess during retrieval will show the same difficulties in later monitoring their recollections that hypnotized subjects show. Studies briefly reported in Jacoby et al. (1989, p. 413) and Roediger, Wheeler, and Rajaram (1993, pp. 114–122) provide evidence for this hypothesis (although neither study used groups tested under hypnosis for comparison). For example, Roediger et al. used a forced recall procedure in which subjects were made to guess during recall. They later asked subjects to rate all items they had produced as to whether the response actually occurred during the study phase of the experiment. They found that subjects who had guessed often judged that their erroneous responses, presumably produced as guesses, had actually occurred. Therefore, it may be that the act of guessing while retrieving information about an event produces false memories even when subjects are not hypnotized. However, study of this possibility is just beginning.

CONCLUSIONS

Perceptual illusions have been thoroughly studied for nearly 150 years, whereas memory illusions have been intensively studied for (perhaps) 30 years. Like perceptual illusions, there are doubtless many types of memory illusions that are caused by different factors. We are as unlikely to find unitary explanations of memory illusions as we are of perceptual illusions.

This essay has touched on only some illusions that can be considered memory illusions. My survey in the second half of this paper was motivated more by setting the stage for articles in the special issue than by an exhaustive review of the relevant phenomena. I conclude by noting briefly a number of phenomena and issues that deserve attention and that have not been emphasized here.

- Individual differences represent a rich

source of information. Are some types of people more susceptible to memory illusions than others? Considerable work has already been conducted with children in an attempt to determine how accurately they remember, especially for the practical purpose of whether children's testimony should be admitted in court (see Ceci & Bruck, 1995, for a comprehensive review). The research activity with older people has also begun, but is less voluminous. For example, Johnson and her collaborators have asked if reality and source monitoring is less accurate for children and for older adults than for young adults (e.g., Foley, Johnson, & Raye, 1983; Hashtroudi, Johnson, & Chrosniak, 1989). Similarly, other studies have shown that people high in imagery ability are more likely to be confused in a reality monitoring paradigm after imagining events than are poor imagers (Johnson, Raye, Wang & Taylor, 1979). As already noted above, another rich source of information is that supplied by various patient populations, as in the Kroll et al., Reinitz et al., and Schacter et al. papers appearing in this issue. Finally, people who score high on scales of hypnotic suggestibility are more easily led to memory illusions than are those who score low.

- Illusions of judging and deciding. Many cognitive illusions discovered by psychologists studying judgment and decision making have a memorial basis. For example, the availability heuristic (Tversky & Kahneman, 1974) refers to the tendency of decision makers to assess the frequency of events by the ease with which instances come to mind. So, for example, subjects judge that more people die from shark attacks than from being hit by falling parts from airplanes, but actually the chances of dying from falling airplane parts are 30 times higher (Plous, 1993). Hindsight bias and the knew-it-all-along effect may similarly be caused by problems in assessing our own metamemories (Fischhoff, 1975; Wood, 1978). After something has happened, we can no longer access our mental state prior to the happening, to see how unlikely we might then have judged the event to be. (The processes may be similar to those studied by Kelley and

Jacoby, this issue.) In a different arena, people notice and remember streaks of events and may then judge them as representative of a general rule, even though careful analyses show that these streaks are probably occurring no more than would be expected by chance. For example, basketball players' belief in the phenomenon of the hot hand—that players suddenly get hot and make streaks of shots—is probably due to this illusion of perceiving and remembering clusters in a random sequence (Gilovich, Vallone, & Tversky, 1985). These and other examples of phenomena of bias and illusion in judgment, often studied more by social psychologists than by cognitive psychologists, seem to have their basis in memory illusions (see Gilovich, 1991; Piattelli-Palmarini, 1994; and Plous, 1993, for surveys of these phenomena). Just as there is no firm dividing line between illusions of perceiving and remembering, there is no firm line between illusions of remembering and those of judging and deciding. Future work may seek commonalities that underlie illusions in different domains.

