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THE CAUSES AND CONSEQUENCES OF REMINDING

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We survive and thrive by making efficient use of our knowledge. When specific prior events are relevant to current situations, aspects of those past events are retrieved and guide us through the present. Sometimes this remembering is deliberate, but often we are *reminded* less by force of our own will than by the stimulus itself. Such instances of reminding reflect fundamental principles of association by similarity, as noted by early theorists in psychology (James, 1890; Woodworth, 1921). Reminding is ubiquitous in higher cognition and daily life, and has found a home in theoretical developments ranging from psychology to artificial intelligence.

It is thus surprising to find little mention of the concept of reminding in the literature on human memory. This absence likely reflects a historical shorthand in memory research, whereby study phases of experiments are considered to be encoding events and tests to be retrieval events. Current research has dispensed with part of this false dichotomy: Tests are now known to be potent learning events (Bjork, 1975; Karpicke & Roediger, 2008). The goal of this chapter is to consider the place of retrieval in learning events, and to demonstrate that the concept of reminding provides a useful unifying theme for memory phenomena that otherwise lack theoretical coherence. As we will demonstrate, the consequences of reminding can only be understood by jointly considering the inherent trade-off between conditions that promote likely reminding and conditions that promote potent reminding. This theoretical position follows naturally from the seminal work by the honoree of this festschrift, which both demonstrated the powerful mnemonic consequences of retrieval (Bjork, 1975; Whitten & Bjork, 1977) and considered the trade-off between likely and powerful retrieval opportunities (Finley, Benjamin, Hays, Bjork, & Kornell, 2010; Landauer & Bjork, 1978).

REMINDING IN HIGHER COGNITION

In many areas of higher-level cognition, research has emphasized the *abstract* knowledge people might use in accomplishing the task—rules or prototypes in categorization, domain-general problem-solving strategies, and generalized knowledge schemas. However, in each area, researchers have found it important to eschew an exclusive focus on abstract knowledge and consider how people might rely on the memory for specific earlier cases to accomplish the tasks. Reminding is thought to be the mechanism by which these relevant specific instances are brought to mind. In this section, we lay out three domains in which reminding has played a role in understanding phenomena in higher-level cognition.

Concept Learning

Concepts are the basic building blocks of cognition. They are critical in all cognitive areas, so how they are acquired has long been of interest. Bruner, Goodnow, and Austin (1956) proposed an active hypothesis-testing role for the learner: the generation and testing of rules about what features or combinations of features allow accurate determination of whether an item is or is not a member of a concept. Rosch (1975; Rosch & Mervis, 1975) later argued that concept representations should not be thought of as rules, but as prototypes—a set of features that vary in how typical they are of category members. Rather than either belonging or not belonging to the category, members could differ in how good a member they were as a function of how many prototype features they contained. Thus, a robin is a typical bird because it has the most common bird features (feathered, winged, small; flies, sings, eats worms, nests in trees), whereas a penguin is a less typical bird because it is large, does not fly, and eats fish. New items are classified by the prototype they are most similar to, and this same representation is used to classify all the instances in the category.

This reliance on building up and using abstract knowledge was challenged by both Medin (Medin & Schaffer, 1978) and Brooks (1978), who argued that prototype views are inadequate as conceptual representations. Rather, people often use much more specific knowledge in making classification judgments. The thrust of this exemplar view is that our memory is constantly encoding specific knowledge, with items consisting of related features and connections to context, and that the presentation of a new item probes memory for similar knowledge. The retrieval of similar items provides a useful means of determining category membership; items that are very similar are likely to be in the same category. The importance of this proposal is twofold. First, because it avoids the need for a generalization mechanism for prototypes, the assumption is simply that people store information about specific items from their interactions with these items. Second, it allows for addressing the various complexities one finds in categories, such as correlations among features. For example, typical birds are small and sing, but it would be unusual for a large bird to sing. The set of exemplars encodes these correlations.

The exemplar view is powerful, and has generally proven superior to prototype views in direct comparisons (e.g., Murphy, 2002; Ross & Makin, 1999). In the case of a new item that is very typical, it will be similar to many earlier items and thus easy to quickly classify. An atypical item will be similar to far fewer items, and will be more difficult to classify. The exemplar view has been extended in a number of ways, including providing an independent means of assessing similarity (Nosofsky, 1986) and a learning model that tunes the weight of various features (Kruschke, 1992). More recently, hybrid models have been introduced that include an exemplar component along with a rule learning module (Erickson & Kruschke, 1998). Some recent models challenge some aspects of how the specific knowledge of exemplars may influence classification (e.g., Love, Medin, & Gureckis, 2004), but no one questions the idea that specific knowledge influences classification. Even real-world tasks have shown large influences of this sort—for example, diagnoses by physicians with much experience in diagnosing dermatology cases are influenced by similarities to recently seen specific cases (Brooks, Norman, & Allen, 1991).

