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The Problem of Differing False-Alarm Rates for the Process Dissociation Procedure: Comment on Verfaellie and Treadwell (1993)

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Results reported by M. Verfaellie and J. R. Treadwell (1993) contain an interesting paradox: Under standard study conditions in which subjects read words, amnesic patients and control subjects performed identically, both in terms of overall recognition hit rate and when the data were decomposed by L. L. Jacoby's (1991) process dissociation procedure into consciously controlled and automatic components of performance. One reason for this curious outcome is that false-alarm rates differed considerably between amnesic patients and control subjects, which is not taken into account in Verfaellie and Treadwell's application of the process dissociation procedure. Considered in this article are three possible reactions to the problem of false-alarm rates differing between subject groups (or between experimental conditions) for the process dissociation procedure. A correction can be applied either (a) before the process dissociation procedure is used or (b) after the consciously controlled component has been estimated from the procedure. Alternatively, (c) data with this problem may simply be uninterpretable through analysis with the process dissociation procedure.

Verfaellie and Treadwell (1993) reported an interesting study in which Jacoby's (1991) process dissociation procedure was applied to recognition memory performance of both amnesic and control subjects following manipulation of an independent variable. The process dissociation procedure was originally developed for separating responding on a consciously controlled basis (remembering) from that driven by automatic factors (presumably based on perceptual fluency [Jacoby, 1983] or intra-item integration [Mandler, 1989]). We do not describe the full logic of the procedure here, but accounts are provided in Verfaellie and Treadwell's (1993) article and in Jacoby's (1991) original article (see too Jacoby, Toth, & Yonelinas, 1993).

During the first phase of Verfaellie and Treadwell's (1993) experiment, subjects read words and generated words from anagrams. During a second phase, subjects heard words. During a third phase, the recognition test, a series of words was presented visually, and subjects were asked to decide, for each word, whether it was old or new. The recognition test was conducted under one of two instructional sets, referred to as inclusion and exclusion conditions. In the inclusion condition, subjects were told to call an item *old* if they had read the word, solved it as an anagram, or heard the word during the first two phases of the experiment. In the exclusion condition, subjects were instructed to call an item *old* only if it had been heard (i.e., they should exclude items they had read or solved as anagrams in Phase 1 of the experiment). The exclusion condition is critical because it is assumed that any responses produced to words read or solved as anagrams (above some baseline level) are due to an automatic influence of memory. If subjects could have consciously retrieved the read or generated words during the test, they would have excluded them.

Jacoby's (1991) process dissociation procedure decomposes overall recognition (in the inclusion condition) into two components: conscious recollection and an automatic (or unconscious) component based on familiarity or perceptual fluency. Responding in the inclusion condition is attributed to a combination of conscious recollection and an automatic component. Responding (above baseline) in the exclusion condition is considered due only to an automatic component; if subjects can consciously recollect an item, then they exclude it. Therefore, by making the assumption that the conscious recollection component included in the inclusion condition is equivalent to the conscious recollection component excluded in the exclusion condition, one can estimate its magnitude by subtracting the probability correct in the exclusion condition from the probability correct in the inclusion condition. Stated in terms of equations, this gives rise to $R = I - E$, or the probability of recollection being equal to the difference in subjects' probability of responding in the two conditions. Jacoby (1991) assumed that the controlled and automatic components are independent of one another; therefore, familiarity, or fluency, can be estimated by the following equation: $A = E/(1 - R)$. That is, the probability of an item being recognized via the automatic component equals the probability that it was recognized in the exclusion condition divided by the probability

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that recollection failed (see Jacoby, 1991, and Jacoby et al., 1993, for further explication of the method).

On the basis of results obtained from application of Jacoby's process dissociation procedure, Verfaellie and Treadwell (1993) concluded that amnesics were much less likely than control subjects to use conscious recollection as a basis for recognition judgments, whereas they were just as likely as controls to base their recognition on automatic factors (presumably response fluency, or ease of producing the response). The motivation for their experiment—using Jacoby's methodology to analyze differences between amnesic patients and control subjects—is perfectly appropriate. However, the conclusions they drew hold for only one set of study items: those that had been solved as anagrams. Here we consider performance on the other set of items: words that were read during the study phase.