- Other illusions of metacognition. The study of metacognition—the assessment of our own knowledge of how we learn and what we know—has greatly informed the study of memory illusions. Studies of source monitoring, of remember/know judgments, and of over- and underconfidence in decisions all rely on metamemory judgments. However, the study of metacognition is rife with other possibilities (see Nelson, 1992, for an introduction). Whenever our metacognitive monitoring fails to track our performance accurately (and especially when our judgments about our performance are totally at odds with our behavior), our judgments reflect an illusion of knowing. For example, Nelson and Leonesio (1988) showed that subjects would continue to study material (under self-paced study conditions) in attempting to master it, even though the additional study time produced little or no gain in performance. Subjects could not accurately monitor when to call it quits in studying the information, which Nelson and Leonesio (1988) referred to as the labor-in-vain effect. In a

related example, Glenberg, Wilkinson, and Epstein (1982) reported an illusion of knowing in which subjects' ratings of how well they comprehended a passage failed to correlate with how well they could later answer questions about it (but see Weaver, 1991, for some limitations on this finding). These examples could be extended (see Nelson, 1992).

Two of the most famous illusions of memory—*déjà vu* and *jamais vu*—are illusions of metacognition. In the former case, which we have considered, people suffer the strange feeling that a new situation is very familiar; as noted, Jacoby and Whitehouse (1989) analyzed this feeling as possibly arising from misattributed perceptual fluency in the apparently new situation. *Jamais vu* is the failure to find familiar something that was recently experienced and should feel familiar. An experimental example may be the phenomenon of the recognition failure of recallable words, reported by Tulving and Thomson (1973). Subjects fail to recognize in one context that a word has recently been presented, yet they can recall that word as a recently experienced episode with a different cue. In pathological cases, amnesic patients fail to recognize as familiar events that have been recently experienced and that can be produced in implicit or indirect tests of memory (Warrington & Weiskrantz, 1968; Graf, Squire, & Mandler, 1985). However, the concept of *jamais vu* has been given very little attention and the two phenomena mentioned here are not usually raised in this context (although they seem to fit the definition).

- The topic of memory illusions has not been confined to the psychologists' laboratory, but is now a topic of concern in several areas of society. The accuracy of eyewitness testimony (Munsterberg, 1908; Loftus, 1979) is of long-standing interest. The problem of false identification of suspects and false reports of details in criminal investigations is of prime concern. Recently, the issue of memories that appear to be recovered in therapy (often an adult recalling being abused as a child) has been a topic of much debate (see Lindsay & Read, 1994; Loftus, 1993a). Do

these recovered memories represent accurate recollections, or are they false memories induced during the process of therapy (by imagining events, by reading about related events, and from therapist suggestions)? Another topic of interest outside the lab is how groups, societies and cultures may systematically misremember their past. Such studies cross disciplinary boundaries, and sociologists and historians are more likely to investigate these topics than are psychologists. Kammen (1995) reports on some commonly believed distortions of American history, and Schudson (1995) reflects on the dynamics that may underlie distortions in collective memories of the past.

All the examples in this section further support the basic premise of this essay and, indeed, of the special issue. Memory illusions exist, they are robust, they come in many types, and they are worthy of systematic study. Just as with perceptual illusions, memory illusions should be considered an established topic whose understanding is critical to develop a successful understanding of remembering. Indeed, the past 30 years has seen an impressive body of scholarship develop on memory illusions, although often under disparate labels and in seemingly unrelated areas of research. The theme of this essay is that we may want to consider interconnections among these topics, to permit them to inform one another. In addition, we should pursue the cases in which remembering is erroneous to inform our theories of memory. As in the study of perception, clues generated from studying illusions may serve as a crucible for testing theories of memory.

