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6. AUTHOR(S)

Henry L. Roediger, III

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Rice University
6100 South Main Street
Houston, Texas 77005-1892

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13. ABSTRACT (Maximum 200 words)

AFOSR Grant F49620-92-J-0437 has provided support for the past three years on nine different lines of research. The first six of these are concerned with priming on implicit memory tests, which was the focus of the grant. The last three topics described below (the experiential basis of serial position effects and two laboratory paradigms for studying the development of false memories) were new research directions generated during the course of the grant. With regard to the main thrust of the grant, we believe we have made progress in understanding (a) the role of imagery in affecting priming on perceptual implicit memory tests; (b) the effect of distinctive or high priority events on implicit memory tests; (c) the specificity of priming on implicit memory tests; (d) the role of repetition in affecting implicit memory tests; and (e) work directed at the issue of whether implicit memory tests are "contaminated" by conscious recollection. During the past three years the grant has supported publication of 12 journal publications (counting in-press articles), 7 book chapters, and the presentation of 16 convention presentations by me and my students. Several more papers are currently being prepared for submission.

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Final Technical Report
Henry L. Roediger, III
Principal Investigator

This Final Technical Report summarizes the primary lines of research in my laboratory that have been supported by AFOSR grant F49620-92-J-0437. The main body of the text outlines nine different, but overlapping, projects that were conducted, providing a synopsis of the methods and the major findings are now available in the scientific literature, except where noted. The body of the text also includes some miscellaneous contributions supported by the grant, directly or indirectly. After the main body of the text I provide the other information that was requested, viz., a cumulative list of people whose research was supported by the grant and a list of publications and presentations supported by the grant.

The first six lines of research were all concerned with implicit memory, which was the main focus of my original proposal. Briefly, implicit memory tests are those that assess the facilitation or priming of recent experiences by indirect means. Explicit memory tests are those (such as recall or recognition) that tap conscious recollection. Implicit memory tests can reveal priming even in the absence of conscious recollection and have been widely studied in the past fifteen years. Roediger and McDermott (1993) provide a review of the literature. There are two main types of implicit memory tests. Perceptual implicit memory tests present subjects with a degraded perceptual stimulus (e.g., a word fragment, a picture fragment, or a word or picture presented very rapidly). In each case, the subject's task is simply to name or identify the stimulus as rapidly as possible. Conceptual implicit memory tests are those that tap general knowledge. For example, after exposure to a list of words (e.g., copper), subjects may be asked questions such as: "What metal comprises 10% of yellow gold?" or they might be asked to free associate to a category name such as *metals*. In both tests, priming is reflected by facilitation in answering questions or generating the item as a category member, relative to the condition when it had not been recently studied. Described below are the nine primary lines of research conducted under the auspices of this grant.

1. <u>The role of imagery in facilitating perceptual priming</u>. One consistent finding in the implicit memory literature is that perceptual priming is strongly affected by the test form of the stimulus that is presented. For example, presentation of the word *elephant* increases priming on later verbal tests involving degraded presentations of the word, but does not affect priming at all on a picture naming test where

subjects are exposed to pictures of the elephant; conversely, on a test such as picture fragment identification, prior presentation of pictures creates priming, but prior presentation of words does not. Therefore, a sharp perceptual specificity occurs in priming.

One primary line of research conducted under auspices of the grant asked whether imagery manipulations would affect priming. For example, if subjects study lists of words and are told to form mental pictures of the referents of those words, would this create priming on pictorial implicit memory tests? Conversely, if pictures are presented and subjects are asked to imagine the word that names the picture, would this boost verbal priming? Kathleen McDermott and I asked these questions (and related ones) in a series of four experiments and discovered that the answer is *yes*. Imagining the relevant percept boosts priming relative to a no-imagery control condition. These results add to the growing body of evidence showing that, when people imagine events, they engage central perceptual mechanisms actually used in visual perception. In our experiments imagery conditions (see a word, imagine a picture) never produced as much priming as actually seeing the relevant scene (seeing the picture of an elephant, for example), but did create reliable priming over the no imagery condition (just reading the word elephant and rating its pleasantness).