For unusual items, or items early in learning, remindings are particularly common. They can influence classification and affect learners' understanding of the category (e.g., Ross, Perkins, & Tenpenny, 1991). Even if a simple rule is given to learners and applied to new items, those new items that are very similar to earlier items may be classified differently than the rule predicts (Allen & Brooks, 1991). This research shows the importance of specific remindings in understanding classification behavior, and reveals that such behavior relies on more than abstract knowledge.

Problem Solving by Analogy

Problem solving is ubiquitous and important in everyday cognitive activities. Early developments in the field emphasized a characterization based on a representation of the problem as a problem space (the knowledge one has of the relevant world states and operators for transforming states) and the search of this space to find the goal state (Newell & Simon, 1972). Problem solving by analogy occurs when we try to solve a new problem by reference to an earlier problem and its solution. For example, students asked to solve a homework problem in a math course often look back through the book for similar examples. Problem solving often involves being reminded of an earlier experience and adapting it to the current situation.

Gick and Holyoak (1980, 1983) presented a series of studies that examined how people solve problems by analogy. The target problem was Duncker's tumor problem: A patient has a tumor that cannot be operated on, and the x-ray strength that can kill the tumor would also kill healthy tissue, resulting in death. The *convergence* solution is to position a set of lower-intensity machines around the body and have them converge at the tumor. Before attempting a solution to this problem, some subjects read a story about a general attacking a fortress that had roads to it mined to allow only small work details. He succeeded by splitting up his forces and having them converge on the fortress. Having this earlier experience increased the use of the convergence strategy for the tumor problem from 10 to 30%, but even this success rate is unimpressive. Perhaps they did not understand the story? No, when asked to summarize the story, performance was no better. Perhaps they did not understand the principle? No, when the principle was made explicit ("The general attributed his success to an important principle: If you need a large force to accomplish some purpose, but are prevented from applying such a force, many small forces applied simultaneously from different directions may work just as well"), performance was no better. Perhaps they did not think back to the earlier problem (i.e., get reminded)? Yes, when told they might want to use the earlier general story, performance increased to an impressive 80%.

Remindings are critical in learning through analogical problem solving. Without a teacher to tell the learner what earlier example to use, remindings determine whether the learner tries to apply an appropriate earlier solution that might help solve the current problem and perhaps help to learn to solve problems of this type, or tries to apply an inappropriate earlier solution unsuccessfully.

What affects which earlier experiences people get reminded of? Remindings are memory retrievals—the solver probes memory with

an initial analysis of the problem and retrieves experiences that match this in some respects. Experts may be able to make a deep analysis of a problem to be reminded of earlier problems with the same deep structure. However, novices often have more superficial analyses and characterize the problem in terms of the particular objects mentioned in the problem, such as the particular story content of a word problem (Chi, Feltovich, & Glaser, 1981; Ross, 1984). Although theories differ on what influences reminding, all propose that the remembering of an earlier example critically influences current problem solving (see Reeves & Weisberg, 1994, for a critical review). In addition, to the extent that remindings allow comparisons that might promote generalization, they may play an important role in learning within a domain (e.g., Gick & Holyoak, 1983; Ross & Kennedy, 1990).

Remindings are an important aspect of problem solving by analogy, a prevalent means of problem solving. In many cases, people do not rely on abstract knowledge, such as problem schemas or general rules, but think back to a specific earlier example and use that to help solve a current problem.

Understanding

One can think of the goal of understanding as the construction of an integrated representation that combines an input with prior knowledge. Early theories that attempted to bring prior knowledge to bear ran into a major obstacle—so much knowledge and so many inferences were needed that processing would not be possible in any reasonable time, for either people or machines (Rumelhart & Ortony, 1977; Schank & Abelson, 1977). The *schema* was an attempt to overcome this obstacle (e.g., Rumelhart & Ortony, 1977). A schema is a generalized knowledge structure that is used for understanding. Rather than combining all the relevant prior knowledge each time it is needed, the schema comes prepackaged: Those situations one has faced a number of times before access a schema that already contains the relevant prior knowledge, inferences, and slots for understanding that particular situation. For example, one has general knowledge of a buying/selling situation, with an understanding that the buyer gives some money (a function of what is being bought), the seller surrenders ownership of the item, and so on. For routine events that include knowledge very similar from time to time (e.g., going to a restaurant), even greater amounts of prior knowledge can be specified (Schank & Abelson, 1977).