REFERENCES

- ALBA, J. W., & HASHER, L. (1983). Is memory schematic? *Psychological Bulletin*, 93, 203-231.
- ANDERSON, R. E. (1984). Did I do it or did I only imagine doing it? *Journal of Experimental Psychology: General*, 113, 594-613.
- ANISFELD, M., & KNAPP, M. (1968). Association, synonymy, and directionality in false recognition. *Journal of Experimental Psychology*, 77, 171-179.
- ATKINSON, R. C., & JUOLA, J. F. (1973). Factors influencing speed and accuracy of word recognition. In S. Kornblum (Ed.), *Attention and performance IV* (pp. 583-612). New York: Academic Press.
- BADDELEY, A. D. (1976). *The psychology of memory*. New York: Harper & Row.
- BARTLETT, F. C. (1932). *Remembering: A study in experimental and social psychology*. Cambridge, England: Cambridge Univ. Press.
- BENEDETTI, F. (1985). Processing of spatial tactile information with crossed fingers. *Journal of Experimental Psychology: Human Perception and Performance*, 11, 517-525.
- BOAS, F. (1901). Kathlamet texts. *Smithsonian Institution Bureau of American Ethnology Bulletin*, 26, 182-186.
- BOWER, G. H., BLACK, J. B., & TURNER T. J. (1979). Scripts in memory for text. *Cognitive Psychology*, 11, 177-220.
- BRANSFORD, J. D., BARCLAY, J. R., & FRANKS, J. J. (1972). Sentence memory: A constructive versus interpretive approach. *Cognitive Psychology*, 3, 193-209.
- BRANSFORD, J. D., & FRANKS, J. J. (1971). The abstraction of linguistic ideas. *Cognitive Psychology*, 2, 331-350.
- BREWER, W. F. (1977). Memory for the pragmatic implications of sentences. *Memory and Cognition*, 5, 673-678.
- BREWER, W. F., & NAKAMURA, G. V. (1984). The nature and function of schemas. In R. S. Wyer & T. K. Srull (Eds.), *Handbook of social cognition*. Hillsdale, NJ: Erlbaum.
- BROADBENT, D. E. (1958). *Perception and communication*. New York: Pergamon.
- BRUNER, J. S., & POTTER, M. C. (1964). Interference in visual recognition. *Science*, 144, 424-425.
- CARMICHAEL, L., HOGAN, H. P., & WALTERS A. A. (1932). An experimental study of the effect of language on the reproduction of visually perceived form. *Journal of Experimental Psychology*, 15, 73-86.
- CECI, S. J., & BRUCK, M. N. (1993). Suggestibility of the child witness: A historical review and synthesis. *Psychological Bulletin*, 113, 403-439.
- CECI, S. J., & BRUCK, M. (1995). *Jeopardy in the courtroom: A scientific analysis of children's testimony*. Washington, DC: American Psychological Association Press.
- CONRAD, R. (1964). Acoustic confusions in immediate memory. *British Journal of Psychology*, 55, 75-84.
- COREN, S., & GIGUS, J. S. (1978). *Seeing is deceiving: The psychology of visual illusions*. Hillsdale, NJ: Erlbaum.
- CRAMER, P. (1965). Recovery of a discrete memory. *Journal of Personality and Social Psychology*, 1, 326-332.
- DEESE, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology*, 58, 17-22.
- DREVER, J. (1964). *A dictionary of psychology*. New York: Penguin.
- DYWAN, J., & BOWERS, K. S. (1983). The use of hypnosis to enhance recall. *Science*, 222, 184-185.
- EBBINGHAUS, H. (1885/1964). *Memory: A contribution*

