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A Process-Dissociation Framework for Investigating Unconscious Influences: Freudian Slips, Projective Tests, Subliminal Perception, and Signal Detection Theory

Larry L. Jacoby and Colleen M. Kelley

The latter half of the title of this article could be taken as an oddity problem of the sort that appears on "Sesame Street." If so, it is clearly signal detection theory that does not belong. Freudian slips, projective tests, and subliminal perception all have to do with unconscious influences and might bring the psychoanalytic tradition to mind. In contrast, signal detection theory is identified with "real science" of the sort engaged in by the most rigorous experimental psychologists. In this article, we argue that all four belong. We show that unconscious influences of memory and perception can be treated in a framework that bears some resemblance to signal detection theory.

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CONSCIOUS AND UNCONSCIOUS INFLUENCES IN OPPOSITION: THE FREUDIAN SLIP APPROACH

The notion of Freudian slips is that unconscious influences are revealed by errors. The advantage of studying errors is that one can be certain that influences were unconscious because the effects are counter to the person's conscious purpose. Similarly, one way of demonstrating the existence of unintended or unconscious influences of memory is to place those influences in opposition to consciously controlled, or intentional, use of memory. A fame judgment experiment we did several years ago[1] illustrates this strategy. In the first phase of that experiment, people read a list of nonfamous names, such as "Sebastian Weisdorf," under conditions of either full or divided attention. Those names were then mixed with new famous and new nonfamous names and presented for a test of fame judgments. We correctly informed subjects that all the names they had read in the first list were nonfamous, so if they recognized a name on the fame test as one from the first list, they could be certain that the name was nonfamous. Thus, conscious recollection of a name from the list opposed the effect of the increase in familiarity that name would gain from being read on the list.

During the fame test, subjects who had studied the names with full attention could recognize names as ones that appeared on the list and therefore know that they were nonfamous. In contrast, subjects who studied the names with divided attention were far less likely to recognize a name as one they had studied, and so were more likely to mistakenly judge old nonfamous names famous compared with new nonfamous names. Figure 1 illustrates this false fame effect in the di-

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vided attention condition. In contrast, the figure shows suppression of false fame in the full attention condition, with old names less often judged famous than new names.

The increase in the probability of calling a name famous, observed in the divided attention condition, must be a result of an unconscious influence of memory because an intentional use of memory would produce an opposite effect. Placing conscious and unconscious influences in opposition rules out the possibility that what one thinks are unconscious influences are actually conscious. Similar unconscious influences of memory occur in the false fame paradigm among the aged, amnesics, and people who hear a list of names while under general anesthesia.[2]

Although placing conscious and unconscious effects in opposition clearly demonstrates the existence of unconscious influences, that procedure underestimates their effects because the effects of unconscious influences are counteracted by consciously controlled processes. In the case of the false fame effect, a name could gain familiarity from prior study, but that would not show up as an unconscious memory influence if the name were also consciously recognized as from the list. What is needed is some method of separately estimating the consciously controlled and unconscious influences. Then it would be possible to see whether various factors such as dividing attention or aging affect unconscious memory as well as consciously controlled memory. We return to this possibility after considering another paradigm used to investigate unconscious influences of memory.

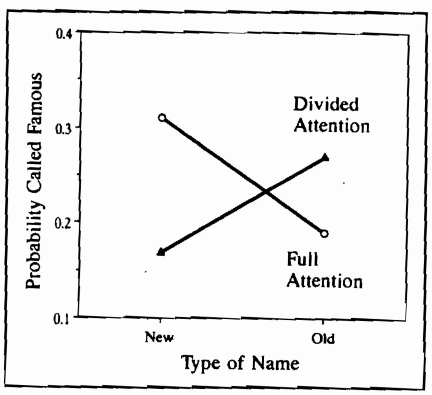

Fig. 1. Probability of judging a nonfamous name famous after reading a list on which the name appeared. A false fame effect is shown after divided attention.