Schemas have become an important idea in a wide variety of psychological domains, as well as in artificial intelligence. Psychological research has found evidence of the existence and use of such abstract knowledge structures (e.g., Bower, Black, & Turner, 1979). However, there have also been indications in both psychological domains and artificial intelligence research that these large knowledge structures may sometimes be too large or inflexible, and that sometimes specific experiences may play a role. For example, Bower et al. (1979) found confusions in recalling information from schemata that shared similar parts, such as waiting rooms for doctors and dentists, suggesting that the overall "script" might be composed of smaller parts that are used across similar situations (such as waiting rooms and payments for health professionals). Schank (1982) argued that computer programs intended to acquire structures must build them up from specific earlier experiences. In processing a new experience, one might be guided by the general knowledge, but might also activate the specific earlier experiences if the situation is new or unusual. For example, if a restaurant experience involved someone choking on a chicken bone, a similar earlier experience might well be thought of and the relevant information utilized. A similar use of remindings can underlie problem solving by novices, as noted earlier (e.g., Ross, 1984).

The idea of using specific episodes for understanding has been very influential in machine learning, leading to a new area of research called case-based reasoning. It allows the analysis of current situations to be processed in terms of earlier cases rather than by abstract knowledge alone. Earlier cases might help in a variety of ways, such as focusing on the important aspects, helping devise a plan, or providing information about what led to failure in a previous similar situation. Even in relatively simple reading comprehension situations, people may think back to earlier texts to help interpret the current one (Gentner, Rattermann, & Forbus, 1993; Ross & Bradshaw, 1994).

REMINDING IN SIMPLE MEMORY TASKS

The preceding examples reveal how memories for individual events and stimuli subserve a variety of intellectual skills, and suggest that reminding is the mechanism by which those memories are efficiently utilized. If reminding underlies those many cognitive capacities, then we should be able to detect footprints of it in basic memory tasks. The type of reminding we all experience occurs not only when being at a wedding reminds us of funny things that happened at a previous wedding, but also when digging an old toy out of the attic reminds us of a childhood experience with that toy. Reminding takes place not only for complex situations and mappings, but also—and maybe even more frequently—for simple individual elements in our lives. Basic memory paradigms, in which people are asked to remember stimuli like words and pictures, seem a fertile ground for seeking evidence for reminding for simple materials.

We start that search in tasks in which related materials are presented at different times, and consider four common experimental paradigms. In each case we ask: If reminding were taking place, what would the consequences be? Two fundamental considerations from well-established memory research guide how we answer that question (Benjamin & Tullis, 2010). First, because we forget things, reminding is less likely at longer intervals. Second, although longer intervals decrease the probability of reminding, they increase the mnemonic potency of reminding. That is, because more laborious retrieval enhances memory more than easy retrieval (Gardiner, Craik, & Bleasdale, 1971; Karpicke & Roediger, 2008; Slamecka & Graf, 1978), difficult reminding enhances memory more for the reminded (i.e., retrieved) event than does easy reminding. Thus, the product of reminding can reveal a trade-off between likely and potent retrieval: if the reminding cue is too late, little reminding occurs and consequently little benefit accrues; if reminding is too soon, reminding occurs but the benefits are minimal.

Memory for Repeated Materials

The most straightforward case of relationship is identity, and so the best reminding cue for a previous event is likely to be a repetition of that event. The most commonly employed repetition paradigm is one in which the lag between the repetitions is varied; such experiments reveal the ubiquitous spacing and lag effects, in which greater distance between the repeated events leads to superior memory for the event (Ebbinghaus, 1885/1962; Melton, 1970). Predominant explanations for this effect include a role for the greater encoding variability afforded by more temporally variable study contexts (Bower, 1972; Estes, 1955) as well as the attenuated processing induced by close repetitions (Hintzman, 1974), but the effects may be more parsimoniously understood by considering the consequences of reminding (Benjamin & Tullis, 2010; Hintzman, 2004).

Let us consider what the benefits of reminding would look like in such a paradigm. As outlined earlier, the probability of reminding decreases with increasing intervals and the potency of the reminding increases with increasing interval (difficulty). Therefore, there should be a sweet spot at which the probability and potency of reminding combine to produce maximal benefits—that is, spacing functions should be nonmonotonic with lag. In addition, because performance reflects not the increasing independence of events (as in encoding variability theories), but rather reveals a joint function of their dependence (which promotes probable reminding) and independence (which promotes difficult retrieval and thus powerful reminding), such theories can accommodate superadditive levels of performance. This is true because, although events can be no more independent than perfectly uncorrelated—an assumption that leads encoding variability to be inconsistent with superadditivity—theories that postulate interaction between the two events, like reminding, are not limited in that way. These two phenomena are shown in Figure 4.1, which plots data simulated from a reminding model of repetition proposed by Benjamin and Tullis (2010). Finally, because association is at the heart of reminding, no benefits should be apparent for unrelated materials—that is, materials that are unlikely to remind the learner of each other.

