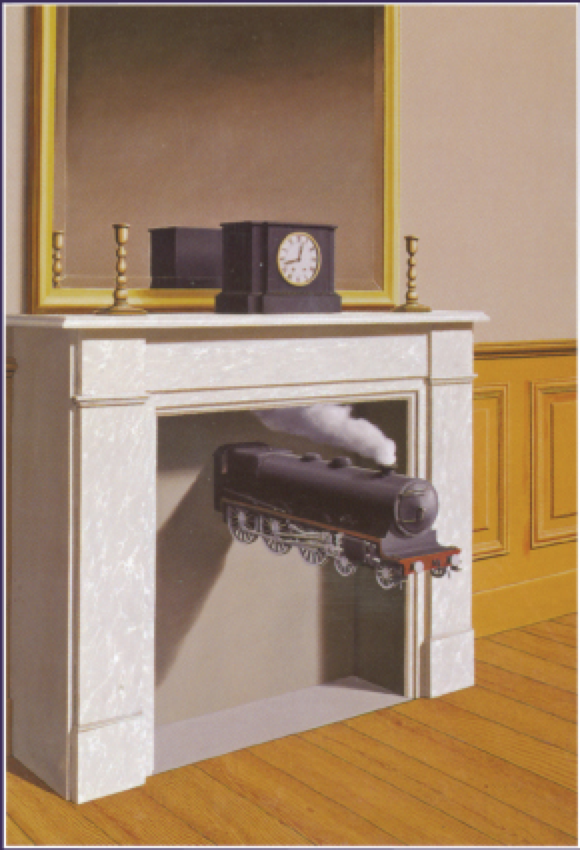
The Foundations of Remembering

Essays in Honor of Henry L. Roediger, III



Edited by James S. Nairne

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Pictured (left to right): **Front row:** Elizabeth Bjork, Alice Healy, Kathleen McDermott, Roddy Roediger, Elizabeth Loftus, Suparna Rajaram, Randi Martin. **Second row:** Aimée Surprenant, Elizabeth Marsh. **Third row:** James Neely, Stephen Schmidt, Robert Bjork, John Wixted, Larry Jacoby. **Fourth row:** David Balota, Robert L. Greene, Richard Shiffrin, Mark McDaniel, Richard Schweickert. **Fifth row:** Randall Engle, Daniel Schacter, Fergus Craik, James Nairne, Ian Neath. (Not pictured: Endel Tulving.)

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Preface

In May, 2004, Purdue University awarded Henry L. Roediger, III an honorary doctor of letters in recognition of his many accomplishments in research and service to the field of psychology. In connection with this award, the Department of Psychological Sciences at Purdue decided to organize a conference, populated by top memory scholars, as a fitting capstone. Although not technically a Festschrift—"I'm too young for that," Roediger exclaimed—the conference was dedicated to honoring Roddy and celebrating his career. The conference, affectionally labeled "RoddyFest," was held Easter weekend, March 24–27, 2005.

Speakers were given a simple charge: choose your own topic, but try to place your work in historical context. Roediger is fascinated by the intellectual lineage of ideas, so addressing historical "foundations" seemed appropriate. The chapters contained in this volume help to establish the foundations of remembering, circa the first decade of the 21st century, as perceived by some of the leading memory researchers in the world. Not surprisingly, each of the chapters touches on Roediger's work as well, largely because his work has helped to define and clarify the topics of interest to the memory field.

The unofficial theme of the conference was the classic Frank Capra movie *It's a Wonderful Life*. The film tells the story of a man, played by Jimmy Stewart, who is allowed a glimpse of what the world would have been like had he never been born. It is a measure of one man's impact, which, as it turned out, far surpassed his awareness and imagination. So, too, has Roddy impacted on the lives of many, including most at the conference, through his mentorship, support, and outstanding contributions in scholarship. Roddy's "reach" has been profound, in ways that I doubt he has ever imagined.

The conference would not have been possible without the support of Purdue University, particularly Dean Toby Parcel of the College of Liberal Arts, Associate Dean Howard Zelaznik (who originated the idea for the conference), and Department Head Howard Weiss. Julie Smith and Erica Wilson played an important role making the conference itself run smoothly. Additional financial support was generously provided by Psychology Press and the American Psychological Society.

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Roddy Roediger's Memory

JAMES S. NAIRNE

Fortunately, unlike memory proper, we can search through Roddy Roediger's memory. With a corpus exceeding 175 publications, the ever-expanding Roediger repository is accessible and open to all. If one chooses to rummage about, turning over things under which, or within which, or alongside of which manuscripts lie, empirical, methodological, and theoretical insight soon comes into view. An exhaustive review is beyond my reach, but I intend in this opening chapter to touch on the highlights, place the work in historical context, and to characterize the "Roedigerian" style.