INDIRECT TESTS: THE PROJECTIVE TEST APPROACH

For experimental psychologists, the investigation of unconscious influences has gained new respectability from findings of dissociations between performance on direct and indirect tests of memory and perception.[3] Striking examples of such dissociations are provided by amnesics. For example, amnesics, who perform very poorly on direct memory tests, such as recall or recognition tests, benefit as much as normal subjects from prior exposure to words when they later attempt to read fragmented versions of the words. Tasks such as reading fragmented words are indirect memory tests because they reveal effects of specific past experiences, such as reading a word, without directing subjects to remember. People with normal memory show similar effects. A widely used indirect test is the stem-completion task. For that task, people are presented with a long list of words and later are asked to complete word stems with the first words that come to mind. Prior study of a word makes it more likely that people will use that word to complete a word stem. For example, having studied the word *motel*, people are more likely to complete the word stem *mot*—— with *motel* than with another word, such as *motor*. This effect seems to be independent of people's ability to recognize or recall the word as one that was studied.

Effects of memory on an implicit or indirect test may reflect unconscious influences in the sense that a person need not be aware of using memory for effects of the past to be observed. In that sense, an implicit test is analogous to projective tests such as free association or the Rorschach. Freud used free association to reveal people's unconscious inner conflicts. Memory in the case of the stem-completion task and inner conflicts in the case of a free-association task are unconscious influences that determine what comes to mind. Unconscious influences are measured by performance on an implicit or projective test, whereas awareness or intended influences are measured by explicit tests.[4]

Psychologists who feel very comfortable interpreting performance on an indirect test of memory such as stem completion might not feel so comfortable if they thought of the parallels to a Freudian free-association test. However, the problems for interpretation are the same and arise in relating processes to tasks. Psychologists are not tempted to treat a free-association test as if it measures only unconscious inner conflicts. They realize that people may sometimes be aware of the intent of a free-association test and so alter their performance on it. Similarly, for the stem-completion task and other implicit tests of memory, people may sometimes intentionally use memory. This problem of the contamination of a supposedly pure measure of unconscious influences by conscious processes is particularly acute in the case of unconscious perception. The history of that area is characterized by claims of unconscious perception followed by counterclaims that what was actually measured was conscious perception.

Given that tests of implicit memory sometimes reflect intentional uses of memory and that tests of unconscious perception sometimes re-

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flect conscious perception, the interpretation of performance on those tests is limited. For example, on an implicit memory test such as word-stem completion, the aged show slightly smaller effects of studying words than do younger subjects. Does this finding mean that the aged have a deficit in implicit memory, or does it mean that younger subjects are more likely to intentionally use memory on a stem-completion test? How does one deal with such problems? One strategy would be to refine the measure of unconscious influences further, attempting to produce a test that is process pure, uncontaminated by conscious influences. This has been the strategy most often used in investigations of unconscious perception, and to a lesser extent in studies of implicit memory.

Such strategies for eliminating conscious influences may not be totally effective. Even if one could construct such a process-pure test, the types of questions about unconscious influences that could be asked would be restricted. For example, consider the fame experiments we described earlier. In those studies, we placed intentional uses of memory and unconscious influences in opposition, so subjects could monitor whether a name had appeared on the study list as a way to avoid unconscious influences. The interplay of unconscious and consciously controlled influences on such monitoring tasks could not be investigated using a test of unconscious influences that fully eliminated the effects of intentional memory. Another problem with investigating conscious and unconscious influences within different tasks is that a process may be qualitatively different across tasks. The issue here is something like the issue of whether it is true that people express what they "truly believe" when drunk. It is possible that what people believe when drunk is qualitatively different from what they believe when sober.