The intent of our commentary is to point out a paradox or problem inherent in Verfaellie and Treadwell's results, if taken at face value, and to consider possible reactions to it. The paradox is this: If one examines performance of the amnesic patients in Verfaellie and Treadwell's study under the standard conditions used to test amnesics in many prior experiments, it looks surprisingly like that of the control subjects. The standard condition used in many prior studies to compare the performance of amnesic subjects with that of control subjects is to have both groups read a list of words and to examine their memories later on a recognition test. This corresponds to the read condition of Verfaellie and Treadwell's experiment, and the results based on this condition are shown in the top two rows of Table 1. Performance in the inclusion condition can be viewed as that of a standard recognition test because subjects were told to judge a word old if they had experienced it in any part of the study phase. (In the exclusion condition, subjects were to call items old only if they had been heard, so items that had been read or solved as anagrams were to be excluded). Verfaellie and Treadwell used performance in the inclusion and exclusion conditions to estimate components of performance based on conscious recollection and the automatic influence attributable to fluency from the equations just given. The surprise in looking at the data in the top two rows of Table 1 is that amnesic patients performed as well as controls on all measures (i.e., recognition in the inclusion condition, performance in the exclusion condition, and consequently recollection and the automatic component as derived from the process dissociation procedure).

Table 1
Data From Verfaellie and Treadwell's (1993) Tables 1 and 2

Study condition and subjects	Retrieval orientation: Inclusion	Retrieval orientation: Exclusion	Components derived from the process dissociation procedure: Recollection	Components derived from the process dissociation procedure: Fluency
Read				
Controls	.45	.33	.11	.36
Amnesics	.49	.38	.11	.41
Anagram				
Controls	.67	.34	.33	.50
Amnesics	.45	.44	.00	.46
New				
Controls	.17	.19		
Amnesics	.32	.27		

Note. From "Status of Recognition Memory in Amnesia" by M. Verfaellie and J. R. Treadwell, 1993, *Neuropsychology, 7,* pp. 8 and 9. Copyright 1993 by the American Psychological Association. Adapted by permission.

How could this pattern of results occur? Verfaellie and Treadwell (1993) noted that other researchers occasionally have found equivalent recognition for amnesics and controls (e.g., Hirst & Volpe, 1982), so perhaps the results on the inclusion test are not surprising. The assumptions are that recognition judgments can be made on more than one basis and that amnesics rely heavily on the automatic (fluency) component in recognizing items. However, even with these assumptions, a puzzle exists in the data, because the process dissociation procedure is supposed to decompose the apparent equivalence in recognition into differences between subject populations in the consciously controlled and automatic aspects of performance. Therefore, we might expect to see differences between amnesics and controls on items that were read in the recollection component, but it is .11 for both groups. The conclusion to be reached from this "standard" read condition is that Verfaellie and Treadwell's amnesic patients behaved just like control subjects.

Of course, if one examines the results from the anagram study items seen in the middle of Table 1, the pattern is quite different. Recognition (reflected in the inclusion condition) was worse for amnesics than for controls; conscious recollection derived from the process dissociation procedure was absent for amnesics and substantial for controls; and the automatic component of performance that Verfaellie and Treadwell term *fluency* was about equal for the two groups of subjects. The results in the middle of Table 1 give rise to Verfaellie and Treadwell's major conclusions (i.e., that amnesics demonstrate impaired recollection but intact fluency), but these conclusions are at odds with the data shown at the top of the table.

Why do the results from the read and anagram conditions lead to different conclusions? Of course, before even entertaining this question, it might be worthwhile to see if these results replicate with a new group of patients and control subjects. There are some unusual features of the data set. For example, the control subjects performed much better on the anagrams than on the items that had been read in the inclusion condition, but there was no such difference in the exclusion condition. That is, subjects did not exclude items solved as anagrams any better than they excluded items that had been read; this asymmetry is one reason for the puzzle in the data. In addition, in the exclusion condition, amnesics actually excluded 6% more studied items that had been previously read than had been solved as anagrams, whereas solving anagrams produced no such advantage in the inclusion condition for these subjects. Thus, these ambiguities cloud interpretation of the data.