Temporally, Roediger's research divides itself neatly into three decade-long periods spent investigating: (1) the mnemonic consequences of recall (particularly its self-limiting properties), (2) retrieval in the absence of conscious intent (implicit memory), and (3) the conditions that foster retrieval errors (i.e., false memory). There is a fourth period, currently in progress, focusing on the educational implications of testing. The common denominator throughout is retrieval. Sample randomly from the Roediger repository and you are certain to find work investigating the characteristics and consequences of retrieval; it is the lens through which his work, both empirical and theoretical, needs to be viewed.

PERIOD ONE: RETRIEVAL AND ITS CONSEQUENCES

Roddy Roediger entered graduate school at Yale in 1969, 2 years after the publication of Neisser's influential *Cognitive Psychology* (1967). The cognitive revolution was ascending, but memory researchers, by and large, remained committed to the verbal learning tradition. As its name implies, verbal *learning* is concerned largely with acquisition, either acquisition rates (e.g., transfer) or acquisition consequences (e.g., interference). The modern notion of a retrieval experiment—holding encoding conditions constant while manipulating the conditions of testing—was virtually unknown, having made only isolated appearances on the empirical landscape (e.g., Luh, 1922; Tulving & Pearlstone, 1966).

Retrieval neglect seems mystifying to the modern memory researcher, but it is understandable in its context. Scholars of the 1960's recognized the distinction between learning and performance; they assumed that responses compete at the point of test, that the availability of a response can change systematically with time (e.g., Briggs, 1954), and that changing stimulus conditions exert powerful effects on performance (McGeoch, 1942; Yum, 1931). Such phenomena were well established empirically and used frequently as tools to explain troublesome findings (see Postman, 1961). But to learning mavens they were tangential, not germane, to the topic of main interest. With an acquisition focus, understandably, researchers sought fixed testing environments that could adequately assess what had been learned.

For Roddy Roediger, however—then and now—accessibility, not acquisition, has occupied center stage. As he noted in 1974, "One of the primary problems in the study of memory is the discovery of why so little of available, stored information can be actively retrieved" (p. 261). In free recall, for example, one typically finds variability across output opportunities. Subjects often recall items on a second test that they failed to recall initially, even in the absence of an interpolated learning trial. An appropriate retrieval cue, such as a pertinent category label, also can dramatically affect both the quality and quantity of what is recalled (Tulving & Pearlstone, 1966). From an acquisition (or storage) perspective such findings may be troubling, or at least a methodological nuisance, but to Roediger they seemed paramount. Accessibility, not availability, forms the *sine qua non* of the study of memory.

Roediger recognized early on that there are two ways to attack the accessibility problem. First, you can study the effectiveness of retrieval cues, a path blazed by one of his mentors, Endel Tulving (e.g., Tulving & Thomson, 1973).[1] (This path led to the development of the encoding specificity principle, a passive version of the more active transfer-appropriate processing that Roediger was to champion a decade later.) Second, the focus can be placed on the retrieval process itself: How does retrieval, or at least the products of retrieval, change the accessibility of other, yet-to-be-retrieved, information? Students of memory have long assumed that recall can be self-propagating. Once recalled, an item can serve as a retrieval cue, triggering the recall of additional information. But in a sweeping review of the literature published in 1974, Roediger argued convincingly that retrieval had inhibitory, or self-limiting, properties as well.

Retrieval, he reasoned, seems to have a curious design flaw: Recalling an item increases its accessibility—it "primes" the item—which then biases, or calibrates, the search process. The act of recall "strengthens the representation of an item in memory, which means that on future attempts to retrieve additional items, the ones already recalled will be retrieved again to the exclusion of new items" (p. 262). The priming part, of course, helps to explain the advantages of repeated testing (Bjork, 1975; Roediger & Karpicke, 2006), and ultimately the importance of transfer appropriate testing (Roediger, Weldon, & Challis, 1989), but it tends to induce forgetting of other relevant target information as a side effect. Sampling with replacement clutters up the search process, making it difficult to recover additional items (see also, Brown, 1968; McGill, 1963; Shiffrin, 1970). Roediger wondered about the evolutionary significance of such a process, concluding that "it seems maladaptive for the very act of recall to produce forgetting of information that needs to be recalled later" (p. 268).

The Empirical Domain

The self-limiting properties of recall, he argued, can be clearly seen in three empirical contexts. First, it is apparent in the temporal course of recall. If you track recall over time, it shows a negatively-accelerated form (Bousfield & Sedgewick, 1944). "In attempting recall of a specified set of items without regard to their order, Ss typically emit items very rapidly at first and show a decreased responding with time" (Roediger, 1974, p. 261). This characteristic pattern occurs for both episodic and semantic recall (e.g., recalling instances from categories) and cannot be explained by appealing simply to fatigue or to temporal variations in item "strength." It is consistent, however, with the assumption that the search for new items is slowed by the resampling of already recalled, and thereby primed, list items.

