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Implicit Memory Tests:

Techniques for Reducing Conscious Intrusion

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Introduction

The universally acknowledged point of origin for empirical research on memory is the classic treatise of Ebbinghaus (1885/1964). Being first, he had to develop materials to be learned and remembered — the now-famous nonsense syllables. But, he also had to develop a way to probe his own memory, and this contribution is less often highlighted. The paradigm that he created was the method of relearning. He measured how many trials it required on a first occasion for him to learn a set of materials to a fixed criterion and then noted the reduction in number of trials to relearn that set of materials on a second occasion after some retention interval. That reduction was evidence of residual information in memory, or savings, for the originally learned material.

The relearning/savings paradigm was the only tool that Ebbinghaus (1885/1964) used to study his memory. Intriguingly, his paradigm did not rely on conscious recollection at all: Savings can and does occur even when the subject has no recollection of the targeted item from the originally learned material. Ebbinghaus was quite cognizant of this feature of his memory measure, saying at the outset that, "Most of the experiences remain concealed from consciousness and yet produce an effect which is significant and which authenticates their previous existence" (p. 2). He had created a test of memory that does not rely on conscious remembering almost a century before the use of such tests would return to center stage in the study of memory.

In the intervening 100 years, the emphasis of virtually all research on memory was on tests that do require awareness that remembering is occurring (see Bower, 2000). Dominant among these have been recall and recognition: In each case, the task is to consciously bridge the present to some past learning episode. It was not until the 1980s (see Graf & Schacter, 1985) that this distinction between tests that do require conscious remembering (*explicit tests*) and those that do not (*implicit tests*) was expressly made, and the comparison of the two types of test became the subject of intensive investigation. We now know a vast amount about a wide variety of implicit tests of memory (for reviews, see Bowers & Marsolek, 2003; Roediger & Geraci, 2005; Roediger & McDermott, 1993), and our understanding of memory has benefited greatly from examining memory implicitly. It is certainly the case that our day-to-day functioning relies much more heavily on unconscious than on conscious uses of memory. Of course, it is the conscious probing of memory of which we are aware, which probably leads us to overestimate the proportion of memory use that is conscious — a metamemory error in its own right.

The Problem of Conscious Intrusion in Implicit Memory Tests

Framed in the way just described, the explicit/implicit contrast may sound quite straightforward: You simply need to inform (an explicit test) or not inform (an implicit test) subjects that their memory is being tested. In fact, though, separating these two uses of memory is considerably more complicated than might first appear. There is one overriding reason why this is the case: the problem of *conscious intrusion*. A thumbnail sketch of the problem goes like this. You choose some nominally implicit test, such as one of the first to be used as these tests began to be studied in the 1980s: word fragment completion (Tulving, Schacter, & Stark, 1982; cf. Warrington & Weiskrantz, 1970). Here, having earlier studied a list of words, the subject is given a series of partially obliterated words, such as d-n-sa--, and is asked to complete each of them with a word. The probability of successful completion (dinosaur) is greater for studied words than for unstudied words, despite no instruction to make reference to the studied words. This advantage for studied words is called *priming* and is seen as evidence of the expression of implicit memory processes.

But what assurance do we have that implicit memory processes are (solely) responsible for the observed priming? Faced with such a difficult problem-solving task, the astute subject may well reason that the recently studied list could provide assistance in completing the fragments. Efforts to consciously retrieve studied words might ensue, perhaps not immediately and perhaps not for all test fragments, but any such conscious retrieval would constitute an instance of conscious intrusion. In the absence of any index of when such retrieval had occurred, we would be at a loss to know whether an observed advantage for studied over unstudied words was truly priming of an implicit nature. This is particularly problematic when a manipulation that improves performance on an explicit memory test also improves performance on an implicit test in that, if conscious retrieval were occurring during the nominally implicit test, this correlated improvement is precisely what would be expected. But it is actually a problem any time that conscious retrieval could be occurring.

The goal of this chapter is to examine ways to deal with the problem of conscious intrusion on implicit memory tests. To measure what we want to measure — what we think we are measuring — it is crucial to minimize the probability of conscious intrusion on implicit tests. By now, a quite wide variety of strategies for optimizing the "implicitness" of implicit tests has been offered. In this chapter, these strategies are described and their relative utility and success are evaluated. Table 1 presents the set of research strategies to be considered here.

