PROCESS DISSOCIATIONS

OF

CONSCIOUS AND UNCONSCIOUS PERCEPTION

By

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Abstract

Conscious perception is substantially overestimated when standard measurement techniques are used. That overestimation has contributed to the controversial nature of studies of unconscious perception. I employed a process-dissociation procedure (Jacoby, 1991) for separately estimating the contribution of conscious and unconscious perception to performance of a stem-completion task. Unambiguous evidence for unconscious perception was obtained in seven experiments. Debner and Jacoby (1994, Experiment 1) showed that decreasing the duration of a briefly presented word diminished the contribution of both conscious and unconscious perception. In Experiments 2, 3 and 4, Debner and Jacoby found that dividing attention reduced the contribution of conscious perception while leaving that of unconscious perception unchanged. Debner (submitted) used the same stem-completion task to show that estimates of unconscious perception could also be affected. In one set of experiments (Experiments 1a and 1b), increasing the interstimulus interval between the briefly presented word and the test of stem completion decreased the contribution of unconscious perception to performance but left that of conscious perception intact. Experiment 2 revealed that a manipulation of visual similarity produced a similar process dissociation. Discussion focuses on the measurement of awareness, the rela-

tionship between perception and memory, and the possible episodic nature of conscious and unconscious perceptual processes.

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INTRODUCTION

Unconscious Perception: The Beginnings

Early in the history of psychology it was noted that subjects often performed better than chance on tasks where they claimed to be guessing (Peirce & Jastrow, 1884). For example, Sidis (1898/1973) reported an experiment in which he asked subjects to identify numerals printed on cards he held a variable distance away. At distances where subjects reported they could no longer see what was printed on the cards, Sidis asked them to guess. To his surprise, subjects were correct much more often than would be predicted by chance, even though they maintained they were purely guessing. Adams (1957), in a review of the literature, stated that these findings were so robust that they could "easily be obtained even as a class exercise."

Considerable interest was generated for this new phenomenon called perception without awareness; subjects were unaware of perceiving a stimulus, yet their performance indicated that the stimulus must have been processed. As critics of perception without awareness pointed out, however, there were several problems with using a subjective definition of awareness (Eriksen, 1960; Merikle, 1984). The most obvious argument against such a definition was its lack of experimen tal rigor. This procedure put the burden of defining awareness in the hands of the subjects. Each subject would likely have their own idea of what "awareness" meant and there would certainly be criterion differences between subjects. As Merikle (1984) suggested, telling subjects they will receive $100 for every stimulus they correctly detect will lead to a different threshold of awareness than will telling them they will lose $100 every time they falsely report a stimulus. Thus, although these experiments provided interesting demonstrations, the results were not regarded by many researchers as conclusive evidence for perception without awareness.

Subsequently, a more rigorous definition of conscious perception was proposed, one that was totally objective (Eriksen, 1960). This definition assumed awareness of a stimulus any time a discriminative response could be made, whether it was a guess or not. With this new definition of awareness, demonstrations of unconscious perception became extinct. The phenomenon was essentially defined out of existence. A debate ensued over what the proper definition of conscious perception should be (Adams, 1957; Dixon, 1971, 1981; Eriksen, 1960; Henley, 1984; Merikle, 1982, 1984). It was an interesting conflict: the robust, counter-intuitive effect of above-chance performance when subjects claimed they were guessing vs. the rigor of the objective definition required by experimental psychology.

One alternative that gained some notoriety was to incorporate both definitions into one's theory of perception. Cheesman and Merikle (1986; Merikle & Cheesman, 1987) discussed two separate perceptual thresholds: an objective threshold whereby no stimulus processing was accomplished and discriminative responses could not be made, and, a subjective threshold where the subjects claimed that they could no longer make discriminative responses. Of course this was not really a solution to the problem but rather a more detailed way of accounting for the fact that different results were obtained depending on the measure of awareness. When awareness was equated with objective threshold, no evidence of stimulus processing could be found. However, when subjective threshold was used to define awareness, dissociations occurred between actual performance and subjective estimates of performance.