However, there is another major difficulty in interpreting the data in the top two parts of Table 1, which is illustrated in the false-alarm rates presented at the bottom of the table. The amnesic patients had much higher false-alarm rates than did the control subjects (roughly .30 and .18, respectively). No correction for guessing was applied in Verfaellie and Treadwell's (1993) analyses, and we suspect that difficulties in interpreting the data for items that had been read are partly attributable to the problem of differing false-alarm rates across subject populations.

If one simply subtracted false-alarm rates from hit rates, then amnesic patients would have shown only .17 corrected recognition for items that had been read in the inclusion condition, whereas control subjects would have shown .28 corrected recognition in the same condition. The difference between control and amnesic subjects is even greater for the anagram items when recognition is corrected in this manner (.50 and .13, for control and amnesic subjects, respectively).

It seems highly likely that this large difference in false-alarm rates is one reason that the results for items that had been read are not consistent with those of the anagram items, as shown in Table 1. We consider below three possible reactions to this state of affairs. First, an appropriate response might be to correct the hit rate in light of the false-alarm rate before applying the process dissociation procedure; we present a method of doing so but also raise grave concerns about this approach to analyzing the data. A second response is to correct for differing false-alarm rates in the automatic component derived from the process dissociation procedure after recollection has been estimated in the usual way. Finally, it may not be possible to validly apply Jacoby's (1991) process dissociation procedure to data with the problem of differing false-alarm rates. We consider these possibilities in turn.

A standard way to correct hit rates when there are differing false-alarm rates is to assume the high-threshold model as a correction for guessing and to subtract the false-alarm rates from the hit rates. Of course, believers in the theory of signal detection and its applicability to recognition memory would argue that such an approach is misguided. However, in our opinion, signal detection theory should not be applied to recognition memory data. The theory assumes that there is a single continuous distribution of familiarity or strength, whereas most recent theories of recognition memory assume (with good evidence) that there are at least two separable bases on which recognition judgments are made (Jacoby, 1991; Mandler, 1980). In our opinion, although the high-threshold correction may have its own problems, it is preferable to the signal detection theory as a correction for guessing in recognition memory. We use it here, although we consider below numerous caveats.

Let us consider what changes occur if we correct for guessing by using the high-threshold correction (i.e., subtracting false-alarm rates from hit rates). We have already used this measure in the preceding paragraphs to illustrate changes in overall recognition in the inclusion condition. The corrected data for the inclusion and exclusion conditions for both amnesic and control subjects are shown in Table 2. In addition, at the right of the table are the new estimates of consciously controlled and automatic responding, derived from the process dissociation procedure after the correction was applied.

Table 2
Using the Standard High-Threshold Correction for Guessing (Hit Rate − False-Alarm Rate) Prior to Entering Verfaellie and Treadwell's (1993) Data into the Process Dissociation Procedure

Study condition and subjects	Retrieval orientation		Components derived from the process dissociation procedure	
	Inclusion	Exclusion	Recollection	Fluency
Read				
Controls	.28	.14	.14	.16
Amnesics	.17	.11	.06	.12
Anagram				
Controls	.50	.15	.35	.23
Amnesics	.13	.17	−.04	.16
M				
Controls	.39	.14	.25	.20
Amnesics	.15	.14	.01	.14

The results in Table 2 look quite reasonable, given what we know about amnesic patients, and from the perspective of the process dissociation procedure. Recognition as indexed from the inclusion condition is much better for control subjects than for amnesic patients in both the read and anagram conditions. Control subjects also show considerable recollection (.25, averaged over read and anagram stimuli), whereas amnesic patients show essentially no recollection (.01). Both groups show effects of automatic influences on responding, although this is a bit higher for control subjects than for amnesics. (Of course, because we are working with aggregate values, it is impossible to perform inferential statistics on the data; they should be considered illustrative rather than definitive.) Overall, results from this method of correction lead to the conclusion that amnesics demonstrate impaired recollection although fluency remains more or less intact.