PROCESS DISSOCIATION: THE SIGNAL DETECTION APPROACH

Rather than identifying different processes with different tasks, as is done with the distinction between implicit and explicit tasks, we have used a very different strategy. We have developed a method for separating the contributions of unconscious and consciously controlled influences within a single task, just as signal detection theory separates the contributions of different processes to performance of a single task.[5] Signal detection theory starts with the assumption that discriminability and bias are independent parameters that determine performance of a task.[6] Similarly, we start with the assumption that unconscious, or automatic, influences of memory and consciously controlled influences of memory make independent contributions to performance. The problem is to measure those two types of contributions separately.

We have used a commonsense approach of defining conscious control as the difference between performance when one is *trying to* engage in some act and performance when one is *trying not to* engage in that act. If one is as likely to do something when trying not to do it as when trying to do it, clearly one has no control. Given a measure of conscious control, one can estimate unconscious influences within the confines of the same task. The stem-completion task provides an illustration.

In one set of experiments, people studied a set of words and were later given the first three letters of each word as a cue for recall (e.g., *mot*—— for *motel*).[7] In the inclusion test, they attempted to recall from the list a word that could complete the stem or, failing that, to guess with the first word that came to mind. In the exclusion test, they had to complete the stem with a word that was not on the list previously studied. Under these instructions, producing a studied word in the inclusion condition can be due to conscious recollection or to prior reading of a word making that word more likely to come to mind when guessing later. Stated formally, the probability of responding with a studied word in the inclusion test condition is the probability of recollection (R) plus the probability of the word automatically coming to mind when there is a failure of recollection, $A(1 - R)$:

probability of producing the studied word in inclusion $= R + A(1 - R)$.

In the exclusion condition, a studied word will be produced only when there is a failure to consciously remember that it was on the list:

probability of producing the studied word in exclusion $= A(1 - R)$.

In the inclusion test, unconscious and consciously controlled influences act in concert. Performance in that condition clearly overestimates unconscious influences, and does not provide unambiguous evidence even for the existence of unconscious influences. The exclusion condition places conscious memory and unconscious influences in opposition, as in the fame experiment. If frequency of use of studied words in the exclusion condition is higher than the base rate (calculated as the likelihood of completing the stem with the critical word when that word was not studied), then one can be sure that unconscious influences exist. However, performance in the exclusion condition underestimates the magnitude of unconscious influences.

For the inclusion test, people try to respond with old words, whereas for the exclusion test, people try not to respond with old words. The difference between the inclusion and exclusion tests provides a measure of conscious control. That is, the probability of conscious recollection can be estimated as the probability of responding with an old word in the inclusion condition minus the probability of responding with an old word in the exclusion condition. Once an estimate of conscious recollection has been obtained, unconscious, or automatic, influences of memory can be estimated by simple algebra. Conscious recollection can support selective responding. If people were always aware that they had read a word on the list, they would always complete the corresponding stem with that word in the inclusion condition and never complete a stem with that word in the exclusion condition. In contrast to conscious recollection, unconscious memory does not support such selective responding. The effect of unconscious memory is to increase the probability of a studied word being given as a completion regardless of whether doing so is in accord with (inclusion condition) or counter to (exclusion condition) one's intentions.

The goal in experiments using process dissociation is to find variables that produce dissociations in the estimated effects of conscious and unconscious processes. The equations assume that the effects of unconscious memory are independent of those of conscious memory. If the processes are independent, it should be possible to find a factor that will greatly influence the likelihood of conscious memory, but leave the effects of unconscious memory unchanged. One variable is the amount of attention allocated to words during study. In one study, while subjects read the word list, they had the additional task of listening to a string of digits and indicating when they heard target sequences, any three odd digits in a row. Under this divided attention condition, conscious recollection was drastically reduced (from .25 to .00), but the automatic, unconscious effects of memory were left unchanged (.47 vs. .46, see Table 1). This dissociation validates the assumption that unconscious influences are independent of a person's ability to engage in consciously controlled use of memory.