The problem of defining conscious perception was made more acute by the methodology chosen to examine unconscious perception. By far the most commonly used method was the task-dissociation paradigm (Reingold & Merikle, 1990). The logic of this paradigm was as follows. Two tasks were chosen: Task 1, a measure of conscious perception (which obviously depended on your definition of conscious perception), and Task 2, a measure of unconscious perception (and possibly conscious perception as well). The idea was to establish a set of experimental conditions whereby conscious perception, measured by Task 1, was fully eliminated. Then, under those same experimental conditions, any effects found on Task 2 must be due to unconscious perception; conscious perception had been eliminated.

Marcel (1983, Experiment 5) conducted one of the most cited examples of the task-dissociation paradigm. Marcel flashed either a word or a blank for a very brief duration and asked subjects to make presence/absence judgments; these judgments represented Task 1. After establishing conditions under which subjects were no longer able to detect when a word was flashed, he used those same conditions in Task 2, a lexical decision task. Marcel showed that lexical decisions were facilitated when related words were flashed immediately prior to making the decision compared to when an unrelated word was flashed. This pattern was found even though the subjects could not tell when a word or a blank was flashed. The effect on lexical decision was attributed to unconscious perception of the flashed words.

Implicit in the use of the task-dissociation paradigm was the assumption that conscious and unconscious perception were separate processes. Therefore, if unconscious perception existed, it should be possible to selectively remove conscious perception and observe effects of unconscious perception in isolation. In theory the logic was sound, but in practice it was impossible to accomplish. Reingold and Merikle (1990) outlined the assumptions that had to be met in order for this paradigm to produce a satisfactory demonstration of unconscious perception. The critical assumption was that the measure of conscious perception had to be exhaustive; it had to measure all conscious perception that occurred. An exhaustive measure was necessary so that conscious perception could be fully eliminated. If conscious perception was not fully eliminated, then skeptics could (and did) argue that any effects found on the second task (the one supposedly revealing unconscious perception) were merely due to residual conscious perception. This criticism was in fact laid against every study of unconscious perception using the task-dissociation paradigm (Holender, 1986).

Use of the task-dissociation paradigm to study unconscious perception caused considerable controversy. There were arguments over which two tasks should be chosen, which definition of conscious perception should be used, whether or not conscious perception was truly eliminated (after all, one is in the position of proving the null hypothesis) and whether such a paradigm could demonstrate the existence of unconscious perception even if such a phenomenon did exist.

The main problem with the task-dissociation paradigm was not the logic but rather the choice of tasks. More often than not the task that was chosen to reveal unconscious perception (Task 2) was affected by conscious perception in the same manner. Using Marcel's lexical-decision task for example, if the words presented prior to lexical decision were flashed for a supraliminal duration, lexical decisions were facilitated

(Meyer, Schvaneveldt & Ruddy, 1975; Neely, 1977). In this case the facilitation is easily explained as due to processes triggered by conscious perception of the flashed words. In the condition where words are presented subliminally, why claim that the facilitation is due to unconscious perceptual processes when a perfectly good explanation (conscious perception) already exists? From the critics point of view, in any instance where conscious perception would cause exactly the same pattern of results as unconscious perception there is no justification for postulating an unconscious process to account for the results. What was needed was some way of distinguishing conscious from unconscious processing.

Qualitative Differences

More recently, the study of unconscious perception has involved the investigation of hypothetical differences between conscious and unconscious processes. According to the logic of this new approach, effects of unconscious perception could be distinguished from those of conscious perception because the two produce qualitatively different patterns of results. In fact, as Reingold and Merikle (1990) commented, if unconscious perception existed but the difference was merely one of degree, then the phenomenon would not even be worth studying.