Each of these predictions is borne out in data. Spacing functions can be and often are nonmonotonic (Benjamin & Tullis, 2010; Peterson, Wampler, Kirkpatrick, & Saltzman, 1963), revealing that, once the probability of reminding is sufficiently low, the net benefits start to decrease with additional spacing. In addition, superadditivity is ubiquitous (Begg & Green, 1988; Benjamin & Tullis, 2010), revealing itself at lags as short as five intervening items and evident in more than 60% of experimental conditions in the literature. Finally, no spacing benefit is evident for unrelated words (Ross & Landauer, 1978); that is, the probability of

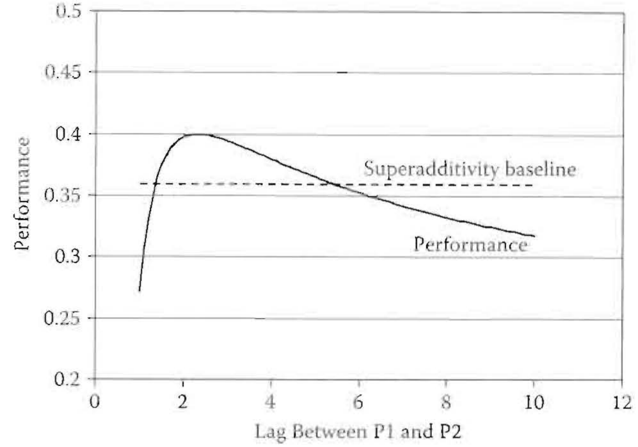

Figure 4.1 Predicted performance for the reminding model proposed by Benjamin and Tullis (2010). Solid line represents memory for the item presented at P1 as a function of the interval between P1 and P2. Dashed lined represents the superadditivity baseline (i.e., the probability summation of remembering one of two things). Baseline performance is set to 0.2, the forgetting rate is 0.7, and the probability of reminding is 0.9.

remembering one of two different words does not vary with the interval between the words. According to reminding theory, such a result is the obvious consequence of the fact that the second word does not remind the reader of the first, and thus does not initiate retrieval of it.

Evidence for the theoretical value of reminding is also apparent in tasks in which items are repeated and memory is tested by evaluating judgments of the recency of an item's occurrence (Hintzman, 2010) and memory for the frequency of an item's occurrence (Hintzman, 2004). In each of these tasks, as in recognition more generally, other perspectives have failed to provide an adequate account of extant phenomena.

Memory for Semantically Related Materials

One benefit of thinking about repetition as similarity-induced reminding is that the principles generalize easily to near-repetition paradigms, in which synonyms or related words are presented. The same principles applied to repetition paradigms can be used to derive simple predictions about the effects of lag of memory for related materials, and about the effects of pure versus near repetition on memory.

Because associates are less similar to one another than are repetitions, both the probability of reminding and the potency of reminding are changed. For example, a second presentation of *king* is likely to remind one of an earlier presentation of *king*, but it could also remind one of *queen*. If one had seen *queen* earlier in the list, a later presentation of *king* would be expected to have different consequences than *hamburger* for reminding. The probability of a word reminding the learner of a related word from earlier in the list would drop off more quickly than would the probability of a repetition doing so, but the potency of the reminding would be commensurately greater. The net effect is that the "sweet spot" in the trade-off is earlier in time than for repetitions. This effect can be seen in the top panel of Figure 4.2, in which two lag functions are simulated from the Benjamin and Tullis (2009) model—one of which has a very high probability of reminding (as one would expect for repetitions), and one of which has a slightly lower probability of reminding (as one would expect for related associates). Note that, as expected, the performance maximum is earlier in time (in fact, at the shortest interval) for associates than for repetitions.