- to experimental psychology. (H. A. Ruger & C. E. Bussenius, Trans.). New York: Dover Publications.
- ERDELYI, M. H. (1985). *Psychoanalysis: Freud's cognitive psychology*. New York: Freeman.
- ERDELYI, M. H., & GOLDBERG, B. (1979). Let's not sweep repression under the rug: Toward a cognitive psychology of repression. In J. F. Kihlstrom & F. J. Evans (Eds.), *Functional disorders of memory* (pp. 355-402). Hillsdale, NJ: Erlbaum.
- FARAH, M. J. (1989). The neural basis of mental imagery. *Trends in Neurosciences*, **12**, 395-399.
- FISCHOFF, B. (1975). Hindsight is not equal to foresight: The effects of outcome knowledge on judgment under uncertainty. *Journal of Experimental Psychology: Human Perception and Performance*, **1**, 288-299.
- FOLEY, M. A., JOHNSON, M. K., & RAYE, C. L. (1983). Age-related changes in confusion between memories for thoughts and memories for speech. *Child Development*, **54**, 51-60.
- FREUD, S. (1895). Project for a scientific psychology. *The standard edition of the complete psychological works of Sigmund Freud*, Vol. I (pp. 295-397). London: Hogarth Press.
- FREUD, S. (1903/1965). *The psychopathology of everyday life*. (J. Strachey, Trans., Ed.). New York: Norton.
- FREUD, S. (1910). Leonardo da Vinci and memory of his childhood. *The standard edition of the complete works of Sigmund Freud*, Vol. XI (pp. 63-137). London: Hogarth Press.
- FREYD, J. J., & FINKE, R. A. (1984). Representational momentum. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **10**, 126-132.
- GARRY, M., MANNING, C. G., LOFTUS, E., & SHERMAN, S. J. (in press). Imagination inflation: Imagining a childhood event inflates confidence that it occurred. *Psychonomic Bulletin & Review*.
- GAULD, A., & STEPHENSON, G. M. (1967). Some experiments related to Bartlett's theory of remembering. *British Journal of Psychology*, **58**, 39-49.
- GILLUND, G., & SHIFFRIN, R. M. (1984). A retrieval model for both recognition and recall. *Psychological Review*, **91**, 1-67.
- GILOVICH, T. (1991). *How we know what isn't so: The fallibility of human reason in everyday life*. New York: The Free Press.
- GILOVICH, T., VALLONE, R., & TVERSKY, A. (1985). The hot hand in basketball: On the misperception of random sequences. *Journal of Personality and Social Psychology*, **17**, 295-314.
- GLANZER, M., & CLARK, W. H. (1963). The verbal loop hypothesis: Binary numbers. *Journal of Verbal Learning and Verbal Behavior*, **2**, 301-309.
- GLENBERG, A., WILKINSON, A. C., & EPSTEIN, W. (1982). The illusion of knowing: Failure in the self-assessment of comprehension. *Memory & Cognition*, **10**, 597-602.
- GRAF, P., SQUIRE, L. R., & MANDLER, G. (1984). The information that amnesic patients do not forget. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **10**, 164-178.
- GREGORY, R. L. (1970). *The intelligent eye*. London: Neiderfield & Nicolson.
- GREGORY, R. L., & GOMBRICH, E. H. (1973). *Illusion in nature and art*. London: Duckworth.
- HALL, J. F., & KOZLOFF, E. E. (1973). False recognitions of associates of converging versus repeated words. *American Journal of Psychology*, **86**, 133-139.
- HARRIS, R. J. (1974). Memory and comprehension of implications and inferences of complex sentences. *Journal of Verbal Learning and Verbal Behavior*, **13**, 626-637.
- HASHER, L., & GRIFFIN, M. (1978). Reconstructive and reproductive processes in memory. *Journal of Experimental Psychology: Human Learning and Memory*, **4**, 318-330.
- HASHTRUDI, S., JOHNSON, M. K., & CHROSNIAK, L. D. (1989). Aging and source monitoring. *Psychology and Aging*, **4**, 106-112.
- HELMHOLTZ, H. VON. (1903). *Popular lectures on scientific subjects*. (E. Atkinson, Trans.). New York: Longmans, Green. [Original work published 1881]
- HERSHENSON, M. (1989). *The moon illusion*. Hillsdale, NJ: Erlbaum.
- HINTZMAN, D. L. (1988). Judgments of frequency and recognition memory in a multiple-trace memory model. *Psychological Review*, **95**, 528-551.
- HUBBARD, T. L. (1995). Environmental invariants in the representation of motion: Implied dynamics and representational momentum, gravity, friction, and centripetal force. *Psychonomic Bulletin & Review*, **2**, 322-338.
- HYMAN, I. E., & PENTLAND, J. (1996). The role of mental imagery in the creation of false childhood memories. *Journal of Memory and Language*, **35**, 101-117.
- INTRAUB, H., GOTTESMAN, C. V., WILLEY, E. V., & ZUK, I. J. (1996). Boundary extension for briefly glimpsed photographs: Do common perceptual processes result in unexpected memory distortions? *Journal of Memory and Language*, **35**, 118-134.
- INTRAUB, H., & RICHARDSON, M. (1989). Wide-angle memories of close-up scenes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **15**, 179-187.
- INTRAUB, H., BENDER, R., & MANGELS, J. (1992). Looking at pictures but remembering scenes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **18**, 180-191.
- ITTELSON, W. H. (1952). *The Ames demonstrations in perception*. Princeton, NJ: Princeton Univ. Press.
- ITTELSON, W. H., & KILPATRICK, F. P. (1951). Experiments in perception. *Scientific American*, **185**, 50-55.
- JACOBY, L. L., ALLEN, L. G., COLLINS, J. C., & LARWILL, L. K. (1988). Memory influences subjective experience: Noise judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **14**, 240-247.