Before discussing the measurement issues, it would be remiss not to consider the theoretical and applied issues. Implicit memory, whether viewed as a unique memory system or as an isolable processing mode in a unified memory, is an important theoretical idea, one that has dramatically changed our conception of memory. It is now quite uncontroversial to say that we use memory without consciousness much or even most of the time, yet this certainly was not the case even 25 years ago. Indeed,

TABLE 1 Strategies for Minimizing Conscious Intrusion in Implicit Memory Tests

1.	Test amnesic individuals.
2.	Obtain a (double) dissociation.
3.	Equate retrieval cues and vary only task instructions (retrieval intentionality).
4.	Disguise the test via diversionary instructions or items.
5.	Ensure absence of awareness during testing.
6.	Minimize the value of conscious recollection.
7.	Measure processes, not tasks (process dissociation procedure).
8.	Use speeded tests that do not require problem solving.
9.	Employ relearning and savings techniques.

the concept has had an impact on all areas of psychology, notably clinical and social psychology. It has been a leading topic in bringing consciousness front and center in the discipline, and it has deep implications for the understanding and even the possible rehabilitation of memory disorders (see, e.g., Glisky & Schacter, 1987, 1988; Glisky, Schacter, & Tulving, 1986). Given the sweeping influence of implicit memory, we want to be able to measure it well, and it is to that goal that the rest of this chapter is dedicated.

Test Amnesic Individuals

From the beginning of research on implicit memory, evidence deriving from the study of individuals with organic amnesias has played a crucial role. Indeed, looking far back, Claparede (1907; see Nicolas, 1996, for a translation) even demonstrated the presence of unconscious memory in a Korsakoff patient using Ebbinghaus's relearning/savings technique and noted that this preserved unconscious memory was apparent despite the patient's almost total failure in conscious memory, whether by recall or by recognition. This nicely presaged the work of the most recent quarter century.

Taking the earlier work of Warrington and Weiskrantz (1970, 1974) as the point of departure, Graf, Squire, and Mandler (1984; see also Graf, Shimamura, & Squire, 1985) demonstrated that amnesic individuals showed quite normal priming on a visual implicit word completion test (e.g., "Say the first word that comes to mind that begins with def") while showing a dramatic deficit on an explicit recall or recognition test. Schacter, Church, and Treadwell (1994) showed similar preservation on an auditory test of implicit memory in the face of explicit memory loss. Jacoby and Witherspoon (1982) reported an analogous finding: Amnesic subjects exhibited the same bias toward the studied meaning of a homonym (e.g., reed vs. read) as did normal subjects on their implicit homonym spelling test, despite the amnesic subjects showing very poor explicit recognition of the words as having been studied. Corresponding results were reported for the preservation of skill memory (Musen, Shimamura, & Squire, 1990; Musen & Squire, 1991).

If the explicit memory of an amnesic subject is effectively inaccessible, then it seems axiomatic that the performance of that subject on an implicit test cannot be contaminated by conscious recollection. This logic has led to the frequent reports of intact (or even just reliable) implicit memory in amnesic individuals being treated as the definitive corroboration that there can be "pure" implicit priming, and that the loss of explicit memory in amnesic individuals is independent of their preserved implicit memory, such that the two expressions of memory must rely on different neural circuitry. But, sometimes implicit memory does suffer in amnesic subjects (e.g., Jernigan & Ostergaard, 1993). As well, there is ongoing debate in the literature regarding whether amnesic individuals learn new associations as well as normal individuals do. Some reports — beginning with the groundbreaking study of Graf and Schacter (1985) — suggested that they do (e.g., Gabrieli, Keane, Zarella, & Poldrack, 1997; see also Goshen-Gottstein, Moscovitch, & Melo, 2000). Others questioned the generality of this claim (Paller & Mayes, 1994; Rajaram & Coslett, 2000), arguing that learning of new associations is impaired in amnesic individuals. The resolution may have come from Gooding, Mayes, and van Eijk (2000), whose meta-analysis indicated that amnesic individuals show intact implicit memory for new associations involving familiar but not novel materials, and that the structures damaged in amnesia may be essential for handling novelty.

The evidence derived from the study of amnesic individuals is quite compellingly in favor of distinct implicit and explicit memory processes (or perhaps systems, but that debate is beyond the scope of this chapter; see Moscovitch, Vriezen, & Goshen-Gottstein, 1993, for a review). It is persuasive evidence, but it is nonetheless limited. Not every task has been or could be investigated in the context of amnesia, and the amnesias that individuals suffer certainly are not all the same. Also, it is not always the case that implicit memory is entirely preserved when explicit memory is decimated, making the contrast more complicated. Thus, as compelling as the amnesia evidence is, we cannot rely on it as providing complete assurance that all nominally implicit tasks are completely implicit. Indeed, even if a given test were to appear fully implicit in one study, a small change in procedure or materials or the like could overturn this in another study.