These predictions can be compared to data from an experiment reported by Hintzman et al. (1975, depicted in the bottom panel of Figure 4.2). One noteworthy feature of these results is that, if the presentation of the two events is close together in time, memory for the first word is superior if the second word is an associate than if it is a repetition. This reflects the fact that event dissimilarity fosters more

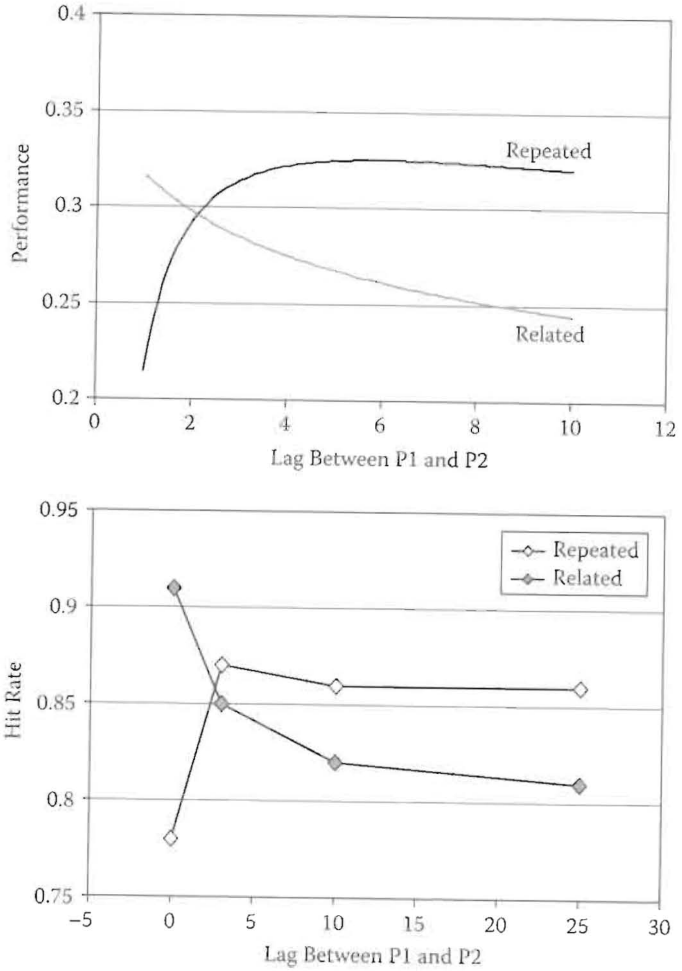

Figure 4.2 Top panel: Predicted performance of the reminding model for memory for an event at P1 following a repetition (darker line) or following a presentation of a related associate (lighter line). Bottom panel: Data from an experiment by Hintzman (1975) showing a similar pattern for analogous conditions.

potent retrieval—thus, being reminded of an event by an associate involves more laborious and thus more mnemonically enhancing retrieval. However, because reminding is increasingly unlikely at long lags, the earlier advantage of dissimilarity becomes a disadvantage as the interval is increased. Picking a cue for maximal mnemonic enhancement of the reminded event must thus be tied to the required interval between learning opportunities.

Learning in A-B A-C Paired-Associate Tasks

There is a large literature on the effects of cue repetition in the literature on proactive and retroactive interference in paired-associate learning (Keppel, 1968). That perspective is quite clear: Because increasing the number of associates to a common retrieval cue has negative effects on the retrieval of any given target item (see also Anderson, 1974), conditions under which cues are repeated should lead to poorer memory for the associated targets. For example, studying *apple—mail* followed by *apple—house* should make it more difficult to remember *mail* when presented with *apple* on a later test. In more abstract terms, memory for B given A following study of A-B A-C lists should be inferior than following study of A-B D-C lists. Because the C target does not share a common cue with B, learning the D-C list should be less interfering than learning the A-C list.

In contrast to this prediction, experiments with this protocol often reveal a retroactive facilitation effect, in which A-B A-C lists lead to superior memory for B (Bruce & Weaver, 1973; Robbins & Bray, 1974). This phenomenon even appears in the learning of complex, real-world materials: Learners showed better memory for a text about Zen Buddhism when learning of a conflicting text on Buddhism was interpolated between study and test than when it was not (Ausubel, Stager, & Gaite, 1968). Educational programs that employ this concept have been similarly successful: Students showed better retention of materials from a seventh-grade science curriculum when they had a second year of science (in eighth grade), even when the specific content was not repeated (Arzi, Ben-Zvi, & Ganiel, 1985).

These phenomena follow naturally from the idea of reminding. Because new information invites reminding of previously studied and related material, that reminding can indeed foster superior memory for the original information. Such a claim does not conflict with the idea that additional retroactive interference is also promoted by such encounters; whether the beneficial effects of reminding are sufficient to overcome the deleterious effects of interference is likely a complex function of the materials and scheduling of learning and testing events, as well as the goals of the learner. It is interesting to note that the very condition that enhances interference—namely, similarity—is also the factor that enhances the likelihood of reminding. This combination of effects makes good cognitive sense: When materials are similar, understanding them often requires generalization or contrast among the competing pieces of information, and reminding allows us to engage in such processes even when the components are temporally disparate.