These results formed the basis of Kathleen McDermott's masters thesis, which won the Shahin Hashtroudi Memorial Prize from the American Psychological Society given for the "best masters thesis or dissertation on the topic of human learning and memory." This work has been published as McDermott and Roediger (1994).

2. Effects of repetition on implicit and explicit memory tests. One fundamental question in the psychology of learning and memory is about effects of repetition: on many tests, repeated events are better remembered than events presented only once. An exception appears to occur on perceptual implicit memory tests, where it has been very difficult to find repetition effects, especially when they occur massed (or the two presentations occur in immediate succession.) (e.g., Roediger and Challis, 1992). We have attacked this problem in two series of experiments that have resulted in two publications (McDermott and Roediger, in press; Weldon, Roediger, Beital, and Johnston, 1995). Briefly, presenting either a word twice or a picture twice enhances recall (either free recall or cued recall) as well as

recognition (of pictures or of words), but these manipulations have no detectable effect on priming on perceptual implicit memory tests. In addition, having subjects study a picture and its corresponding name (in two successive presentations) greatly boosts performance relative to the case of single presentation on explicit memory tests, but has no effect on priming on the relevant implicit tests. Surprisingly, repetition effects are also difficult to obtain on conceptual implicit tests, too. This set of results is quite surprising and is difficult for most theories to accommodate (including my own theory, transfer-appropriate processing; Roediger, 1990). McDermott and Roediger (in press) have speculated on how various theories must be changed to accommodate the noneffect of pattern of findings on implicit conceptual tests.

3. Specificity of priming. Another thrust of my research on implicit memory tests has been to examine specificity of priming on the perceptual tests. As noted in the first section above, specificity of priming is often found: words produce priming on verbal tests and pictures produce priming on pictorial tests, but there is little cross-form priming (except when subjects are told to imagine the relevant percept). Interestingly, when subjects hear words, they still show priming on verbal tests that present items visually (word fragment completion or word identification). The previously described research by McDermott and Roediger (1994) and by Weldon, Roediger, Beital, and Johnston (1995) examined specificity of priming and found it to be quite sharp. In addition, Rajaram and Roediger (1993) showed that on verbal implicit memory tests such as word fragment completion and word stem completion, visual presentation produced greater priming than auditory presentation and, in turn, both modes of presentation produced greater priming than did pictorial presentations (which produced either no or negligible priming). Rajaram and Roediger (1993) directly compared four implicit memory tests: word fragment completion, word stem completion, word identification, and anagram solution (rearranging sets of scrambled letters to form words). This approach, which we have used in other work, is novel in that most researchers in the area simply pick one test and assume it generalizes to others. We directly compared four tests in the same experiment and, indeed, did show that they revealed similar effects (see too Roediger, Weldon, Stadler & Riegler, 1992).

4. Effects of high-priority events on word stem completion. One fact of memory is that distinctive events of our lives are well remembered. One way to simulate this in laboratory paradigms is to present a homogeneous list of items and then present one that is quite different from the others and ask subjects to pay special attention to it. When Tulving (1969) used this procedure, he found (not surprisingly) that recall of the distinctive or high-priority event item was very good. More interestingly, he found that items immediately preceding the high-priority event were poorly remembered. That is, the high-priority event created retrograde amnesia for the preceding event.

Melissa Guynn and I used this paradigm to discover its effects on perceptual implicit memory tests (particularly, word stem completion) as well as on two explicit tests (free recall and word stem cued recall). We had subjects see lists of words from different semantic categories and we told them to pay special attention to items from one category, so that they would be sure to report the item later. So, for example, one group of subjects listened for words referring to sports (volleyball, soccer, etc.) amidst numerous other words and were told to be especially sure to remember sports items for the later tests. We found that subjects did recall the items almost perfectly, as expected on a free recall test, and we also found retrograde amnesia (i.e., poor recall of the immediately preceding item), although this effect was somewhat weak and variable across experiments. Our interest was in examining the effect on perceptual implicit memory tests. Briefly, we found enhanced priming on the high-priority items relative to other items on the word stem completion tests and we found no retrograde amnesia on this test. Therefore, just as organic amnesia spares priming on implicit memory tests, so does experimentally induced "amnesia" in Tulving's (1969) paradigm. These results were published in a special issue of **Psychological Research** devoted to implicit memory (Guynn and Roediger, 1995).