Finally, of course, there is the predicament that we cannot await an amnesia-based certification of every conclusion that we wish to draw about implicit memory based on research with nonamnesic individuals. Cases of amnesia are too rare for that. Moreover, the extent of damage to cognitive processes outside memory is often not known, making the comparability of amnesic individuals to nonamnesic individuals more complicated.

Obtain a (Double) Dissociation

In behavioral studies as in neuropsychological studies, a powerful argument for distinct processes is the identification of a task dissociation, the more so if it forms half of a double dissociation (see Dunn & Kirsner, 2003; Shallice, 1988). If a manipulation affects performance on one task (T1) but not on another task (T2), that is a single dissociation; the pattern just described of intact implicit but sharply diminished explicit memory in amnesia represents a single dissociation. If a second manipulation has the opposite effect (i.e., it affects performance on T2 but not on T1), that is a second single dissociation, and the co-occurrence of these two opposite single dissociations constitutes a double dissociation. Under such circumstances, it is generally seen as extremely difficult to argue that performance on one task mediates performance on the other, given their opposite directions of effect.

A good illustration of a double dissociation in behavioral data involving implicit and explicit memory was provided by Jacoby (1983b). Subjects read isolated words or generated them from antonym cues during study. On an explicit recognition test, the generated words were remembered much better than the read words (the familiar generation effect; Slamecka & Graf, 1978). But, on an implicit perceptual identification test, in which masked words had to be identified, the words read at study were better identified than those generated at study. Although this pattern is not entirely general (see Masson & MacLeod, 1992), it is a particularly striking example because it is not just that each task is affected by one level of encoding while the other is not, but that the effects on the two tasks are actually opposite to each other. Dunn and Kirsner (1988), Shallice (1988), and others have distinguished this "crossed" double dissociation from the basic "uncrossed" double dissociation described in the preceding paragraph. There are many examples of double dissociations in the cognitive literature (e.g., Gabrieli et al., 1995). How could priming on the implicit task be the covert result of contamination by conscious recollection when conscious recollection would have produced the opposite pattern?

Dunn and Kirsner (1988, 2003) argued that, despite their widespread use and plausibility, the logic behind dissociations is not unassailable. Single dissociations can reflect a single process with a level of function that is not apparent in a given task. They extended this analysis to both types of double dissociation as well, concluding that, "In summary, functional dissociation, whether single or double, is not logically inconsistent with the single-process model. By varying the transformation relating process function to task performance while retaining a monotonic mapping, it is possible to derive single-process accounts that are consistent with all kinds of dissociation" (1988, p. 96). Add to this the problem that implicit memory tests are often considerably less reliable indices than are explicit memory tests (Buchner & Brandt, 2003; Buchner & Wippich, 2000), and the problem becomes a complex one, especially given that it is most often the explicit test that shows an effect and the implicit test that does not.

Van Orden, Pennington, and Stone (2001) took a different tack — questioning the logic of underlying modularity that they saw as fundamental to the logic of dissociation — in reaching a similarly skeptical conclusion about dissociations. This is related to Reingold's (2003) argument that the tasks that give rise to a (double) dissociation may not be as comparable as the often strongly made contrast assumes: Frequently in memory experiments, the cues available on the implicit and explicit tasks differ considerably (see the discussion concerning the retrieval intentionality criterion), the response measurement is dissimilar, and the role of response bias is not or cannot be equated. Reingold also pointed out the too-often-overlooked problem that a different class of processes (e.g., retrieval vs. decision) may be affected in two tasks that appear to dissociate. To the extent that tasks are difficult to compare directly, the interpretation of a dissociation becomes less straightforward.

A recent issue of *Cortex* featured a target paper by Dunn and Kirsner (2003) and a series of reactions by other researchers. In broad summary, the contributors agreed that dissociations are not definitive but also for the most part agreed with Baddeley (2003), who saw dissociations as useful statistical tools in that they can place quite strong constraints on our process theories. Dissociations force us to think about the underlying processes and, in the case of dissociations between implicit and explicit memory tests, do sometimes provide comfort that conscious intrusion is not a salient factor in implicit test performance because such intrusion would have worked against the observed effect.