Memory for Lists of Semantic Associates

A currently popular word list learning paradigm involves the study of long lists of associates to a common unstudied word. Following such study, incorrect recall and recognition of the common unstudied word are often apparent (Gallo, 2006; Roediger & McDermott, 1995). One proposed basis for this effect is that each associate in the list "activates" the common word somewhat, and that the net effect of these relations is to boost activation to a point where the rememberer is likely to attribute it to having been studied (Gallo & Roediger, 2002). This theory can be reframed in terms of reminding and, in doing so, can avoid the theoretical murkiness of what activation is or how it is monitored. Each item in the list has some probability of reminding the learner of the common associate, and the large number of items makes reminding highly likely. Monitoring is then an issue of source monitoring: If the learner can discriminate between retrieved (i.e., reminded) and seen words, then incorrect recall and recognition can be avoided. Consistent with this interpretation, manipulations that enhance memory for actually studied list members decrease false memory (Benjamin, 2001), as do manipulations that enhance the distinctiveness of such information (Dodson & Schacter, 2001).

The only difference between reminding, as we have laid it out in previous sections, and reminding in such tasks concerns what is being reminded. In repetition, near-repetition, and paired-associate paradigms, that reminding is episodic: Single events that occurred previously in the experiment are retrieved. In semantic associate paradigms, the reminding is semantic: Individual concepts or words are retrieved from our knowledge, rather than from our memory for the experiment. A similar type of semantic reminding may be at work in the classic paradigm of Bower, Clark, Lesgold, and Winzenz (1969), in which the provision of organizational information at encoding led to superior memory for the material than when that information was absent or unorganized. In a second, less well-known experiment, Bower et al. provided organizational information in a later, separate list. That case also led to superior recall, and Bower et al. primarily attributed that enhancement to the benefits provided by an effective retrieval plan (see Benjamin, 2008). However, they also noted the possibility of a "mediational" interpretation, in which the presentation of the associated terms during the later list inspired covert rehearsal of members from the first list. This alternative interpretation is rooted in the concept of reminding, and illustrates the wide breadth of paradigms for which the idea might prove useful. In this case, a direct comparison of a retrieval organization explanation and a reminding explanation would require a condition in which associated, but not hierarchical, cues were presented during the second list.

THE PURPOSE OF REMINDING

We have outlined here principles that guide reminding, rules that determine the mnemonic consequences of reminding, and the higher-level cognitive capacities that reminding appears to support. If reminding is a basic building block of cognition, rather than just another boutique theoretical concept, we should be able to make sense out if its role in terms of general evolutionary principles of the mind. This short concluding section outlines our ideas about what that role is.

We start from the perspective that the mind is constantly engaged in two parallel but somewhat conflicting goals. First, pattern matching mechanisms take the bewildering amount of input to our senses and reduce it to manageable proportions by relating that input to our prior knowledge. Our assessment (understanding) of a situation and the actions we take depend upon access to appropriate and goal-relevant information. Second, information is constantly scrutinized in order to tune those pattern matching mechanisms. Situations and objects that are commonly encountered are biased in favor of, and dimensions that identify critical differences are enhanced relative to ones that do not contribute to important distinctions. In order to extract such dimensions, common characteristics of related stimuli must be identified and distinctive characteristics of similar but critically different stimuli must be identified. Often, this occurs when the world copresents such stimuli. An art gallery that features modern art allows us to generalize across the dimensions that uniquely identify such art. Similarly, watching a baseball game attunes us to subtle but important differences between pitchers, such as their arm angles, windups, and pick-off motions, that we would not otherwise be likely to attend to.

Reminding is what affords these opportunities at a distance. Even if we cannot visit a museum, occasional exposure to modern art—and the attendant reminding that ensues—allows us to compare art works directly (if imperfectly) even when our experiences occur at different times. Similarly, we can learn about baseball without watching a dozen pitchers at one time. Reminding allows the past to be part of the present, and so affords us the chance to generalize and contrast episodes that occur at different points in our day, or in our life.

Remindings also afford opportunities to learn in unexpected ways. If we were to purge from our memory all characteristics of stimuli that we deemed irrelevant upon our encounter with that stimuli, we would be unable to test new hypotheses about the composition of categories or inferential rules for a given problem without revisiting those stimuli. Reminding is thus also a hedge against changing ideas and changing goals: Characteristics of potential romantic partners that are important to a college student might, for example, differ from ones important to a person seeking to have children in the near future. We cannot anticipate all our future goals, but retaining individual prior experiences provides the potential for our learning objectives to change in arbitrary and unanticipated ways. Remindings provide one means by which this potential can be realized.