Second, under controlled testing environments, such as cued recall, performance declines regularly as a function of the position of the item in the testing sequence. Testing early items impairs performance on later items, a phenomenon known generally as output interference (Tulving & Arbuckle, 1963). Although initially controversial—output interference was thought to result only from primary memory loss—later research established it as a potent factor in many retrieval contexts, especially recall (see Roediger & Schmidt, 1980). Again, the act of recall primes representations, biasing the search process and thereby hindering the accessibility of yet-to-be-recalled items.

Third, if subjects are supplied with some list items as retrieval cues after list presentation—so-called part-list cueing—recall of the remaining "critical" items can suffer compared to recall under noncued conditions. This vexing empirical phenomenon, first demonstrated by Slamecka (1968), runs counter to the claim that recall is self-propagating. To the extent that interitem dependencies are formed during list acquisition, list cues should facilitate, not impair, subsequent recall. On the other hand, if the memory traces for the cued items are primed by the cueing process, thereby biasing the search process away from the noncued items, then part-list cueing can be seen as yet another example of retrieval-based inhibition or interference (see Rundus, 1973).

Throughout the 1970s, much of Roediger's research focused on the idea that items, once retrieved, block the accessibility of otherwise available information in memory. Portions of this research are reviewed elsewhere in this volume (see especially Bjork et al. chapter 2) but his main empirical concerns were twofold: (1) mapping out the conditions under which experimenter-provided cues help and hinder performance, and (2) understanding the role that retrieval dynamics, particularly the time course of free recall, play in mnemonic phenomena (particularly hypermnesia). I briefly review this research in the following two sections.

Part-List Cueing

The phenomenon of part-list cueing puzzled Roediger as a graduate student, for good reason. After all, as a protégé of Endel Tulving, he had been imprinted on the idea of cue-driven remembering. Tulving and Pearlstone (1966) had shown that the presentation of category labels at test substantially improves recall of a categorized list. Yet, given Slamecka's (1968) findings, wouldn't we expect these category labels to block rather than cue subsequent recall? For that matter, why is elaboration such an effective mnemonic strategy? Internally generating associates to target words, we typically argue, increases the constellation of potential retrieval cues. But why don't these elaborations, presumably primed by the generation process, block recall of the target words in a manner akin to part-list cueing?

Roediger (1973) offered a simple solution in his dissertation. He suggested that retrieval cues, produced internally or externally, facilitate recall if and only if they provide access to relevant "higher order units." Memory traces are not stored haphazardly, he argued, but rather in organized domains or bundles—e.g., as elements of List 1, the category *furniture*, or as some other subjective unit. To recover a particular target requires first accessing the relevant bundle, from among many potentially searchable bundles, and then recovering its content. Pertinent category labels improve recall because they direct the search to relevant bundles. However, "when more retrieval cues than are needed to produce access to higher-order units are provided (for example, other instances from the higher-order unit) recall of items from the higher-order unit will be impaired" (p. 645).

He provided evidence for this two-factor theory of cueing in a clever twist on the Tulving and Pearlstone (1966) paradigm. Following the presentation of a categorized list, subjects were provided with the appropriate category labels accompanied, or not, by additional within-category instances. The category labels, he reasoned, should provide access to relevant higher-order units, aiding recall, but additional category instances, those not needed to access the category, will block recall of its remaining members. This is exactly what Roediger found and, moreover, the within-category impairment grew with the number of cued instances. He later showed that similar things operate at the category level: Presenting some of the category labels from a categorized list improves recall of words from the cued categories (relative to free recall), but impairs recall of the other categories on the list. Importantly, this category-based part-list cueing effect was specific to the recall of categories and failed to affect recall of words within a category, once accessed (cf. Roediger, 1978, p. 61).

Roediger viewed his results as broadly consistent with several contemporary search models, especially a hierarchical model proposed by Rundus (1973; see also, Estes, 1972; Shiffrin, 1970), and with classical interference theory as well. The first factor of the famous two-factor theory of interference (McGeoch, 1942) is response competition, wherein the stronger of two associated responses to a single cue effectively blocks the weaker one; in Roediger's case, primed instances, strengthened by virtue of their presentation as retrieval cues, effectively block recovery of noncued instances (that is, those associated to the same higher-order unit) because of biased sampling. The mechanisms may be somewhat different—e.g., biased sampling is not necessarily cue-based—but both appealed ultimately to the notion of response competition (see Roediger, 1974; Roediger & Neely, 1982).

Retrieval Dynamics

As noted above, the self-limiting character of recall can also be seen by tracking its temporal course. Subjects continue to recall items successfully over an extended period of time, quite long in fact, although successes arrive at a slower rate. Recall of later items is delayed, presumably, because early recalls clutter up the search process (i.e., there is response competition from primed traces). Search models of this type make specific predictions. For example, mean recall latency—the average amount of time that it takes to recall an item—is expected to increase with the size of the search set or space (see Wixted & Rohrer, 1994); similarly, because it takes longer, on average, to recall an item, it should take longer to reach asymptotic recall levels when the sample set is large.