Equate Retrieval Cues and Intentionality

The fact that the retrieval cues on the implicit and explicit memory tests are so often very different is itself a quite fundamental problem. Contrast explicit recognition, for which the entire studied word is (re)presented, to implicit fragment completion, for which only some of the letters of the studied word are shown, as was the case in Tulving et al. (1982). Or, compare explicit recognition, for which the test items are fully exposed, to perceptual identification, for which the mask sharply limits perceptual analysis, as was the case in Jacoby (1983b). Not only are there stimulus differences, but also those stimulus differences bring into play different processes — decision making in the case of recognition and visual problem solving in the case of fragment completion and perceptual identification, as illustrations. Such comparisons are not straightforward and direct.

It was with this problem in mind that Schacter, Bowers, and Booker (1989) put forward the retrieval intentionality criterion, invoking this logic: "If the external cues are held constant on two tasks and only the retrieval instructions are varied, then differential effects of an experimental manipulation on performance of the two tasks can be attributed to differences in the intentional versus unintentional retrieval processes that are used in task performance" (p. 53).

Graf and Mandler (1984) reported just such a comparison. They gave subjects three-letter word stems as retrieval cues under two sets of instructions: implicit (stem completion: produce the first word that comes to mind) and explicit (stem-cued recall: produce a studied word). Their results revealed a dissociation: Semantic processing at study resulted in a substantial advantage over nonsemantic processing on the explicit test (a levels-of-processing effect; cf. Craik & Lockhart, 1972) but had no effect on the implicit test. Given the identical stem cues on the two tests and only a difference in instruction, this study fits the retrieval intentionality criterion. Numerous other examples exist (e.g., Richardson-Klavehn & Gardiner, 1996; Roediger, Weldon, Stadler, & Riegler, 1992).

If possible, having identical stimuli presented on the explicit and implicit tests certainly is preferable because this eliminates one task difference. Results can also be impressive, as in Java's (1994) finding of a double dissociation when only instructions differed between otherwise identical implicit and explicit tests. But using identical stimuli is not a perfect solution, either. As Reingold (2003) argued, although the problems of cue difference and response measure difference are solved by the retrieval intentionality criterion, the problem of bias differences in the two types of test remains. So, there must be a higher goal — to equate the tests on as many elements as possible. Butler and Berry (2001, p. 194) pointed out that equating the stimuli alone "does not solve the more intractable issue of phenomenological awareness," citing the findings of Richardson-Klavehn, Clarke, and Gardiner (1999), who showed that performance on a nominally implicit test was driven exclusively by an unintentional retrieval strategy (see also Seamon, McKenna, & Binder, 1998).

Finally, of course, the proximal stimulus on which the subject operates may not coincide with the distal stimulus actually presented and may well differ between the explicit and implicit tasks. It must also be noted that requiring strict adherence to the retrieval intentionality criterion would rule out many conceivable and potentially informative variations in test format, in particular for implicit tests. Critically, it remains possible that subjects could still opt to engage in conscious recollection on the nominally implicit test, the implicit instructional set notwithstanding.

Disguise the Test via Diversionary Instructions or Items

Closely related to the preceding strategy is another one, one that was prevalent early in the effort to compare implicit and explicit memory tests and to identify the processes underlying them. Researchers attempted to disguise the fact that their implicit tasks were actually memory tests (see Schacter, 1987, p. 510). One approach was to use incidental study, the goal being to conceal the study–test relation, thereby preventing subjects from realizing, first, that there had in fact been a study phase and, second, that the test was actually a test. Thus, for example, Jacoby (1983a) represented his study phase for a list of words as a measure of reading speed, what he called a "cover task." However, Greene (1986; see also Bowers & Schacter, 1990) demonstrated that incidental versus intentional learning instructions really did not matter with respect to priming on an implicit test.

A more frequently used approach has been not to try to conceal the study–test relation but rather to disguise that the implicit test is actually a memory test. Sometimes, this has been done using diversionary instructions. Thus, Bowers and Schacter (1990) recruited subjects for a "study of picture and word perception." MacLeod (1989a) informed subjects that an implicit word fragment completion test was part of the research of a colleague, and that it was not the promised memory test. Others represented the implicit test as a "filler task" before the memory test. To avoid concerted efforts at retrieval, it was also quite common to emphasize quick responding, and to highlight that what was sought as a response was "the first word that came to mind" (see Schacter & Graf, 1986). Careful consideration of the task instructions is always important in cognitive psychology; nowhere is this more true than in the case of implicit tests of memory.