- JACOBY, L. L., & DALLAS, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General*, **110**, 306–340.
- JACOBY, L. L., KELLEY, C. M., & DYWAN, J. (1989). Memory attributions. In H. L. Roediger & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 391–422). Hillsdale, NJ: Erlbaum.
- JACOBY, L. L., & WHITEHOUSE, K. (1989). An illusion of memory: False recognition influenced by unconscious perception. *Journal of Experimental Psychology: General*, **118**, 126–135.
- JAMES, W. (1890). *Principles of psychology*. New York: Dover.
- JOHNSON, M. K. (1983). A modular model of memory. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 17, pp. 81–123). New York: Academic Press.
- JOHNSON, M. K. (1991). Reality monitoring: Evidence from confabulation in organic brain disease patients. In G. P. Prigatano & D. L. Schacter (Eds.), *Awareness of deficit after brain injury: Clinical and theoretical issues* (pp. 176–197). New York: Oxford Univ. Press.
- JOHNSON, M. K. (1995). *The relation between memory and reality*. Paper presented at the 103rd Annual convention of the American Psychological Association: New York, NY.
- JOHNSON, M. K., BRANSFORD, J. D., & SOLOMON, S. K. (1973). Memory for tacit implications of sentences. *Journal of Experimental Psychology*, **98**, 203–205.
- JOHNSON, M. K., FOLEY, M. A., SUENGAS, A. G., & RAYE, C. L. (1989). Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General*, **117**, 371–376.
- JOHNSON, M. K., HASHTROUDI, S., & LINDSAY, D. S. (1993). Source monitoring. *Psychological Bulletin*, **114**, 3–28.
- JOHNSON, M. K., NOLDE, S. F., & DE LEONARDIS, D. M. (1996). Emotional focus and source monitoring. *Journal of Memory and Language*, **35**, 135–156.
- JOHNSON, M. K., & RAYE, C. L. (1981). Reality monitoring. *Psychological Review*, **88**, 67–85.
- JOHNSON, M. K., RAYE, C. L., WANG, A. Y., & TAYLOR, T. H. (1979). Fact and fantasy: The role of accuracy and variability in confusing imaginations with perceptual experiences. *Journal of Experimental Psychology: Human Learning and Memory*, **5**, 229–240.
- JOHNSON, M. K., TAYLOR, T., & RAYE, C. L. (1977). Fact and fantasy: The effects of internally generated events on the apparent frequency of externally generated events. *Memory and Cognition*, **5**, 116–122.
- JAMEN, M. (1995). Some patterns and meanings of memory distortion in American history. In D. L. Schacter, J. T. Coyle, G. D. Fischbach, M. M. Mesulam, and L. E. Sullivan (Eds.), *Memory distortion* (pp. 329–345). Cambridge, MA: Harvard Univ. Press.
- KELLEY, C. M., & JACOBY, L. L. (1990). The construction of subjective experience: Memory attributions. *Mind & Language*, **5**, 49–68.
- KELLEY, C. M., & JACOBY, L. L. (1996). Adult egocentrism: Subjective experience versus analytic bases for judgment. *Journal of Memory and Language*, **35**, 157–175.
- KINTSCH, N. (1995). Introduction. In Bartlett, F. C. *Remembering: A study in experimental and social psychology* (pp. xi–xv). Cambridge: Cambridge Univ. Press.
- KOLERS, P. A. (1964). The illusion of movement. *Scientific American*, **211**, 98–108.
- KORIAT, A., & GOLDSMITH, M. (in press). Memory metaphors and the laboratory/real life controversy: Correspondence versus storehouse views of memory. *Behavioral and Brain Sciences*.
- KROLL, N. E. A., KNIGHT, R. T., METCALFE, J., WOLF, E. S., & TULVING, E. (1996). Cohesion failure as a source of memory illusions. *Journal of Memory and Language*, **35**, 176–196.
- LINDSAY, D. S., & JOHNSON, M. K. (1989). The eyewitness suggestibility effect and memory for source. *Memory and Cognition*, **17**, 349–358.
- LINDSAY, D. S., & KELLEY, C. M. (1996). Creating illusions of familiarity in a cued recall Remember/Know paradigm. *Journal of Memory and Language*, **35**, 197–211.
- LINDSAY, D. S., & READ, J. D. (1994). Psychotherapy and memories of childhood sexual abuse: A cognitive perspective. *Applied Cognitive Psychology*, **8**, 281–338.
- LOFTUS, E. F. (1979a). *Eyewitness testimony*. Cambridge: Harvard Univ. Press.
- LOFTUS, E. F. (1979b). The malleability of memory. *American Scientist*, **67**, 312–320.
- LOFTUS, E. F. (1993a). The reality of repressed memories. *American Psychologist*, **48**, 518–537.
- LOFTUS, E. F. (1993b). Made in memory: Distortions in recollection after misleading information. In D. L. Medin (Ed.), *The psychology of learning and motivation: Advances in theory and research* (pp. 187–215). New York: Academic Press.
- LOFTUS, E. F., MILLER, D. G., & BURNS, H. J. (1978). Semantic integration of verbal information into a visual memory. *Journal of Experimental Psychology: Human Learning and Memory*, **4**, 19–31.
- LOFTUS, E. F., & PALMER, J. C. (1974). Reconstruction of automobile destruction: An example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior*, **13**, 585–589.
- LYNN, S. J., & NASH, M. R. (1994). Truth in memory: Ramifications for psychotherapy and hypnotherapy. *American Journal of Hypnosis*, **36**, 194–208.
- MANDLER, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review*, **87**, 252–271.