5. Effects of generating and reading on perceptual implicit memory tests. Two series of experiments have been directed at the controversial issue of whether reading words produces more priming than generating them on perceptual implicit memory tests. Jacoby (1983) and Blaxton (1989) originally reported that reading a word (cold) produced more priming on word identification and word fragment completion tests than did generating if from a conceptual clue. (What is the

opposite of hot? _____). This finding fit well with the claim that these tests were data driven (e.g., Roediger, 1990). However, Masson and MacLeod (1992) reported some experiments in which read and generated words produce equivalent priming on a word identification test. (In all these experiments, generated words produced greater recall and recognition on explicit tests.)

A set of experiments conducted in collaboration with Mustaq Khan has examined the effects of generating and reading on the word fragment completion test. We have replicated the Masson and MacLeod finding of equal priming on the two tests and are now in the process of conducting a long series of experiments trying to track down the variables that determine when reading is better than generating and when the two produce equal amounts of priming. The story thus far is rather complex, and we are currently on Experiment 9 in the series. A variable that may be critical, and which is now under direct examination, is the amount of time subjects have to read and to generate the items at study. This variable had been overlooked in much of the work and, therefore, confounded across experiments (and sometimes within experiments). This program of research is still underway.

Todd C. Jones conducted three experiments in his dissertation that were also directed at the issue of generating and reading. He used a paradigm pioneered by Jacoby (1978) in which reading a word prior to generating it undermines performance on explicit memory tests. That is, generating normally produces much better recall and recognition than reading, but if one reads a word just before the generation is required, no benefit accrues. Jones examined this finding in three experiments, both replicating and confirming Jacoby's previous work and extending the paradigm to priming on perceptual implicit memory tests. The results of the three experiments were generally consistent with predictions made from Roediger's (1990) transfer appropriate processing theory. Jones is currently writing up his dissertation for publication.

6. Direct comparison of the process dissociation procedure and the retrieval intentionality criterion for assessing contamination by conscious recollection on implicit memory tests. Another large project that is currently under preparation for publication (Jones, McDermott, and Roediger, in preparation) used two different methods to assess a persistent problem in the entire implicit memory literature: the role of conscious awareness during the ostensibly "implicit" test. Many

researchers have worried that what are thought to be implicit tests are really affected by conscious recollection. Two methods of assessing this problem -- the retrieval intentionality criterion advocated by Schacter, Bowers, and Booker (1989; see too Roediger, et al., 1992) and the process dissociation procedure advocated by Jacoby and his colleagues (e.g., Jacoby 1991; Jacoby, Toth, and Yonelinas, 1993) -- were directly compared in one experiment. In all prior work people have used either one procedure or the other. The description of these two procedures would take us too far afield in this technical report. Suffice it to say that we conducted a very large and powerful experiment to directly compare the two procedures for correcting implicit memory performance. The conclusions we are reaching in our report are that (a) implicit memory tests are not badly compromised by contamination from conscious (explicit) recollection, and (b) the process dissociation procedure and the retrieval intentionality criterion seem to provide consistent stories as to the small level of contamination. In another discussion of this problem, Roediger and McDermott (in preparation) are writing a review article arguing that the whole problem of conscious contamination on implicit memory tests has been greatly overblown. The problem exists, but it is relatively unimportant. This claim defies conventional wisdom in the field, but is consistently supported by our research and results of others.

The remaining three lines of research to be described were not in the original grant proposal, but are projects developed in my lab since the time of the proposal; nonetheless, the grant from AFOSR helped support this research, so we describe it here. The last two lines of research are concerned with memory illusions, or remembering events that never happened.