REFERENCES

Allen, S. W., & Brooks, L. R. (1991). Specializing the operation of an explicit rule. *Journal of Experimental Psychology: General, 120*, 3–19.

Anderson, J. R. (1974). Retrieval of propositional information from long-term memory. *Cognitive Psychology, 5*, 451–474.

Arzi, H. J., Ben-Zvi, R., & Ganiel, U. (1985). Proactive and retroactive facilitation of long-term retention by curriculum continuity. *American Educational Research Journal, 22*, 369–388.

Ausubel, D. P., Stager, M., & Gaite, A. J. H. (1968). Retroactive facilitation in meaningful verbal learning. *Journal of Educational Psychology, 59*, 250–255.

Begg, I., & Green, C. (1988). Repetition and trace interaction: Superadditivity. *Memory and Cognition, 16*, 232–242.

Benjamin, A. S. (2001). On the dual effects of repetition on false recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*, 941–947.

Benjamin, A. S., & Tullis, J. (2010). What makes distributed practice effective? *Cognitive Psychology*.

Bjork, R. A. (1975). Retrieval as a memory modifier. In R. Solso (Ed.), *Information processing and cognition: The Loyola Symposium* (pp. 123–144). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bower, G. H. (1972). Stimulus sampling theory of encoding variability. In A. W. Melton & E. Martin (Eds.), *Coding processes in human memory*. Washington, DC: V. H. Winston and Sons.

Bower, G. H., Black, J. B., & Turner, T. F. (1979). Scripts in memory for text. *Cognitive Psychology, 11*, 177–220.

Bower, G. H., Clark, M. C., Lesgold, A. M., & Winzenz, D. (1969). Hierarchical retrieval schemes in recall of categorized word lists. *Journal of Verbal Learning and Verbal Behavior, 8*, 323–343.

Brooks, L. (1978). Nonanalytic concept formation and memory for instances. In E. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization* (pp. 169–211). Hillsdale, NJ: Erlbaum.

Brooks, L. R., Norman, G. R., & Allen, S. W. (1991). Role of specific similarity in a medical diagnosis task. *Journal of Experimental Psychology: General, 120*, 278–287.

Bruce, D., & Weaver, G. E. (1973). Retroactive facilitation in short-term retention of minimally learned paired associates. *Journal of Experimental Psychology, 100*, 9–17.

Bruner, J. S., Goodnow, J. J., & Austin, G. A. (1956). *A study of thinking*. New York: John Wiley & Sons.

Chi, M. T. H., Feltovich, P., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science, 5*, 121–152.

Dodson, C. S., & Schacter, D. L. (2001). "If I'd said it I would've remembered it": Reducing false memories with a distinctiveness heuristic. *Psychonomic Bulletin and Review, 8*, 155–161.

Ebbinghaus, H. (1962). *Memory: A contribution to experimental psychology*. New York: Dover. (Original work published 1885)

Erickson, M. A., & Kruschke, J. K. (1998). Rules and exemplars in category learning. *Journal of Experimental Psychology: General, 127*, 107–140.

Estes, W. K. (1955). Statistical theory of distributional phenomena in learning. *Psychological Review, 62*, 369–377.

Finley, J. R., Benjamin, A. S., Hays, M. J., Bjork, R. A., & Kornell, N. (2010). The benefits of accumulating versus diminishing cues in recall. Manuscript under review.

Gallo, D. A. (2006). *Associative illusions of memory: False memory research in DRM and related tasks*. New York: Psychology Press.

Gallo, D. A., & Roediger, H. L., III. (2002). Variability among word lists in evoking memory illusions: Evidence for associative activation and monitoring. *Journal of Memory and Language, 47*, 469–497.

Gardiner, J., Craik, F. I. M., & Bleasdale, F. (1973). Retrieval difficulty and subsequent recall. *Memory and Cognition, 1*, 213–216.

Gentner, D., Rattermann, M. J., & Forbus, K. D. (1993). The roles of similarity in transfer: Separating retrievability from inferential soundness. *Cognitive Psychology, 25*, 524–575.

Gick, M. L., & Holyoak, K. J. (1980). Analogical problem solving. *Cognitive Psychology, 12*, 306–355.

Gick, M. L., & Holyoak, K. J. (1983). Schema induction and analogical transfer. *Cognitive Psychology, 15*, 1–38.

Hintzman, D. L. (1974). Theoretical implications of the spacing effect. In R. L. Solso (Ed.), *Theories in cognitive psychology: The Loyola Symposium* (pp. 77–99). Potomac, MD: Erlbaum.