Roediger recognized that retrieval dynamics of this sort have implications for a variety of mnemonic phenomena. For example, if subjects effectively "recall" experimenter-provided cues, subjecting the remaining critical items to output interference, then it should take longer for subjects to recall the critical items compared to uncued controls (either because the subjects "check" sampled items against the cues, or continually sample the cues themselves). Indeed, Roediger, Stellon, and Tulving (1977) found that when cues were present subjects took longer to reach asymptotic levels of performance; final asymptotic levels were lower as well, suggesting that subjects either give up recalling items that are potentially accessible (i.e., they employ a stopping rule) or some other factor inhibits or blocks the accessibility of the uncued items.

From a purely practical level, the observation that subjects approach asymptotic recall levels at different rates, depending on the size of the search set, suggests that important mnemonic differences can be masked when short recall intervals are used. In an elegant analysis, Roediger used this observation to help explain why hypermnesia—the increase in recall performance that is sometimes seen across successive tests—varies across materials and type of encoding task. Lists containing pictures, for example, typically show more hypermnesia than lists of words. Although it might be tempting to conclude that hypermnesia therefore depends on some form of imaginal encoding (Erdelyi & Becker, 1974), Roediger, Payne, Gillespie, and Lean (1982) showed how a much simpler account, based solely on retrieval dynamics, could explain the data (see also Roediger, 1982).

Imagine that an initial recall test of 7 min is employed after subjects study lists containing either pictures or words. A second test is then given, without any intervening study trial, and net improvements in performance are noted (hypermnesia). Because pictures ultimately produce higher levels of recall than words, perhaps because imaginal processing leads to more net target encodings, the approach rate to asymptote will be lower for pictures than for words. This means that after the first 7-min test, more picture targets should be available for sampling on a successive test—hence, more hypermnesia will potentially be observed for pictures than for words. In this sense recall level, because of the inverse relationship between recall asymptote and the rate of approaching that asymptote, can be used to "predict" the extent of hypermnesia. Roediger and his colleagues brought the recall-level hypothesis under experimental control by manipulating type of encoding (e.g., shallow or deep) and showing that hypermnesia varied directly with final recall level (for a review, see Roediger & Challis, 1989).

Roediger et al.'s (1982) recall-level hypothesis is not meant to be a complete account of hypermnesia. Hypermnesia ultimately depends on a trade-off between the forgetting that occurs between successive tests (intertest forgetting) and the amount of new information that is recovered (reminiscence),[2] but the original insight about retrieval dynamics remains important. Understanding how retrieval unfolds over time provides a window into the recovery process; and, depending on the length of the recall interval employed, it can be easy to underestimate, or fail to detect, potentially accessible mnemonic information. Researchers today still tend to employ relatively short recall intervals, but the time course of recall is now a popular weapon in the arsenal of the memory researcher. Roediger's pioneering efforts in this area helped make this happen (see Wixted & Rohrer, 1994).

Summarizing Period One

Over the first decade and a half of his career, Roediger established his signature as a researcher: Start with a simple idea, consider its empirical implications, and stick close to the data. In choosing to focus on the determinants of accessibility, in particular how retrieval potentially blocks access, his laboratory established a variety of empirical benchmarks, ones that continue to provide grist for the mill of the memory modeler. He was one of the first scholars to recognize the importance of retrieval-based (output) interference and its potential relevance to a host of mnemonic phenomena, including the tip-of-the-tongue state (Roediger, 1974) and even Einstellung (set) effects in problem solving (Roediger & Neely, 1982). In this sense, of course, he was prescient because the field has now moved sharply in his direction; the study of retrieval-induced "inhibition," for example, now rages (e.g., see Anderson, 2003; Bjork et al., chapter 2, this volume).

It is worth remembering as well that the Roediger lab toiled away on problems of accessibility during the "golden age" of encoding, the ascendancy of the levels of processing framework (Craik & Lockhart, 1972). This may have put Roediger somewhat out of the loop, in terms of initial impact, but it helped him develop a perspective that would serve him, and the field, extremely well in the future. For example, his focus on retrieval, specifically on how recall affects accessibility, colored his approach to the study of implicit memory and to the general memory systems debate, as discussed in the next section.

PERIOD TWO: RETENTION IN THE ABSENCE OF AWARENESS

In the 1980s, memory researchers began to embrace alternative assessment techniques, particularly ones designed to measure retention in the absence of conscious awareness. Traditional *explicit* memory tests, ones that direct the subject to consciously recollect the contents of a prior episode (e.g., the items from a just-presented list), were contrasted with *implicit* tests, those meant to detect mnemonic residue when the subject is not actively trying to remember. Popular examples of implicit tests included word stem or fragment completion, perceptual identification, category generation, and, at least nominally, the famous Ebbinghaus savings method (see Roediger, 1990).