More often, the test has been disguised by the inclusion of diversionary distracters. Schacter and Graf (1986) constructed a set of filler items for their implicit test "to disguise the fact that the completion test included previously studied pairs" (p. 434). In a concerted attack on this approach, Challis and Roediger (1993; see also Jacoby, 1983a) systematically varied from 0% to 100% the ratio of studied to unstudied items on a word fragment completion test. One would expect the implicit nature of the test to be better hidden when there were fewer studied items on the test (or less study–test overlap; see Fujita, 1994), but variation in the studied-to-unstudied ratio had no effect on priming. Although this outcome can be seen as good news for the assumption that the test was implicit, it also suggests that such diversionary tactics may not be effective.

A related approach that might occur to an investigator would be to bury the studied material in some kind of larger context, for example, to put the critical words in sentences or passages. This would reduce the isolation of the items and make conscious retrieval less tempting and presumably less successful. Relatively early studies showed, however, that this tactic resulted in substantially reduced priming (e.g., MacLeod, 1989b; Oliphant, 1983). Of course, this could be in part because such contextual embedding foiled subsequent efforts to consciously retrieve the studied items. More likely, though, it is because the integration of the critical items into context makes them less distinctive and accessible for subsequent, usually perceptual, implicit tests (for more on distinctiveness, see Hunt & Worthen, 2006).

Ensure Absence of Awareness During Testing

It would seem logical that if a subject were unaware that his or her memory was being tested, then conscious intrusion should be unlikely: Why use memory strategically if you do not even know that it is being interrogated? This logic has been used with some success in conjunction with perceptual implicit tests. Thus, priming on such tests has been obtained even when subjects report no awareness that the implicit test is in fact a test (i.e., that it is related to the preceding study phase). Following study and test, Bowers and Schacter (1990) had subjects respond to a series of questions that first generally and then more pointedly probed whether they had made the connection between study and test. They then separated their subjects into those who were test aware versus those who were not. Both subsets showed reliable priming, but consistent with their confession that they were aware of the test, test-aware subjects showed more priming on semantically encoded relative to structurally encoded items, whereas this was not the case for test-unaware subjects. Using awareness questions and the remember/know procedure, Java (1994) showed that even when subjects became aware that some test items were studied, they still showed a dissociative pattern on the implicit and explicit tests for the items that they were not aware of having studied. She essentially evaluated awareness on an individual item basis, which is unusual: Typical awareness indices follow the entire test so as not to disrupt it.

Indices of awareness often do show, however, that subjects had at least some awareness of studied items reappearing on the test by the end of the test (see, e.g., Richardson-Klavehn, Lee, Joubran, & Bjork, 1994). The difficulty is in knowing when they became aware and how much this awareness influenced their performance. Were only a couple of items affected, or were most affected? Did this start early in the test or only later? The problem is that a stringent criterion that required elimination of all data for which there was any hint of postexperiment awareness would eliminate much of the literature. Furthermore, this only results in the elimination of data for which subjects remember and report being aware: It must be kept in mind that on such posttest awareness evaluations there is always the possibility of subjects forgetting the degree of their earlier awareness, or of subjects reporting no awareness when in fact they were aware. Awareness measures certainly do tell us, though, that subjects can be quite exquisitely tuned to the study–test relation despite our best efforts to prevent (and to measure) such tuning.

Minimize the Value of Conscious Recollection

Data elimination because of reported awareness is a problem with respect to many studies using perceptual implicit tests, but it is especially problematic in the case of conceptual implicit tests. Thus, using a general knowledge test, Thapar and Greene (1994) found that all of their subjects were aware of the study–test connection, and that they were aware very soon after beginning the test. When Mulligan and Hartman (1996) required subjects to produce category members, more than 90% of their subjects indicated awareness of the study–test relation. This represents a very serious concern in the case of implicit conceptual tests, particularly given the frequently coinciding influences of conceptual processing on conceptual explicit and implicit tests. Are the effects the same because these two types of tests, when functioning as intended, respond similarly or because the implicit tests are being (heavily) contaminated?

The logic of conceptual implicit tests typically requires that a meaningful probe be used to elicit the studied target, whether the probe be for general knowledge (e.g., having studied "Jacques Plante" and subsequently being asked "Which NHL goalie won the most Vezina trophies?") or category exemplar generation (having studied "hockey" and subsequently being given the probe "Name sports"). The problem is that such probes require a quite demanding retrieval involving extended search thereby inviting conscious recollection, perhaps particularly when the answer does not spring immediately to mind. And, of course, retrieval probability is good when information has been encoded semantically, increasing the likelihood of success.