Hintzman, D. L. (2004). Judgment of frequency vs. recognition confidence: Repetition and recursive reminding. *Memory and Cognition, 32*, 336–350.

Hintzman, D. L. (2010). How does repetition affect memory? Evidence from judgments of recency. *Memory and Cognition, 38,* 102–115.

Hintzman, D. L., Summers, J. J., & Block, R. A. (1975). Spacing judgments as an index of study-phase retrieval. *Journal of Experimental Psychology: Human Learning and Memory, 1,* 31–40.

James, W. (1890). *Principles of psychology.* New York: Holt and Company.

Karpicke, J. D., & Roediger, H. L. (2008). The critical importance of retrieval for learning. *Science, 319,* 966–968.

Keppel, G. (1968). Retroactive and proactive inhibition. In T. R. Dixon & D. L. Horton (Eds.), *Verbal behavior and general behavior theory* (pp. 172–213). Englewood Cliffs, NJ: Prentice Hall.

Kruschke, J. K. (1992). ALCOVE: An exemplar-based connectionist model of category learning. *Psychological Review, 99,* 22–44.

Landauer, T. K., & Bjork, R. A. (1978). Optimum rehearsal patterns and name learning. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory* (pp. 625–632). London: Academic Press.

Love, B. C., Medin, D. L., & Gureckis, T. M. (2004). SUSTAIN: A network model of category learning. *Psychological Review, 111,* 309–332.

Medin, D. L., & Schaffer, M. M. (1978). A context theory of classification learning. *Psychological Review, 85,* 207–238.

Melton, A. W. (1970). The situation with respect to the spacing of repetitions and memory. *Journal of Verbal Learning and Verbal Behavior, 9,* 596–606.

Murphy, G. L. (2002). *The big book of concepts.* Cambridge, MA: MIT Press.

Newell, A., & Simon, H. A. (1972). *Human problem solving.* Englewood Cliffs, NJ: Prentice-Hall.

Nosofsky, R. M. (1986). Attention, similarity, and the identification-categorization relationship. *Journal of Experimental Psychology: General, 115,* 39–57.

Peterson, L. R., Wampler, R., Kirkpatrick, M., & Saltzman, D. (1963). Effect of spacing presentations on retention of a paired associate over short intervals. *Journal of Experimental Psychology, 66,* 206–209.

Reeves, L. M., & Weisberg, R. W. (1994). The role of content and abstract information in analogical transfer. *Psychological Bulletin, 115,* 381–400.

Robbins, D., & Bray, J. F. (1974). Repetition effects and retroactive facilitation: Immediate and delayed test performance. *Bulletin of the Psychonomic Society, 3,* 347–349.

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.

Rosch, E. (1975). Cognitive representations of semantic categories. *Journal of Experimental Psychology: General, 104,* 192–233.

Rosch, E., & Mervis, C. B. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology, 7,* 573–605.

Ross, B. H. (1984). Remindings and their effects in learning a cognitive skill. *Cognitive Psychology, 16,* 371–416.

Ross, B. H., & Bradshaw, G. L. (1994). Encoding effects of remindings. *Memory and Cognition, 22,* 591–605.

Ross, B. H., & Kennedy, P. T. (1990). Generalizing from the use of earlier examples in problem solving. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 42–55.

Ross, B. H., & Landauer, T. K. (1978). Memory for at least one of two items: Test and failure of several theories of spacing effects. *Journal of Verbal Learning and Verbal Behavior, 17,* 669–680.

Ross, B. H., & Makin, V. S. (1999). Prototype versus exemplar models. In R. J. Sternberg (Ed.), *The nature of cognition* (pp. 205–241). Cambridge, MA: MIT.

Ross, B. H., Perkins, S. J., & Tenpenny, P. L. (1990). Reminding-based category learning. *Cognitive Psychology, 22,* 460–492.

Rumelhart, D. E., & Ortony, A. (1977). The representation of knowledge in memory. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge* (pp. 99–136). Hillsdale, NJ: Erlbaum.

Schank, R. C. (1982). *Dynamic memory.* Cambridge, UK: Cambridge University Press.

Schank, R. C., & Abelson, R. (1977). *Scripts, plans, goals and understanding.* Hillsdale, NJ: Erlbaum.

Slamecka, N. J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory, 4,* 592–604.

Whitten, W. B., & Bjork, R. A. (1977). Learning from tests: The effects of spacing. *Journal of Verbal Learning and Verbal Behavior, 16,* 465–478.

Woodworth, R. S. (1921). *Psychology: A study of mental life.* New York: H. Holt.