The process-dissociation procedure combines assumptions from classic test theory with assumptions from signal detection theory. An important difference between the process-dissociation procedure and signal detection theory is that we have proposed and found evidence for two bases for performance on a direct test of memory rather than the single strengthlike basis assumed by signal detection theory. By our view, one must distinguish between recollection and more automatic memory influences in tasks such as cued recall. As in classic test theory, we assume that guessing is independent of "true" remembering. In contrast with classic test theory, however, we assume that memory influences guessing. That is, guessing is informed by unintended, or unconscious, influences of memory.

Table 1. *The probabilities of completing a stem with a word previously studied and estimates of the contributions of recollection and automatic influences*

	Test performance		Estimate of memory effects	
Attention	Inclusion	Exclusion	Recollection	Automatic memory
Full	.61	.36	.25	.47
Divided	.46	.46	.00	.46

UNCONSCIOUS PERCEPTION

We have extended the process-dissociation procedure to separate conscious and unconscious effects of perception.[8] Those studies also used the stem-completion task but briefly flashed a completion word immediately before presentation of each stem. In the inclusion condition, subjects were asked to complete the stem with the briefly presented word that preceded it, or the first word that came to mind if the preceding word did not complete the stem. In the exclusion condition, subjects were asked not to complete the stem with the briefly flashed word. Aware perception of the flashed word should allow either its inclusion or its exclusion, in line with instructions. Using the process-dissociation procedure, the contributions of aware and unconscious perception were estimated. In addition, subjects' attention to the briefly flashed word was either full or divided. The procedure yielded strong evidence of unconscious perception in the completion of stems. Furthermore, the estimate of conscious perception was dramatically reduced by divided attention, whereas the estimate of unconscious perception was invariant over the two attention conditions (see Fig. 2).

In further experiments, lengthening the duration of the flashed item increased conscious perception, as one might expect, but also increased the estimate of unconscious perception. This result points out the utility of a procedure that allows one to investigate an unconscious process under the same conditions that permit the conscious process to operate. One of the most common criticisms of supposed demonstrations of unconscious perception appeals to criterion differences[9] and treats unconscious perception as just a weaker form of conscious perception, detectable when subjects lower their criterion. In contrast, the cur-

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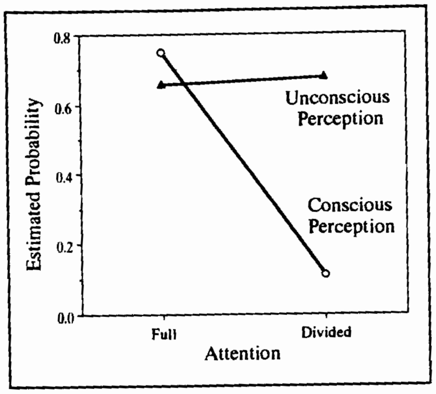

Fig. 2. Estimates of conscious and unconscious perception of words flashed briefly. Dividing attention during the brief presentation of a word reduces conscious perception but does not change unconscious perception.

rent experiments on unconscious perception indicate that there are two qualitatively different bases for perceptual judgments rather than simply a difference in criterion. Weiskrantz's[10] analysis of blindsight is similar. Blindsight is a neurological syndrome in which people who deny any subjective experience of seeing can nonetheless make visual discriminations when forced to guess. Weiskrantz presented evidence that blindsight cannot be described as merely a quantitative difference in a single criterion for responding. Conscious and unconscious perception serve as qualitatively different modes of perception.

People find the concept of subliminal perception frightening, as in the controversy over the effects of "backmasked" messages that are supposedly embedded in some rock music. These are messages that are reversed and unnoticed when the music is played normally, but that can be understood when the music is played in reverse, with a little help from expectations.[11] However, outside the laboratory, people probably more often encounter information when their attention is divided than when their perception is "subliminal." Moreover, the unconscious influences produced by dividing people's attention can probably be much larger than those produced by presenting material briefly or even backwards. Rock music is commonly listened to as background music when attention is on some other activity. Perhaps there is more to fear from the influence of "backgrounding" than of "backmasking."