7. Experiential basis of serial position effects. Tulving (1985) developed a procedure for assessing conscious states of awareness during explicit memory tests. In particular, he argued that we have two means of accessing our personal past: remembering and knowing. Remembering is the sense that we all have of traveling back in time and re-experiencing events that happened to us; knowing is the more impersonal access that occurs when we believe with certainty that an event happened in our past, but we do not remember the event's occurrence. So, for example, I might remember vividly events surrounding a recent airplane trip, but I might know that I traveled by airplane between two cities in 1970, and yet fail to remember the experience at all. Tulving developed this procedure and adapted it

to a list-learning paradigm whereby, during a recognition test, subjects were asked to classify each test word as having either been studied before in the list or not. For items subjects deemed to be old or studied, they were then further asked to make a judgment as to whether they remembered (R) or knew (K) that the event occurred. *Remember* and *know* instructions are given according to a scripted plan to make the subjects understand the distinction. A considerable body of literature is now collecting on this topic. Rajaram and Roediger (in press) summarize much of what is known and indicate some puzzles that have arisen. In addition, Jones and Roediger (1995) examined the experiential basis of serial position effects. Do the enhanced primacy and recency effects often seen in list learning reflect *remember* responses or *know* responses? A recent theory by Tulving suggests that serial position effects reflect *know* responses. However, in our experiment, Jones and Roediger found the opposite: serial position effects clearly were reflected in *remember* responses, not *know* responses.

8. Remembering words that were not presented in lists. James Deese reported a procedure in 1959 that could potentially be used to study the development of false memories, but the technique was largely overlooked for thirty-five years. Deese had subjects study highly-related lists of words (dream, nightmare, awake, snore...) that were all derived as associates from a single word (in this case, sleep). He tested subjects with single-trial free recall immediately after the lists were presented. Interestingly, he found that some lists produced very high levels of false recall for the critical nonpresented word from which the list was derived (*sleep*). Roediger and McDermott (1995) adapted Deese's paradigm and reported two experiments showing striking levels of false recall and false recognition. Briefly, we found that subjects recalled missing words from our set of lists in 40% - 55% of the cases. In addition, the false alarm rates for the critical nonpresented items equaled the hit rates. Further, subjects were highly confident that the nonpresented words had been included in the list. They gave very high confidence ratings and they reported (using the *remember/know* technique) that they actually remembered the occurrence of these nonevents. A further finding was that if subjects had previously falsely recalled a word, they were much more likely to falsely recognize it on a later test and say that they remembered its occurrence in the list. We are currently exploring this paradigm in many experiments. Kathleen McDermott's doctoral dissertation, part of which has been accepted for publication

(McDermott, 1995), is supported by this research. Altogether she will report seven experiments using this technique. We see this as a promising method to study the illusion of remembering events that never happened.

9. Repeated testing in the eyewitness memory paradigm. In a related series of experiments, Roediger, Jacoby and McDermott (in press) have examined the role of repeated testing in the development of false memories in Elizabeth Loftus's eyewitness memory paradigm. Briefly, subjects see a slide sequence depicting a crime, then they read a narrative about the crime in which some pieces of misinformation are embedded in an otherwise accurate description. They later take two tests covering the material. We manipulated report criterion on the first test to increase or to lessen reporting of misinformation. On a second test, given two days later, we asked subjects to report only what they could remember from the original experience, and we also asked for *remember/know* judgments. If subjects had produced the misinformation on the first test, we found that they would recall it again on the second test and also be more likely to say that they remembered its occurrence. Repeated testing seems to be a key in the development of false memories.

In addition to the research described above, a number of other projects have begun but have not yet reached fruition. I will describe these briefly.

- Todd Jones is conducting research on priming of possible and impossible objects. In particular, he hopes to identify conditions under which it would be possible to observe priming on impossible objects, a result not obtained in prior work by Schacter, Cooper, and their collaborators.
- Chris Schacherer, a graduate student conducting his dissertation under my supervision, is applying David Rubin's "unit analysis" technique to study differences and similarities among explicit and implicit memory tests. The unit analysis approach treats individual items (or units) in experiments as the entity of interest and examines whether performance is correlated across items on various tests. To the extent that there are positive correlations, he infers similarity in processes underlying the tests. To the extent that the correlations are zero, or even negative, he infers that processes underlying the tests must be different. No one has yet applied the unit analysis approach to similarities and differences of implicit and explicit tests, which Schacherer

intends to do this year in a series of three experiments. This research constituted part of the original proposal (which was for five years of work).