Merikle and Cheesman (1987) provided an excellent illustration of the qualitative differences approach using a variation on the Stroop (1935) task. In this version of the Stroop task, subjects named the color of a colored bar which was preceded by a color word (e.g., a red color bar preceded by the word "green"). Normally, color-naming response times for congruent (i.e., the word name and the color bar are the same) trials are faster than for incongruent trials (when name and color are different). This is the standard Stroop effect. As Logan, Zbrodoff and Williamson (1984) demonstrated, however, when a large proportion of the trials in the experiment were incongruent, a qualitatively different pattern emerged: incongruent trials showed faster response times than congruent trials. This latter pattern of results was believed to result from a conscious strategy. Because only two colors were used, it was easy to predict the color of the upcoming color bar. Therefore, if the word "green" preceded a red color bar on most of the trials, this information could be used to facilitate performance on those trials compared to the relatively infrequent congruent trials.

Merikle and Cheesman (1987) hypothesized that unconscious perception of the color words would not support the use of such a strategy. They predicted that for subliminally presented color words the standard Stroop effect should be observed even when the vast majority of trials were incongruent. The comparison of interest in their experiment was between two conditions in which most of the trials were incongruent. In one condition, the color words were flashed at a duration previously determined to be at subjective threshold: the point where subjects claimed they could not see the stimuli. In the other condition, the words were flashed for a much longer duration, above subjective threshold, to ensure conscious perception. Although the two conditions used exactly the same materials, the results showed a qualitatively different pattern of results. For the long duration condition, response times were faster for incongruent trials thus replicating the findings of Logan et al. (1984). However, when the words were flashed at subjective threshold, response times were faster for the congruent trials. Merikle and Cheesman argued that conscious perception of the flashed color words, which generated faster responses on incongruent trials, could not possibly have produced the opposite pattern of results found in the subjective threshold condition.

Several investigations of unconscious perception utilized the qualitative differences approach (Cheesman & Merikle, 1986; Jacoby & Whitehouse, 1989; Joordens & Merikle, 1992; Marcel, 1980). Unlike the task-dissociation paradigm, which was heavily criticized, the qualitative differences approach sparked a renewed interest in the field of unconscious perception.

The Process-Dissociation Procedure

The experiments reported in this thesis incorporated a new methodology, the process-dissociation procedure, for studying unconscious perception. There were two primary reasons for switching to a new methodology. It was apparent from the decades of controversy that the task-dissociation paradigm was not going to produce a convincing demonstration of unconscious perception. Although the qualitative differences approach did provide evidence for the existence of unconscious perception, it did not allow the measurement of either conscious or unconscious influences. Further, most of the past attempts to study unconscious perception had been conducted under conditions meant to eliminate conscious perception (as was required by the task-dissociation paradigm). Rather than studying unconscious perception in isolation, it seemed more useful to study unconscious perception in the presence of conscious perception. This situation is probably more representative of the real world.

I had several goals for this thesis. The first goal was to provide a solid demonstration of unconscious perception. Although the field of unconscious perception is quite old (Kihlstrom, Barnhardt & Tataryn, 1992), there is still a paucity of evidence for the phenomenon. Second, I wanted to go beyond demonstrations of unconscious perception and actually quantify the contribution of conscious and unconscious perception to performance within a single task. Such a quantification allowed an investigation of the processes of conscious and unconscious perception that could not have been done using existing methods. Finally, the process-dissociation procedure offered a solution to the ongoing debate over the definition of conscious perception.

In the following paragraphs I briefly discuss the process-dissociation procedure. A more thorough discussion is undertaken in the manuscripts that follow.

The basic premise of the process-dissociation procedure is that conscious and unconscious perception represent two qualitatively different processes. The procedure involves separately estimating the contribution of the two processes to performance. In this way, the process of unconscious perception can be studied in the presence of conscious perception thus avoiding the rather thorny problem of having to eliminate conscious perception. Moreover, since conscious perception does not have to be eliminated, the procedure permits one to examine variables affecting conscious perception.