Implicit tests attracted attention for two primary reasons: First, comparisons between implicit and explicit tests revealed tantalizing empirical dissociations, which occur when independent variables show differing, even opposite, effects on selected dependent variables. Generating an item usually produces a significant mnemonic advantage over reading on an explicit test, such as recall or recognition, but reading can yield the superior performance on an implicit test (Jacoby & Dallas, 1981). Second, the performance patterns found on implicit tests resembled those found for amnesic patients; for example, amnesic patients perform well below normal control subjects on traditional explicit tests of memory, but performance is often equivalent when implicit tests are employed (Warrington & Weiskrantz, 1970). This suggested that implicit tests tap a different form of retention—perhaps even a different memory system—than explicit tests, one that is preserved for many amnesic patients (e.g., Schacter, 1987; Squire, 1987; Tulving, 1983).

The Value of Dissociations

Like the rest of the field, Roediger found these empirical dissociations intriguing. What is it about completing word fragments in an implicit domain, for example, that preserves the effects of experience in a way that an explicit test does not (see Tulving, Schacter, & Stark, 1982)? For someone immersed in the problem of accessibility, any test-based pattern of dissociation is apt to perk interest. But he was skeptical about their diagnostic value, especially as metrics for identifying memory systems. To Roediger, empirical dissociations need to be attacked functionally, as patterns of data generated by idiosyncratic tests. He doesn't deny that distinct memory systems exist—quite the opposite, he believes they must on logical grounds—his major beef is with the wild and woolly use of empirical dissociations to draw inferences about hypothetical systems. True identification of systems should be left to direct investigations of the brain, an enterprise that he endorses wholeheartedly (e.g., Roediger, Marsh, & Lee, 2002).

Here's the problem: Empirical dissociations are the norm, not the exception (Kolers & Roediger, 1984). Consequently, without converging operations (preferably neural-based), rampant use of dissociations as a diagnostic metric will lead to proliferating—even nonsensical—memory systems. Functional dissociations are common across recognition and recall (e.g., after manipulating word frequency), yet few, if any, scholars would appeal to separate memory systems to handle such effects. Similarly, it is relatively easy to demonstrate empirical dissociations within acknowledged systems, such as episodic memory or priming in semantic memory (Roediger, Buckner, & McDermott, 1999). Within a completely implicit domain, for instance, generating words from conceptual cues can either benefit or impair performance compared to reading depending on the nature of the implicit test (Blaxton, 1989).

From a Roedigerian perspective, of course, the issue is one of accessibility: How do explicit and implicit tests, and the retrieval processes they engender, differentially tap the remnants of prior experience? The major lesson from Period One was that priming, or increased accessibility, biases or calibrates the search process. More generally, experience tunes or sharpens cognitive processes, regardless of whether the experience arises from encoding or the act of retrieval. Performance on a test will reflect this tuning, leading to either facilitation (priming) or impairment (inhibition) depending on the circumstance. To understand a dissociation, then, requires one to start from the back-end, by studying the nature of the test.

Transfer-Appropriate Procedures

Unfortunately, comparing performance across retention tests is a dangerous business, fraught with potential confoundings (much like comparing across items raises the specter of item selection concerns). Retention tests are not single entities, tapping single processes, but instead represent more or less complex concatenations of component processes (Roediger, Gallo, & Geraci, 2002). This makes unraveling empirical patterns (such as those produced by implicit and explicit tests) difficult because changing a single component out of many can produce a dissociation.

In the case of implicit versus explicit tests, the critical component is assumed to be retrieval intentionality—does the task require one to access a particular prior episode intentionally? But building on ideas proposed initially by Jacoby (1983), Roediger and his colleagues shifted the locus away from intentionality toward a set of more tractable candidates. Most implicit memory tests, it turns out, tap primarily perceptual (or data-driven) processes—that is, processes that rely on perceptual data, or data fragments, to drive stimulus identification. Explicit tests, on the other hand, tend to be conceptually-based, relying on meaning, elaboration, and inferences based on context. Depending on the specific processes that are tuned by encoding, data-driven or conceptually-driven, one can then expect either implicit or explicit tests to benefit, but probably not both (Roediger & Blaxton, 1987; Roediger & Weldon, 1987).

Consider the classic case of reading versus generating. As noted above, generating an item usually produces a significant advantage over reading on an explicit test, such as recall or recognition, but reading yields the superior performance on some implicit tests, such as perceptual identification. Generating is clearly a conceptually-driven encoding task—no target-specific "data" are actually presented—whereas reading an isolated word out of context maximizes data-driven operations. Each encoding task calibrates the settings of particular component processes, which then transfer, appropriately or not, to the component processes engendered by the test. Accordingly, one finds a generation advantage for conceptually-driven tests and a read advantage for data-driven tests.