- McCOLLOUGH, D. (1965). Color adaptation of edge-detectors in the human visual system. *Science*, **149**, 1115-1116.
- McDERMOTT, K. B. (1996). The persistence of false memories in list recall. *Journal of Memory and Language*, **35**, 212-230.
- McGEOCH, J. A. (1932). Forgetting and the law of disuse. *Psychological Review*, **39**, 352-370.
- MELCHER, J. M., & SCHOOLER, J. W. (1996). The misremembrance of wines past: Verbal and perceptual expertise differentially mediate verbal overshadowing of taste memory. *Journal of Memory and Language*, **35**, 231-245.
- MELTON, A. W., & IRWIN, J. M. (1940). The influence of degree of interpolated learning on retroactive inhibition and the overt transfer of specific responses. *American Journal of Psychology*, **53**, 173-203.
- MILLER, G. A. (1956a). Human memory and the storage of information. *IRE Transactions on Information Theory*, **IT-2**, 129-137.
- MILLER, G. A. (1956b). The magical number seven plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, **63**, 81-97.
- MITCHELL, K. J., & ZARAGOZA, M. S. (1996). Repeated exposure to suggestion and false memory: The role of contextual variability. *Journal of Memory and Language*, **35**, 246-260.
- MOSCOVITCH, M. (1995). Confabulation. In D. L. Schacter, J. T. Coyle, G. D., & Fischbach, M. M., Mesulam, and L. E. Sullivan (Eds.), *Memory distortion* (pp. 226-251). Cambridge, MA: Harvard Univ. Press.
- MÜLLER, G. E., & PILZECKER, A. (1900). Experimentelle Beiträge zur Lehre vom Gedächtnis. *Zeitschrift für Psychologie*, **1**, 1-300.
- MUNSTERSBERG, H. (1908). *On the witness stand: Essays on psychology and crime*. New York: Clark, Boardman, Doubleday.
- NEISSER, U. (1968). The processes of vision. *Scientific American*, **219**, 204-214.
- NEISSER, U. (1967). *Cognitive Psychology*. New York: Appleton-Century-Crofts.
- NELSON, T. O., & LEONESIO, R. J. (1988). Allocation of self-paced study time and the "labor-in-vain effect." *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **14**, 676-686.
- NELSON, T. O. (Ed.) (1992). *Metacognition: Core readings*. Boston, MA: Allyn and Bacon.
- OPPEL (1854). Über geometrisch-optische Täuschungen. *Jahresbericht des Frankfurter Vereins* 37-47.
- OWENS, J., BOWER, G. H., & BLACK, J. B. (1979). The "soap-opera" effect in story recall. *Memory and Cognition*, **7**, 185-191.
- PAUL, I. H. (1959). Studies in remembering: The reproduction of connected and extended verbal material. *Psychological Issues*, **1**, (Monograph 2), 1-152.
- PAUL, L. M. (1979). Two models of recognition memory: A test. *Journal of Experimental Psychology: Human Learning and Memory*, **5**, 45-51.