The correction for guessing that was just used, the outcome of which is shown in Table 2, assumed that it was appropriate to correct the hit rate by the false-alarm rate prior to entering the data into the process dissociation procedure. However, Larry L. Jacoby (personal communication, May 24, 1993) and Jeffrey P. Toth (personal communication, August 5, 1993) have argued that this is not an appropriate correction, for several reasons. One reason is that the process dissociation procedure is itself a correction of the data for countervailing influences. Just as subtracting false alarms from hits is thought to correct for guessing, the process dissociation procedure is intended to separate different bases of responding—conscious recollection from some more automatic component. Trying to correct the recognition data before applying the process dissociation procedure makes many strong (and probably untenable) assumptions about what factors produce responses in these situations. The resulting data in Table 2 may more resemble numerology than science, even though they do seem to accord with what we believe about amnesic patients' performance. A second problem, however, has to do with just this feature. Although the first correction of subtracting false alarms from hits before applying the process dissociation procedure rationalizes Verfaellie and Treadwell's (1993) data set, applying the correction to other data in the literature leads to a change in most conclusions that have been derived from the process dissociation procedure. That is, if we use the method to analyze situations in which false-alarm rates did not differ across conditions, then the conclusions arrived at by this correction procedure are unlikely. For these reasons and others raised by Toth and Jacoby, we believe that the procedure of subtracting false alarms from hits and then applying the process dissociation procedure, while providing sensible results in the present case, may not provide a general solution to this problem. Further study is clearly needed.

Larry L. Jacoby (personal communication, May 24, 1993) argued that false-alarm rates are more likely to arise from automatic processes than controlled processes. In the present case, the false-alarm rate of amnesic patients is almost twice as high as that of control subjects. Jacoby suggested that any correction should be applied only after the process dissociation procedure has been used to calculate the conscious recollection component of performance. That is, if the false-alarm rate is driven by automatic (fluency) components of recognition, then the correction should be applied only to the automatic or fluency component. In signal detection theory, subjects have always been assumed to compare the strength or familiarity of a test item along a single dimension of item strength. Although assuming a single unidimensional memory strength does not make much sense for overall recognition, for reasons given previously, the assumption may very well hold for the familiarity component derived from the process dissociation procedure. Indeed, Jacoby et al. (in press) presented a method for correcting the data in just this way. Without going into detail, the process dissociation procedure is applied as usual (proportion correct under the inclusion condition minus proportion correct under the exclusion condition) to estimate responding based on conscious control or recollection. After this step, a signal detection model is applied to estimate the automatic or fluency component, which is how differing false-alarm rates can be taken into account. This new technique is potentially quite promising, but as yet the details have not been published and the technique has not been evaluated. However, if Jacoby et al.'s (in press) method is the appropriate one, then the mystery left by Verfaellie and Treadwell's (1993) data remains: They showed that amnesics and control subjects had equivalent levels of recollection for items that had been previously read. Because conscious recollection would be estimated the same way with Jacoby et al.'s (in press) procedure, this aspect of Verfaellie and Treadwell's data would be unaffected by their procedure. Therefore, the paradox would remain.

The assumption in Jacoby et al.'s (in press) correction is that the false-alarm rate is purely an index of automatic responding. However, if one assumes that recognizing is a constructive process, then it may well be that at least on some occasions people remember or recollect that an item was on the list when in fact it was not. If some proportion of false alarms are due to processes of conscious recollection, however misguided, then Jacoby et al.'s procedure for correcting guessing outlined in the previous paragraph may not be entirely appropriate either.

This leads us to a third possibility: It may simply be the case that data compromised by differing false-alarm rates between subjects or between conditions cannot be subjected to the process dissociation procedure. A similar problem exists when the inclusion and exclusion instructions cause differences in responding to nonstudied items or otherwise affect false-alarm rates.[1]

There may be other situations that create ambiguities for interpretation of the process dissociation procedure. Fergus I. M. Craik, in reviewing this article, mentioned an interesting possibility. He pointed out that the component of conscious recollection in the process dissociation procedure