What is required is a task that makes conscious retrieval of little value. Hourihan and MacLeod (2007) have proposed and tested an alternative form of conceptual implicit test. The task is a modified version of implicit word association (e.g., Vaidya et al., 1997) in which ordinarily the subject must produce the first associate that comes to mind to a probe word (e.g., the subject might produce the studied word "saddle" with heightened probability in response to the probe word "horse"). The problem is, once again, the need to produce a studied word in response to a new probe: Subjects could try to consciously retrieve the studied item. Hourihan and MacLeod simply switched from probing with a new word to elicit the studied target to probing with the studied target to elicit a new word — any new word. This rendered conscious recollection useless.

Because subjects would produce a response on every trial, Hourihan and MacLeod (2007) switched from an accuracy measure to a latency measure, measuring time to produce the associate on the reasonable assumption that associates should be produced faster to primed items than to unprimed items, especially when encoding had been conceptual. To determine the contribution of repetition priming for the probe, given that it was studied, they included a separate block of trials in which subjects were timed while they simply read the probes aloud. Even when repetition priming was subtracted out of associative priming, there was still substantial conceptual priming remaining, and that conceptual priming benefited from prior conceptual processing but not from prior nonconceptual processing. It seems very unlikely that such priming could result from conscious recollection.

Probably the Hourihan and MacLeod (2007) technique is not "pure," either, and subsequent research will reveal its difficulties. But, the main message is that we need to develop paradigms that help to reduce the utility of and contribution of conscious recollection, on the "ounce of prevention is worth a pound of cure" platform. Making the studied information the probe instead of the target is just one of the possible ways to do so.

Measure Processes, Not Tasks (Process Dissociation Procedure)

Calling a test implicit or explicit suggests that the test is *only* implicit or *only* explicit — that it involves only unconscious or only conscious processes. Indeed, this sometimes seems to be the assumption underlying contrasts in the literature between these two categories of tests. Yet, the very recognition that a nominally implicit test might be contaminated by conscious recollection makes clear that such task purity is highly questionable. Jacoby (1991, 1997) brought this assumption of purity under close scrutiny with the introduction of his process dissociation procedure (PDP). He argued that all processing involves both automatic and intentional influences, and crucially, that there is no existing way to completely isolate these two processing elements in individual tasks. His emphasis on processes, not tasks, is absolutely correct. As a solution, he offered a novel and intriguing approach to separating processes.

In Jacoby's initial — and prototypical — PDP experiment (Jacoby, 1991, Experiment 3), subjects studied two lists. In List A, the words were studied in one of two ways: as anagrams to be solved or as printed words to be read aloud, with all items presented visually. In List B, all words were presented auditorily. There were two groups tested under different instructions. In the *inclusion* group, subjects were to respond "old" to any previously studied item from either list. In the *exclusion* group, subjects were to respond "old" only to words heard in List B, excluding the anagram and read words from List A. Conscious processing could then be estimated by subtracting performance in the exclusion condition from that in the inclusion condition: $C = E - I$. Automatic processing could be estimated by the equation $A = E/(1 - C)$. (In a dual-process model of recognition [Yonelinas, 2002], conscious processing is equated with recollection, and automatic processing is equated with familiarity.) Jacoby carefully noted that two key assumptions underlie this approach: The automatic and conscious processes are independent, and the two processes do not change as a function of instruction.

Using the PDP procedure, Jacoby (1991) demonstrated that dividing attention at test produced a decrement in performance that was largely restricted to conscious processing with little influence on automatic processing. This opened the floodgates for studies using this new approach to separate processes within task, rather than between tasks. Thus, for example, Jacoby, Toth, and Yonelinas (1993) used PDP to show that automatic influences on an explicit stem-cued recall test were very sensitive to perceptual manipulations that had little effect on the conscious influences but not to attentional manipulations that strongly affected the conscious influences. There are by now at least 200 published articles using the PDP method, representing domains of study as diverse as decision making (Ferreira, Garcia-Marques, Sherman, & Sherman, 2006) and depression (Jermann, Van der Linden, Adam, Ceschi, & Perroud, 2005).