This explanatory framework, which Roediger calls *transfer-appropriate procedures or processing* (Kolers & Roediger, 1984; Morris, Bransford, & Franks, 1977), generates testable predictions. For example, it should be possible to create implicit tests that tap conceptual processing and thereby mimic retention patterns that are characteristic of explicit tests. Category exemplar generation is one obvious candidate, and generate rather than read advantages have been detected in this task (Srinivas & Roediger, 1990). It should also be possible to produce dissociations within a class of purely implicit tests by manipulating the conditions of encoding. The picture superiority effect—the mnemonic advantage that pictures hold over words on most explicit tests—reverses on an implicit (data-driven) word fragment completion test, but reappears on a implicit picture fragment naming test (Weldon & Roediger, 1987). Again, what matters is not retrieval intentionality, but the fit between the processing components primed by encoding and the processing components required by the retention test.

Over the course of a decade, Roediger and his team produced a stream of elegant studies showcasing the value of the transfer-appropriate procedures approach, especially as applied to the interpretation of implicit memory tests. Many of these studies have become standards in the field and have accumulated hundreds of citations (e.g., Roediger, 1990; Roediger & McDermott, 1993). Yet, perhaps ironically, Roediger remains a staunch critic of implicit memory *per se*, a term he worries adds little to our understanding of retention. The fact that experience changes, or primes, behavior in the absence of conscious awareness is important, but it encompasses "much of the experimental study of behavior" (Roediger, 2003, p. 13). Various structures in the body show lasting effects of experience, such as the immune system or even the female reproductive system (Roediger, 1993), but is it sensible to characterize somatic-based "priming" as memory proper? In this sense the concept of implicit memory, defined simply in terms of priming without awareness, points to everything and thereby points to nothing (cf. Roediger, 2003).

Despite these reservations, Roediger is a strong advocate for broadening how we think about remembering and, without question, the implicit memory "boom" has greatly increased the size of the retention test toolkit. Moreover, even though the presence or absence of conscious recollection may be but one of many processing components separating explicit from implicit tests, the role of consciousness in remembering is certainly a worthy topic of investigation (Tulving, 1985). In fact, the Roediger lab has played a pivotal role in developing appropriate methodologies to study the role of phenomenological experience in remembering (e.g., Rajaram, 1993, which is based on a dissertation conducted under Roediger's direction). Perhaps most importantly to Roediger, though, the study of implicit memory places the focus of attention where it should be, on how the characteristics of the retrieval environment enhance or constrain accessibility.

Summarizing Period Two

On the surface, the study of part-set cueing, retrieval blocking, hypermnesia, and implicit memory seem vastly different. But from a Roedigerian perspective, of course, each is simply a manifestation of how retrieval environments afford accessibility. The second stage of Roediger's career, focusing largely on implicit memory, is the point at which the majority of memory researchers caught up with his perspective. Although the natural tendency of some, once again, was to think in terms of acquisition, via the postulation of unique memory systems, Roediger's elegant and influential case for transfer-appropriate procedures (or processing) provided the field with a telling, and highly influential, alternative.

PERIOD THREE: REMEMBERING FALSELY

By any metric, Roediger entered the 1990s as one of the most influential memory psychologists of his time. But like many accomplished scholars, he remains fascinated by the intellectual lineage of ideas; he refuses to relinquish the past, and often relies on it as a source of ideas, both theoretical and empirical. A case in point is the mnemonic effect of repeated testing, a phenomenon that has interested Roediger throughout his career. As discussed earlier, net improvements are sometimes found across repeated tests in free recall (hypermnesia), even in the absence of an intervening study trial, and subjects often recall items on the second test that they failed to recall initially (reminiscence).

These basic effects were noted nearly a century ago by Ballard (1913), but they contrast sharply with the findings of Ebbinghaus (1885/1964) and Bartlett (1932) who showed that memory worsens with delay in predictable ways. In Bartlett's case, of course, college students were asked to recall the Indian folktale *The War of the Ghosts* repeatedly over time—performance not only got worse, but the students reconstructed the story in false, but now-famous schematic, fashion. How do we account for the fact that repeated testing leads to increases in performance in one case and decreases in another? This is exactly the kind of historical paradox that interests Roediger and he invested considerable energy in attempting to reconcile the two data patterns (for the solution, see Wheeler & Roediger, 1992; also see Bergman & Roediger, 1999, for a replication of Bartlett's, 1932, study).

More pertinent to the third period of Roediger's career, however, is a study reported by James Deese in 1959. Deese was interested in using the associative structure of word lists to generate predictions about recall, including so-called errors of commission—that is, instances in which subjects intrude nonlist items into their recall protocol. Extralist intrusions are usually quite rare in free recall, but Deese discovered that he could rig word lists to improve recall and/or to increase the probability of intrusions. The critical determinant of an intrusion, not surprisingly, was the likelihood that it would be generated as an associate to the individual words in the list. For example, if subjects are given *thread, pin, sewing, point, pricked, thimble*, and *sharp* in a list, there is a good chance that the nonpresented word *needle* will be generated as an associate and produced as an incorrect intrusion in subsequent recall. In fact, Deese discovered that intrusion rates for critical nonpresented items exceeded 40% for some lists.