- Lyn Goff, a second-year student at Rice, is conducting research on the levels of processing effect and its impact (or lack thereof) on implicit memory tests. Briefly, earlier research had shown that levels of processing had little or no effect on priming on implicit memory tests, even under the same conditions in which huge effects were observed on standard explicit tests. However, later research has tended to undermine this simple conclusion by sometimes obtaining levels effects on these tests. In addition, and in contradiction to many other studies, the effects are actually larger in between-subjects manipulations of levels of processing than in within-subjects manipulations. We have hypotheses as to why this curious state of affairs may have arisen and Goff is testing these ideas in her first year project.
- A framing effect in recognition memory. Kathleen McDermott and I have discovered that, if subjects are given a two-alternative, force-choice recognition test and are asked to circle the distractor or lure items rather than their targets, they sometimes show higher overall performance than when seeking the targets, and they also show a greater effect of the independent variable. This is a surprising finding and we are trying to replicate and extend it. We will present a preliminary report at the meetings of the Psychonomic Society in November.
- Melissa Guynn and Gilles Einstein have conducted research, under auspices of the grant and at Lackland Air Force Base, on prospective memory. In addition, I wrote a chapter on this topic to appear in a book that will soon be published (Roediger, in press).
- Mark Wheeler, as part of his doctoral dissertation under my direction, conducted several experiments on the role of spontaneous recovery in memory. This work, now published in the **Journal of Experimental Psychology: Learning, Memory, & Cognition**, was supported by the grant
- Finally, the grant has supported my writing of a number of chapters. The most important of these is the compendious review chapter with Kathleen McDermott on implicit memory in the **Handbook of Neuropsychology** in 1993. Others include the aforementioned chapters on prospective memory (Roediger, in press) and on remembering and knowing (Rajaram & Roediger, in press). In addition, I wrote a chapter with Melissa Guynn on retrieval processes that will appear in the new **Handbook of Memory**, edited by Elizabeth and Robert Bjork (Roediger & Guynn, in press).

Conclusion. I believe we made excellent progress toward attaining the goals of the original proposal on "Comparing performance on implicit memory tests." The original proposal was written to support five years of research and, as of this writing, we have accomplished three lines of research there proposed, are well on the way on two others, and have also had interesting offshoots into new directions (particularly on the development of false memories). The support of AFOSR grant F49620-92-J-0437 has afforded excellent support for me and my graduate students to make progress toward our goals. We are most appreciative.

Henry L. Roediger, III

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In Preparation

Jones, T.C., McDermott, K.B., & Roediger, H.L. Direct comparison of retrieval intentionality and the process dissociation procedures as means of separating intentional from incidental retrieval.

Khan, M. & Roediger, H.L. Attempts to unravel the puzzle of how reading and generating words affects priming on perceptual implicit memory tests.

Roediger, H.L. & McDermott, K.B. Implicit memory tests (usually) measure incidental retrieval.

Names of Participating Professionals

Listed here are the names of people who worked under the auspices of the grant during its three-year course.

(1) Henry L. Roediger, III; Principal Investigator. Lynette S. Autrey Professor of Psychology at Rice University, Ph.D., 1973, from Yale University.

(2) Melissa J. Guynn; Graduate student; Rice University; B.S., in Psychology, Furman University, 1991. M.S., 1994. Currently at the University of New Mexico.

(3) Todd C. Jones; Ph.D., Rice University, 1995; B.S. and M.S. in Psychology from Southern Methodist University in 1990 and 1991, respectively.

(4) Kathleen B. McDermott; Graduate student; Rice University; B.S. in Psychology, University of Notre Dame, 1990. M.S., Rice, 1994; Ph.D. expected, May, 1996.

(5) Chris Schacherer, Graduate student; Rice University; B.S. from Iowa State University in 1987 and M.S. from the University of Nevada at Las Vegas in 1989. Ph.D. expected in May, 1996.

(6) Lyn Goff. Graduate student, Rice University. M.S. candidate this year.