From the perspective of minimizing conscious recollection in implicit memory tests, the PDP method seems ideal: Separating conscious from unconscious processes is its raison d'être. And, indeed it has been put to widespread and revealing use in the service of this goal. But, it is not the last word, and critics have expressed concerns with its major assumptions. Thus, among others, Graf and Komatsu (1994) and Curran and Hintzman (1997) questioned whether automatic and conscious processes are ever truly independent (see Jacoby, Yonelinas, & Jennings, 1997, for a defense of the independence assumption, and Hirshman, 1998, for more on the logic of testing this assumption). Dodson and Johnson (1996) argued that the influence of familiarity is not fully automatic, and that recollection is not all or none, which they saw as conflicting with core assumptions of the PDP approach. So, the method is not iron clad, but it has been and continues to be very valuable in focusing research on the fundamental processes rather than the tasks. Moreover, the introduction of exclusion instructions as a technique has by itself been important (see, e.g., Merikle, Joordens, & Stolz, 1995).

Use Speeded Tests That Do Not Require Problem Solving

What would lead a subject to invoke conscious recollection during an implicit test? Certainly, awareness of the study–test relation could promote this strategy, but even such awareness might not precipitate recollection if the implicit test is easy enough. As it happens, though, many implicit tests are not at all easy, requiring solution of difficult fragments (e.g., Tulving et al., 1982), or identification under distinctly suboptimal perceptual conditions (e.g., Jacoby, 1983a). Faced with such demanding tasks, for which success is quite limited, subjects may resort to trying to remember the studied material, thereby converting the nominally implicit test into an explicit test. This situation suggests that one way to limit conscious recollection would be to make the subject's task on the implicit test as easy as possible. Why would one use conscious recollection when it is actually easier not to do so?

Possibly the word-based task that requires the least problem solving is speeded reading (also known as *naming* or *pronunciation*; see Scarborough, Cortese, & Scarborough, 1977), which makes it an interesting candidate as a possible implicit test. All the subject need do is say a common single word aloud into a microphone, so it is difficult to imagine that conscious recollection would seem like a worthwhile strategy. MacLeod (1996) showed that subjects were faster to read aloud words that they had studied than words that they had not studied, and this pattern has since been observed in several other studies (MacDonald & MacLeod, 1998; MacLeod & Daniels, 2000; MacLeod & Masson, 2000). In particular, MacLeod and Masson (2000) conducted a series of experiments exploring priming in speeded reading and observed patterns similar to another well benchmarked implicit test: masked word identification (see Masson & MacLeod, 1992). Speeded reading also showed the familiar modality effect in implicit memory, with more priming for words studied visually than auditorily, given the visual presentation of the test items. Moreover, there were no alterations in the data pattern when an effort was made to encourage conscious recollection by alternating speeded reading trials and recognition trials, despite improved explicit memory on the recognition test relative to when the entire recognition test followed the entire speeded reading test. The overall conclusion was that speeded reading is a good measure of repetition priming, likely not very contaminated by conscious recollection.

In a series of studies, Horton and his colleagues (Horton, Wilson, & Evans, 2001; Horton, Wilson, Vonk, Kirby, & Nielsen, 2005; Vonk & Horton, 2006; Wilson & Horton, 2002) have made a more concerted effort to examine response time as a measure of automatic retrieval. They began (Horton et al., 2001) by comparing a speeded implicit task with two other "bracketing" conditions; all tests used word stems as cues. In the speeded implicit test, conscious recollection was discouraged both by having a long initial set of stems that were all unstudied and by instructions to respond as quickly as possible with the first word that came to mind. One of the other conditions was otherwise identical to the implicit test but was explicit, requiring conscious retrieval of studied items. The final condition provided a baseline in that it did not permit conscious retrieval because all test cues were new. Their core idea was that if the implicit test involved conscious retrieval, then latencies on the implicit test should be longer than those on the "all-new" test for which conscious retrieval was not possible, and more like the latencies on the explicit test, for which conscious retrieval was required. In fact, response time data indicated no slowing relative to baseline for the implicit test, evidence that conscious retrieval was not occurring.

From there, Wilson and Horton (2002), Horton et al. (2005), and Vonk and Horton (2006) went on to contrast their speeded method to the PDP (Jacoby, 1991) and argued from their experiments that the PDP underestimated automatic retrieval, whereas the speeded measure provided an accurate estimate. Indeed, Vonk and Horton summarized by saying that the speeded measure represents "a purely automatic retrieval strategy" (p. 505). Although claims for the purity of any measure are suspect, and the speeded measure may not suit every situation, the consistent evidence across the studies by Horton and colleagues does point to this approach as valuable. If it is possible to measure speeded responding in a situation that does not require much in the way of problem solving, this method holds considerable promise for at least minimizing the intrusion of conscious recollection.