What we find exciting about the process-dissociation procedure is the variety of domains in which it can be applied. For example, we and our colleagues have applied the procedure to separating bases for recognition memory, analyzing the Stroop effect, separating intuition from logic, separating heuristics from analytic bases for judgments, and analyzing the memory effects of aging and of amnesia. Currently, we are attempting to extend process-dissociation procedures to separate unconscious influences of attitudes from effects of social desirability.

The process-dissociation procedure is a valuable tool to separate conscious and unconscious processes in domains where conscious processes contaminate unconscious measures. It may prove equally valuable in assessing the role of unconscious, or automatic, processes in tasks that are now mistakenly regarded as pure measures of conscious memory or perception. Imagine, for example, how one could measure the ability of an amnesic to recollect a prior event. On a cued-recall test, amnesics can perform relatively well, which might lead the investigator to conclude that amnesics can consciously recollect events. But to what extent is their performance due to recollection and to what extent is it due to automatic, or unconscious, influences? The advantage of the process-dissociation procedure is that it allows one to separate recollection, an ability that is largely lost by amnesics, from unconscious influences, a use of memory that is preserved by amnesics. Failure to distinguish between the two types of memory effect can lead to seriously mistaken conclusions. The same may be true also on any direct test of memory for subjects with normal memories.[12] The problem occurs when measuring conscious perception as well. Standard measures of perception fail to distinguish between the contributions of conscious and unconscious perception. Unconscious influences can lead to informed guesses that must be taken into account when measuring awareness and effects of conscious control.

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Auditory Perception and Sound Source Determination

William A. Yost

When someone is asked what he or she hears, the usual response describes the various sound sources that surround the listener: "I hear the fan, the car, the wind blowing the leaves. . . ." Determining the sources of sounds has obvious ecological value for almost any organism.[1] The ability to locate food, avoid predators, find a mate, and communicate depends on being able to determine the sources of sounds. A number of authors[2] have recently reinstituted the concept of sound source determination as a major dimension of auditory perception.

When we listen to sounds in our environment, the sounds from various sources are combined into one complex sound field and do not reach us as individual sounds. In terms of perception, the task of sound source determination is often referred to as auditory object, image, or entity perception.[2] Bregman[2] described the perception of the complex sound field as a scene of auditory images, where each image corresponds to a sound source. Given that we receive a single complex sound field, how are the various auditory images formed in an auditory scene?

The complex sound field consisting of all sources is first coded by the auditory periphery, and then this code is processed by higher neural centers to allow for sound source determination. Figure 1 depicts this process simplistically: Sounds from each source are described physically in the two dimensions of frequency and time (amplitude could also be depicted in a three-dimensional time-varying spectral representation). The frequency components of each source are represented in the figure by a distinctive line type. These physical properties of each source are combined into one complex sound input. The neural code for this complex sound input consists of a pattern of neural discharges that represents the spectral and temporal properties of the incoming sound. The flow of neural information from the auditory periphery to the central auditory system contains an excellent neural picture of the complex sound field, but no code for the individual sources.

Figure 1 indicates the "problem" the central nervous system faces for sound source determination: The peripheral code contains the relevant information associated with each source, but how does the nervous system determine that the information associated with each line type "belongs together" (forms an auditory image)? That is, what mechanisms or processes pool or fuse the neural information into three distinct subsets (images)? Answering this question is the challenge for understanding sound source determination.

The depiction in Figure 1 suggests that the entire array of information flowing from the periphery must be processed for sound source determination to occur. This notion of broad-band frequency processing contrasts with the approach taken for years by many hearing scientists. A great deal has been learned about hearing by studying individual auditory channels (nerves), each tuned to a particular frequency. A popular model of auditory processing is a tuned-channel model, sometimes referred to as the critical-band model,[3] in which it is assumed that the auditory system processes sound by monitoring the output of channels, each of which is tuned to a different narrow band of frequencies.

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