(7) Mustaq Kahn. Post-doctoral fellow. B.S., University of Toronto. Ph.D., University of Western Ontario. Was primarily supported by a Canadian NSERC Fellowship.

(8) Lubna Manal. B.A. Psychology, Rice University.

(9) Ron Haas, Undergraduate student; Rice University; psychology major.

(10) Bettina A. Johnson; Undergraduate student; Rice University; B.A. 1995. Currently Ph.D. student at the University of Illinois.

(11) Keith Rozendal; Undergraduate student; Rice University; B.A. in Psychology, May, 1995. Currently a Ph.D. student at the University of California, Santa Barbara.

(12) Mark A. Wheeler; Rice University; B.S. in Psychology from Trinity University, 1989; M.S. in Psychology from Rice, 1991; Ph.D. in Psychology from Rice, 1993. Mark's research on spontaneous recovery was conducted partly at Armstrong Laboratories and therefore was supported by the grant. Currently on a postdoctoral fellowship at the Rotman Research Institute in Toronto.

(13) Jody Hughes; undergraduate student; Rice University; B.A. in English Literature, 1994. Jody became interested in psychology through taking my course on human memory and worked during the summer as an undergraduate research assistant. Currently at the University of Texas Law School.

(14) Ryan Brown; B.S. in Psychology, Rice University, 1993. Ryan was another undergraduate who worked as a research assistant during the summer. Currently a graduate student at the University of Texas.

(15) Nicole Cornette; B.S. in Education, University of Nebraska, 1991. Nicole was a pert-time clerical worker/research assistant for 1992-1993 working on grant-related projects.

Presentations at Professional Meetings

Roediger, H.L. (1993). Remembering, knowing and reconstructing past events. Presidential Address, Midwestern Psychological Association, Chicago.

Roediger, H.L. (1993). Perceptual priming. International Society for Psychophysics 9th Annual Meeting. Palma de Mallorca, Spain.

Roediger, H.L. & McDermott, K.B. (1993). Effects of imagery on perceptual implicit memory tests. The Psychonomic Society, Washington, D.C.

McDermott, K.B. (1993). Effects of imagery on perceptual implicit memory tests. Texas Cognition Conference, Fort Worth.

Jones, T.C. (1994). The experiential basis of serial position effects. Texas Cognition Conference; San Antonio, May, 1994.

McDermott, K.B. (1994). Creating false memories: Remembering words not presented in lists. Texas Cognition Conference; San Antonio, May, 1994.

McDermott & Roediger, H.L. (1994). Effects of imagery on perceptual implicit memory tests. The Midwestern Psychological Society, Chicago.

Roediger, H.L. & McDermott, K.B. (1994). Creation of false memories: Remembering words that were not presented in lists. The Psychonomic Society, St. Louis.

Roediger, H.L. (1994). Remembering events that never happened. British Psychological Society. Brighton, England.

Roediger, H.L. (1994). Implicit memory tests (usually) measure incidental retrieval. Symposium on Implicit Memory. British Psychological Society. Brighton, England.

Roediger, H.L. (1994). Remembering events that never happened. American Psychological Association. Los Angeles, CA.

Roediger, H.L. (1995). Remembering events that never happened: New experiments on false memories. Boulder, CO: Rocky Mountain Psychological Association.

Roediger, H.L. (1995). Midwestern Psychological Association.

McDermott, K.B. (1995). Factors affecting the creation of false memories. Paper presented at the First Annual Meeting of the Society for Applied Research in Memory and Cognition (SARMAC), Vancouver.

McDermott, K.B. (1995). The influence of test delay and repeated list presentation on the creation of false memories. Paper presented at the 6th Annual Meeting of the Southwestern Cognition Conference, College Station, Texas.

McDermott, K.B. (1995). Remembering words that were not presented in lists: The role of testing in inducing false memories. Paper presented in a symposium on Memory Illusions at the Sixty-Seventh Annual Meeting of the Midwestern Psychological Association, Chicago.

McDermott, K.B. & Roediger, H.L. (1994). The creation of false memories. Paper presented at the 5th Annual Meeting of the Southwestern Cognition Conference, San Antonio, Texas.