- PAYNE, D. G., ELIE, C. J., BLACKWELL, J. M., & NEUSCHATZ, J. S. (1996). Memory illusions: Recalling, recognizing and recollecting events that never occurred. *Journal of Memory and Language*, **35**, 261-285.
- PIATELLI-PALMARINI, M. (1994). *Inevitable illusions: How mistakes of reason rule our minds*. New York: Wiley.
- PLOUS, S. (1993). *The psychology of judgment and decision making*. New York: McGraw-Hill, Inc.
- POSNER, M. I., & KEELE, S. W. (1970). Retention of abstract ideas. *Journal of Experimental Psychology*, **83**, 304-308.
- POSTMAN, L., & UNDERWOOD, B. J. (1973). Critical issues in interference theory. *Memory and Cognition*, **1**, 19-40.
- RAJARAM, S., & ROEDIGER, H. L. (in press). Remembering and knowing as states of consciousness during recollection. In J. D. Cohen and J. W. Schooler (Eds.), *Scientific approaches to consciousness*. Cambridge, MA: MIT Press.
- REINITZ, M. T., LAMMERS, W. J., & COCHRAN, B. P. (1992). Memory-conjunction errors: Miscombination of stored stimulus features can produce illusions of memory. *Memory and Cognition*, **20**, 1-11.
- REINITZ, M. T., MORRISEY, J., & DEMB, J. (1994). The role of attention in face encoding. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **20**, 161-168.
- REINITZ, M. T., VERFAELLIE, M., & MILBERG, W. P. (1996). Memory conjunction errors in normal and amnesic subjects. *Journal of Memory and Language*, **35**, 286-299.
- REYNA, & BRAINERD (1995). Fuzzy-trace theory: An interim synthesis. *Learning and Individual Differences*, **7**, 1-75.
- RILEY, D. (1964). Memory for Form. In L. Postman (Ed.), *Psychology in the making: Histories of selected research problems*. New York: Knopf.
- ROEDIGER, H. L., JACOBY, J. D., & McDERMOTT, K. B. (1996). Misinformation effects in recall: Creating false memories through repeated retrieval. *Journal of Memory and Language*, **35**, 300-318.
- ROEDIGER, H. L., & McDERMOTT, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **21**, 803-814.
- ROEDIGER, H. L., WHEELER, M. A., & RAJARAM, S. (1993). Remembering, knowing and reconstructing the past. In D. L. Medin (Ed.), *The psychology of learning and motivation: Advances in theory and research* (Vol. 30, pp. 97-134). New York: Academic Press.
- ROSS, D. F., READ, J. D., & TOGLIA, M. P. (1994). *Adult eyewitness testimony: Current trends and developments*. Cambridge: Cambridge Univ. Press.
- SCHACHTER, S., & SINGER, J. (1962). Cognitive, social, and physiological determinants of emotional states. *Psychological Review*, **69**, 379-399.