> does not measure direct recollection of items, but rather the ability to discriminate auditorily presented from visually presented items. It measures recollection of the presentation context, not recollection of the item itself. For this reason, subjects in the exclusion condition may quite correctly recollect that an item had been presented but be unclear as to its presentation mode, so wrongly check it. (Fergus Craik, personal communication, August 17, 1993)

Craik noted that the significance of this distinction can be illustrated in the following way: Consider two groups of hypothetical subjects who have identical item memory but differing source memories. One group (perhaps old subjects) is poorer than the other (young subjects) at remembering the presentation mode; therefore, the scores in the inclusion condition would be the same (because recollecting mode of presentation does not matter), but old subjects would wrongly respond under the exclusion condition (i.e., they would not exclude items because they could not recollect their source). Such a pattern of results would lead to higher recollection scores for the young subjects but higher familiarity scores for the old subjects. However, Craik pointed out that "it would be misleading to conclude to that the old subjects found words more 'familiar' or had a larger automatic component; they consciously recollected that the words were presented in the experiment but had a poorer memory for source" (Fergus I. M. Craik, personal communication, August 17, 1993).

The problem of source memory affecting the components derived from the process dissociation procedure can be demonstrated not only with differing subject groups but also with certain items sets (i.e., confusable items). In a recent dissertation, Willis (1993) had subjects study sets of statements that were alleged to be about two people, a former

[1] Jacoby, Toth, and Yonelinas (1993), in comparing performance across experiments in which baseline rates of responding differed by 20%, found that estimates of automatic or fluent processing remained the same (see their Experiments 1a and 1b and the discussion on p. 145). However, in this between-experiment comparison, the baselines were equivalent across inclusion and exclusion conditions within an experiment.

employee in an organization and a prospective employee being interviewed. Subjects read two different kinds of statements, ones relevant to job performance and ones irrelevant. Later in the experiment, subjects were instructed to recognize statements that applied to either the former employee or the prospective employee (the inclusion condition), or they were instructed to recognize only statements that pertained to the prospective employee (i.e., they were to exclude statements pertaining to the former employee and to endorse only ones concerning the prospective employee). A problem that Willis discovered in analyzing the results is that subjects were unable to maintain constant criteria in the inclusion and exclusion conditions. However, a more serious problem was that items relevant to job performance were more confusable than the irrelevant items. This problem is analogous to Verfaellie and Treadwell's (1993) problem. Willis therefore also encountered the problem of differing false-alarm rates (they were greater for job-relevant items) across experimental conditions, clouding interpretation of the data within the process dissociation procedure.

Although many of the data reported by Jacoby and his colleagues have been free of the kinds of problems encountered by Verfaellie and Treadwell (1993) and Willis (1993), we expect that these problems will be quite common in many experimental situations. Groups of subjects (young and old, brain-damaged and normal) may very well differ in their overall false-alarm rates and in how experimental conditions affect these rates. Similarly, experimental conditions will also play a role. In many of the successful uses of the process dissociation procedure, the to-be-excluded set is highly discriminable from the other set because the sets are presented at different points in time and in different presentation modalities, and so forth. However, under many other circumstances, subjects have great difficulty in excluding appropriate information from retrieval (e.g., Roediger & Tulving, 1979). To the extent that subjects have difficulty in following the exclusion direction because items are mutually confusable, because subjects have source monitoring problems, or for some other reason, application of the process dissociation procedure becomes problematic.

In short, before data can be subjected to the process dissociation procedure, it may be necessary that false-alarm rates and other extraneous sources of responding do not differ across experimental conditions (such as type of material or type of subject) or across the inclusion and exclusion instructions, except for the target items to be included and excluded. This requirement of equivalent baseline rates is unfortunate because we suspect that these conditions (differing false-alarm rates or base rates) will occur often and will therefore limit applicability of this new method.

In summary, we have pointed out a paradox in the data of Verfaellie and Treadwell (1993): Amnesics and controls showed similar recognition performance after having read words from a study list. In addition, we have outlined three possible reactions to the apparent source of the problem (i.e., amnesics produced much higher false-alarm rates than control subjects) in their experiment and, more generally, to the problem of differing false-alarm rates for the process dissociation procedure. However, resolution of this matter must await further research.

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