Deese's (1959) study was given some attention when it first appeared, but its impact languished in the ensuing decades. Its replication and extension by Roediger and McDermott (1995) needs no introduction and, of course, an entire industry of Deese–Roediger–McDermott (DRM) studies subsequently emerged (see chapter 18 for a personal account of how the DRM research originated). In addition to replicating Deese, Roediger and McDermott extended the paradigm to recognition memory, yielding remarkably high false alarm rates for the critical distractors, and applied Tulving's remember–know procedure to assess subjects' phenomenological experiences during false recognition. Not only do subjects falsely recognize critical distractors at a high rate, they claim to "remember" the experience.

Why all the fuss? From an associative framework, the Deese findings are understandable, even comforting, but the high intrusion rates are perplexing. Again, intrusions in free recall are typically rare because, it has long been assumed, we possess excellent response selector mechanisms that enable us to discriminate list from nonlist items (Underwood & Schulz, 1960). When we engage in elaboration, drawing connections between to-be-remembered information and other things in memory, we rarely, if ever, intrude the "elaborations." What then is it about DRM lists that leads to such spectacular breakdowns in our response selector mechanisms? Besides introducing the DRM paradigm to modern memory researchers, the Roediger team has worked hard to develop an adequate explanatory account of the phenomenon.

Activation/Monitoring

If we put on our Roedigerian thinking cap, the logical focus shifts to retrieval. Perhaps, for example, veridical recall of DRM lists primes related but nonpresented items leading to intrusions in the recall protocol. The fact that false recalls tend to occur relatively late during output is certainly consistent with such an account (Roediger & McDermott, 1995). During recognition as well, presentation of related list items is apt to occur prior to the critical distractor thereby priming the distractor and leading to false recognition. However, subsequent research has failed to provide much support for a simple retrieval account. In recognition and cued-recall, little, if any, evidence for test-induced priming has been found (Dodd, Sheard, & MacLeod, 2006; Marsh, McDermott, & Roediger, 2004; although see Coane & McBride, 2006). Moreover, warning people about the likelihood of false recall or recognition prior to list presentation reduces the effect somewhat (McDermott & Roediger, 1998), but warnings just prior to retrieval produce little effect (Gallo, Roediger, & McDermott, 2001).

In response to the data, Roediger and his colleagues offered an activation/monitoring account that combines a focus on associative activation with selective monitoring at retrieval, as in Johnson's source monitoring framework (e.g., Johnson, Hashtroudi, & Lindsay, 1993). During list presentation, activation spreads along associative lines priming related, but not necessarily presented, items; the fact that false memory is predicted well by measuring backward associative strength—the extent to which the falsely remembered item is produced by list items in a free association task (Deese, 1959; Roediger, Watson, McDermott, & Gallo, 2001)—dovetails nicely with this proposal. At test, primed items are recalled, but accuracy depends on the ability of the subject to discriminate between items activated by list presentation as opposed to other, presumably internal, means. In the case of the critical (nonpresented) item, the activation induced by the list of strongly related items is sufficient to trick the subject into thinking it occurred. Note this account assigns important roles to both encoding (activation induced by associative connections) and retrieval (failure to discriminate the source of the activation).

In addition to the data already discussed, the activation/monitoring account is supported by experiments showing that false recall rises and falls with list presentation rates; very short presentation times reduce the effect, presumably because less activation is available to "spread" to the critical item (McDermott & Watson, 2001; Seamon, Luo, & Gallo, 1998). In addition, if list-specific distinctive information is given about studied items, such as presenting them in pictorial format, false memories are reduced somewhat because the subject is better equipped to discriminate actual occurrence information (e.g., Schacter, Israel, & Racine, 1999). Similar reductions in false memory occur with multiple study–test opportunities—again, any manipulation that enhances the subject's ability to discriminate what did and did not actually occur, over and above the presence of activation, moderates the extent of false recognition (Watson, McDermott, & Balota, 2004).

Some issues remain unresolved. For example, relying on "activation" as the main diagnostic dimension is troubling because the concept is poorly specified. False memories induced by DRM-like procedures have been observed after long delays (e.g., weeks), far longer than the typical span of semantic activation (cf. McDermott & Watson, 2001). Moreover, it is still not clear exactly why DRM lists, as opposed to more typical list constructions, break down our usually efficient response selector mechanisms. It is unlikely to be the extent of priming *per se*—e.g., list items prime the related distractor above some critical threshold—because subjects are quite capable of excluding strongly activated associates from a recall protocol (e.g., the byproducts of elaborative processing). The key may lie in some kind of conscious marking of the source of the activation, but no one knows for sure.