- SCHACTER, D. L. (1995). Memory distortion: History and current status. In D. L. Schacter, J. T. Coyle, G. D. Fischbach, M. M. Mesulam, L. E. Sullivan (Eds.), *Memory distortion* (pp. 1-43). Cambridge, MA: Harvard Univ. Press.
- SCHACTER, D. L., CURRAN, T., GALLUCIO, L. D., MILBERG, W. P., & BATES, J. (in press). False recognition and the right frontal lobe: A case study. *Neuropsychologia*.
- SCHACTER, D. L., VERFAELLIE, M., & PRADERE, D. (1996). The neuropsychology of memory illusions: False recall and recognition in amnesic patients. *Journal of Memory and Language*, 35, 319-334.
- SCHOOLER, J. W., & ENGSTLER-SCHOOLER, T. Y. (1990). Verbal overshadowing of visual memories: Some things are better left unsaid. *Cognitive Psychology*, 22, 36-71.
- SCHUDSON (1995). Dynamics of distortion in collective memory. In D. L. Schacter, J. T. Coyle, G. D. Fischbach, M. M. Mesulam, and L. E. Sullivan (Eds.), *Memory distortion* (pp. 346-376). Cambridge, MA: Harvard Univ. Press.
- SHEEHAN, P. W. (1988). Memory distortion in hypnosis. *International Journal of Experimental and Clinical Hypnosis*, 36, 296-311.
- SHEPARD, R. N. (1981). Psychophysical complementarity. In M. Kubovy & J. Pomerantz (Eds.), *Perceptual organization* (pp. 279-341). Hillsdale, NJ: Erlbaum.
- SHIFFRIN, R. M., HUBER, D. E., & MARINELLI, K. (1995). Effects of category length and strength on familiarity in recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 267-287.
- SMITH, M. C. (1983). Hypnotic memory enhancement of witnesses: Does it work? *Psychological Bulletin*, 94, 387-407.
- SOLSO, R. L., & MCCARTHY, J. E. (1981). Prototype formation of faces: A case of pseudomemory. *British Journal of Psychology*, 72, 499-503.
- SPIRO, R. J. (1980). Accommodative reconstruction in prose recall. *Journal of Verbal Learning and Verbal Behavior*, 19, 84-95.
- SULIN, R. A., & DOOLING, D. J. (1974). Intrusion of a thematic idea in retention of prose. *Journal of Experimental Psychology*, 103, 255-262.
- TITCHENER, E. B. (1928). *A text-book of psychology*. New York: Macmillan.
- TREISMAN, A., & SCHMIDT, H. (1982). Illusory conjunctions in the perception of objects. *Cognitive Psychology*, 14, 107-141.
- TULVING, E. (1962). Subjective organization in free recall of "unrelated" words. *Psychological Review*, 69, 344-354.
- TULVING, E. (1964). Intratrial and intertrial retention: Notes towards a theory of free recall verbal learning. *Psychological Review*, 71, 219-237.
- TULVING, E. (1985). Memory and consciousness. *Canadian Psychologist*, 26, 1-12.
- TULVING, E., & THOMSON, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 80, 352-373.
- TVERSKY, A., & KAHNEMAN, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185, 1124-1130.
- UNDERWOOD, B. J. (1957). Interference and forgetting. *Psychological Review*, 64, 49-60.
- UNDERWOOD, B. J. (1965). False recognition produced by implicit verbal responses. *Journal of Experimental Psychology*, 70, 122-129.
- UNDERWOOD, B. J., KAPELAK, S. M., and MALMI, R. A. (1976). Integration of discrete verbal units in recognition memory. *Journal of Experimental Psychology: Human Learning and Memory*, 2, 293-300.
- UNDERWOOD, B. J., & ZIMMERMAN, J. (1973). The syllable as a source of error in multisyllable word recognition. *Journal of Verbal Learning and Verbal Behavior*, 12, 701-706.
- WARRINGTON, E. K., & WEISKRANTZ, L. (1968). A new method of testing long-term retention with special reference to amnesic patients. *Nature*, 217, 972-974.
- WEAVER, C. A. (1991). Constraining factors in the calibration of comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, 214-222.
- WEINGARDT, K. R., TOLAND, H. K., & LOFTUS, E. F. (1994). Reports of suggested memories: Do people truly believe them? In D. F. Ross, J. D. Read, and M. P. Toglia (Eds.), *Adult eyewitness testimony: Current trends and developments* (pp. 3-26). NY: Cambridge Univ. Press.
- WHEELER, M. A., & ROEDIGER, H. L. (1992). Disparate effects of repeated testing: Reconciling Ballard's (1913) and Bartlett's (1932) results. *Psychological Science*, 3, 240-245.
- WHITEHOUSE, W. G., ORNE, E. C., ORNE, M. T., & DINGES, D. F. (1991). Distinguishing the source of memories reported during prior waking and hypnotic recall attempts. *Applied Cognitive Psychology*, 5, 51-59.
- WHITTLESEA, B. W. A. (1993). Illusions of familiarity. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 6, 1235-1253.
- WHITTLESEA, B. W. A., JACOBY, L. L., & GIRARD, K. (1990). Illusions of immediate memory. *Journal of Memory and Language*, 29, 716-732.
- WOOD, G. (1978). The knew-it-all-along effect. *Journal of Verbal Learning and Verbal Behavior*, 4, 345-353.
- WULF, F. (1922). Über die veränderung von Vorstellungen. *Psychologische Forschung*, 1, 333-373.
- ZARAGOZA, M. S., & LANE, S. M. (1994). Source misattributions and the suggestibility of eyewitness memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20, 934-945.

(Received December 7, 1995)

(Revision received December 21, 1995)