Employ Relearning and Savings Techniques

At the beginning of this chapter, the classic work of Ebbinghaus (1885/1964) was described, including his savings technique for studying memory (for more on this, see Nelson, 1985; Slamecka, 1985a, 1985b). In closing the discussion of how to handle contamination of implicit tests by conscious recollection, it seems fitting to return to Ebbinghaus's approach. The relearning/savings method was rarely used in research on human learning and memory after Ebbinghaus, with the occasional notable exception (e.g., Bunch, 1941). This limited use may stem in part from the demands of the procedure, often including extensive original learning together with a delayed retention test requiring a second session. But, Thomas O. Nelson (1971b) revived the technique, modifying it to optimize the procedure. Nelson then proceeded to employ relearning/savings in a series of studies that explored the residue in memory for information that could not be consciously remembered (see Nelson, 1971a, 1978; Nelson, Fehling, & Moore-Glascock, 1979; Nelson & Rothbart, 1972; Nelson & Vining, 1978).

Nelson's version of the relearning/savings paradigm involved a series of stages. During original learning, subjects intentionally learned a series of number–noun paired associates, typically to the stringent criterion of errorless performance on the entire list. After a retention interval of 1 or more weeks, they returned to take part in the remaining phases. First, they were tested for their ability to consciously remember the original pairs, permitting division of the items into a forgotten and a remembered set. Subjects next completed a single learning trial in which Nelson contrasted relearning of pairs that were either identical to original learning or related in some way (e.g., acoustically, Nelson & Rothbart, 1972; semantically, Nelson et al., 1979) to the baseline learning of unrelated new pairs on the subsequent test. To the extent that pairs shown to be forgotten on the pre-relearning test were relearned better than baseline unrelated pairs, there was evidence of savings. That savings was seen as necessarily unconscious given that an immediately preceding test failed to show conscious recollection of the target items.

The relearning/savings paradigm is therefore an implicit one. From the standpoint of the intrusion of conscious recollection, its advantage is that inability to consciously recollect the target information is demonstrated prior to relearning either by recall (e.g., MacLeod, 1976; Nelson, 1971b) or by recognition (MacLeod, 1988; Nelson, 1978). Thus, conscious recollection appears not to be the basis for relearning. Indeed, MacLeod (1976) pushed this analysis a step farther by including a post-relearning measure of whether relearned items had reinstated the originally learned items: Did relearning work by making what had been unconscious become conscious (i.e., by reminding)? Examination of only the items forgotten on the initial test after the retention interval showed that there was reliable savings for these items even when subjects could not recall the originally learned items after relearning.

Despite the difficulty of conducting relearning/savings studies, this method would appear to be worthy of further use and exploration in the context of the problem of conscious recollection contaminating implicit tests.[1] Using this method, we can be considerably more certain of what subjects remember consciously prior to an implicit test. At the very least, although likely also not a perfect solution to the problem, this tool is one that should be considered more often in trying to rule out contamination of implicit tests, thereby adding to the arsenal of methods considered in this chapter.

The Big Picture

There are no doubt other ways that we might try to address the problem of conscious processes and content intruding on what are intended to be unconscious measures.[1] A notable possibility not addressed here is to augment cognitive studies of memory with various forms of brain imaging that may be able to reveal when there is activity in regions associated with conscious processing, especially on tasks intended to be unconscious. But, the goal here has been to cover the major approaches that have been and currently are used to minimize conscious intrusion and to illustrate their advantages and disadvantages. Jacoby (1991) was certainly right in noting that process-pure tests are impossible, so we must try to develop ways to deal with the problems that this creates.

New strategies and paradigms will emerge, but at this juncture, just as it is hard to imagine a process-pure task, it is hard to imagine a process-pure solution. The optimal strategy, as always in experimental research, is a combination of replication and convergence. New measures must be put to stringent test, and their relations to existing measures must be better established than is often the case. When an interesting pattern is observed on a nominally implicit test, it is then appropriate to bring to bear some of the methods described here to enhance the likelihood that the pattern is indeed occurring implicitly, without the intrusion of conscious recollection. Perhaps it is in their very nature that subtle changes in implicit paradigms can produce quite dramatic changes. For that reason, these tests must be examined thoroughly and used with care.

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Note

1. In considering contamination of implicit tests, it may also be important to discriminate the intrusion of conscious retrieval from the intrusion of conscious content. Testing amnesic individuals, using the process dissociation procedure, and using relearning and savings paradigms all seem to reduce the likelihood of conscious content intruding. The other techniques described here seem more aimed at reducing the likelihood of a conscious retrieval strategy being applied. This distinction between process and content warrants further consideration as we develop our methods and theories relating to implicit memory.

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