Summarizing Period Three

Chapter constraints prevent me from discussing the full impact of the DRM movement, or the viability of competing accounts (e.g., Reyna & Brainerd, 1995; Whittlesea, Masson, & Hughes, 2005). Suffice to say, though, the impact has been substantial: The Roediger and McDermott (1995) article has amassed nearly 600 citations in its relatively short lifetime (as of July 2006) and the original Deese (1959) study, which was cited approximately 40 times between 1959 and 1995, has now accumulated over 400 citations.

One should note as well that Roediger's interest is not really in DRM lists *per se*, but rather in developing simple procedures for investigating illusory recollections. The DRM paradigm has received the brunt of the attention, but the Roediger lab has explored other procedures as well. For example, Goff and Roediger (1998) showed how imagining that an action has been performed (such as breaking a toothpick) can lead subjects to believe later that they actually performed it (see also Loftus and Cahill, chapter 23, this volume). Roediger, Meade, and Bergman (2001) showed how erroneous reports from confederates can produce false memories through a kind of social contagion. The third "period," like the previous two, is really about delineating the determinants of accessibility, although the emphasis shifted from "true" to "false" items. From the perspective of the memory system, of course, the problem is the same—how do the conditions of encoding and the requirements of test conspire to produce an appropriate response?

CONCLUSIONS

In this chapter I have attempted to retrieve some of Roddy Roediger's memory. It has been a selective sampling, with some notable omissions, but common themes do abound. Perhaps most important, as noted throughout, is Roediger's proclivity to interpret the mnemonic landscape through the lens of retrieval—a decision, by the way, he believes is firmly grounded in principled logic. If you think about it, virtually every experience leads to some kind of experiential residue in our brains. Each stored experience affords the opportunity for memory, like light affords the opportunity for visual perception, but what matters is the process that selects and converts these experiences into conscious experience. "Experiences that are encoded and stored but never retrieved are like reflected light that is never perceived—the information is available but of no use" (Roediger, 2000, pp. 57–58). To a Roedigerian, retrieval is the key to understanding memory.

In terms of specific contributions, I have tried to show how each research period has played an important role in establishing empirical benchmarks and in shaping theoretical perspectives. In some cases the field has lagged behind a bit—e.g., the study of retrieval-induced blocking—but in others Roediger's contributions have been recognized promptly and profoundly (e.g., implicit memory and DRM). Of course, besides his scholarly contributions, which have been the exclusive focus of this chapter, Roediger is well known in other ways as well—as a journal editor, department chair, office holder (e.g., APS President), mentor, and general prognosticator. But his contributions to the science of memory are pervasive and likely to last the longest. The chapters in this volume all touch on Roediger's influence, both personal and intellectual, and stand as a fitting testament to his impact.

NOTES

1. Roediger had two primary mentors in graduate school, Endel Tulving and Robert G. Crowder. Crowder was Roediger's graduate advisor at Yale and an enormous

influence on the development of the Roedigerian functional style of investigative analysis. Roediger has written elsewhere about Crowder's influence, both personal and professional, on his work (see Roediger & Stadler, 2001). It was Crowder, for example, who first introduced Roediger to the mysteries and allure of the part-list cueing phenomenon.

2. For a fuller discussion, the reader is referred to a dissertation by David Payne, which was conducted under Roediger's direction (e.g., Payne, 1987).

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flashbulb

forgotten

frontal

future

general

general political

generic

genetic

genuine

gist memory

global

habit

hippocampally-mediated

historical

human

iconic

illusive

illusory

immediate

immunological

impaired

implicit

implicit conceptual

improved

inaccessible

inaccurate

independent

indirect

individual autobiographical

infant memory

intentional

involuntary

involuntary conscious

item-based

item memory

labile

latent

later

lexical

life

list

literal

locale memory

long-term

long-term familiarity

material-specific

mechanical

medial temporal lobe

melodic

meta-memory mobile memory modal memory mood-dependent motor muscular musical narrative natural network neural neuronal new memory nonconscious nondeclarative nonhippocampally dependent normal object-in-place object-object association object-recognition object-reward association object working odor memory older memory olfactory ordinary organized original particular political Pavlovian Pavlovian fear perceptual perceptually-rich permanent personal personal episodic personal semantic phonetic phonological place memory political potential practiced prefrontal primary primate primitive prior procedural prose prospective public autobiographical raw reactivated re-embodied real-world recall memory recent recognition recollective reconstructive recovered reference reflective relational remote repisodic representational representative retrieved retrograde retrospective reviewed right memory rote scratch-pad screen secondary self-defining self memory semantic semi-permanent sense memory sensitive sensory sentence shape memory short-term single skilled sleep memory social socialized source spatial spatial working specific standard state-dependent stimulus–response habit stored subcortical subsequent superior synaptic tacit target memory temporal temporal context test memory time memory topographical traceless traditional transactive trauma traumatic trial-unique object recognition true typical unaware unconscious uncontaminated unimpaired unintentional unitary unwanted verbal verbatim veridical visual visual spatial voice waking well-practiced working

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