Several assumptions are made with respect to the application of the process-dissociation procedure. One key assumption is that only conscious processes support controlled or intentional responding. Indeed, it is my contention that conscious perception can be understood in terms of controlled responding: specifically, the difference in performance when one is <u>trying to</u> as opposed to <u>trying not to</u> engage in some behavior (Jacoby, 1991). This assumption is relatively uncontested and, in fact, similar assumptions have been adopted by others (Joordens & Merikle, 1993). One benefit of using control as the basis for inferring awareness is that it closes the gap between the layperson's and the experimentalist's definition of awareness. Both would agree that control is the important issue when dealing with the concept of awareness (Jacoby, Toth, Lindsay & Debner, 1992; Merikle & Cheesman, 1987; Posner & Snyder, 1975).

A second, more controversial assumption is that conscious and unconscious perceptual processes make independent contributions to performance (Joordens & Merikle, 1993; Jacoby, Yonelinas & Jennings, in press; Jacoby, Toth, Yonelinas & Debner, in press). In order to quantify the contribution of conscious and unconscious processes to performance, some relation between the two processes has to be assumed. Mathematically speaking, the independence assumption is the easiest one to make and thus provides a good starting point. Based on intuitive grounds, others favor a redundancy relation in which conscious processes only occur in the presence of unconscious processes (Joordens & Merikle, 1993). A major theme of this thesis is the presentation of data in support of the independence assumption.

If the processes of conscious and unconscious perception are in fact independent, then it should be possible to find variables that affect the estimates of one process but leave the estimates of the other process unchanged. This is the essence of independence. The experiments included in this thesis reveal six such "process dissociations".

To anticipate, Experiments 2-4 of the first manuscript (Debner & Jacoby, 1994) show that dividing attention affects estimates of conscious perception without influencing estimates of unconscious perception. The sheer consistency of these results alone is evidence for the independence of the two processes. The assumption receives even more support, however, from the three experiments reported by Debner (submitted). In this manuscript, I describe two variables, interstimulus interval (ISI) and visual similarity, which affect estimates of unconscious perception while leaving estimates of conscious perception intact.

Many of the experiments in this thesis were motivated by previous research in the field of memory. In fact, the dissociation of conscious and unconscious perception produced by dividing attention has been replicated for consciously controlled and automatic influences of memory (Jacoby, Toth & Yonelinas, 1993). Furthermore, the effects of ISI and visual similarity on estimates of unconscious perception are consistent with previous research using indirect tests of memory and perception (Chalfonte, 1989; Jacoby & Hayman, 1987; Roediger & Blaxton, 1987). Taken together, these results provide compelling evidence for the existence of unconscious perception as a qualitatively different process independent of conscious perception.

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Unconscious Perception: Attention, Awareness, and Control

James A. Debner and Larry L. Jacoby

Conscious perception is substantially overestimated when standard measurement techniques are used. That overestimation has contributed to the controversial nature of studies of unconscious perception. A process-dissociation procedure (L. L. Jacoby, 1991) was used for separately estimating the contribution of conscious and unconscious perception to performance of a stem-completion task. Unambiguous evidence for unconscious perception was obtained in 4 experiments. In Experiment 1, decreasing the duration of a briefly presented word diminished the contribution of both conscious and unconscious perception. In Experiments 2–4, dividing attention reduced the contribution of conscious perception while leaving that of unconscious perception unchanged. Discussion focuses on the measurement of awareness and the relation between perception and memory.

Unconscious perception is perhaps the oldest and most controversial area within experimental psychology (for reviews, see Greenwald, 1992, and accompanying commentaries). Kihlstrom, Barnhardt, and Tataryn (1992) suggested that an experiment examining unconscious perception done by C. S. Peirce and Joseph Jastrow in 1884 was the first psychological experiment performed in America. Peirce and Jastrow's experiment, in which they themselves were the subjects, concerned people's ability to discriminate minute differences in the pressure placed on their fingertips. The task amounted to deciding which of two pressures was the heavier and then rating confidence in that decision. Peirce and Jastrow's results demonstrated that discrimination was at an above-chance level even when conditions were such that they considered their decisions to be pure guesses.

The dissociation between effects in performance and awareness reported by Peirce and Jastrow (1884) is directly analogous to findings from many subsequent studies of unconscious perception. By far, the most popular methodology for studying unconscious perception has been the task-dissociation paradigm (Reingold & Merikle, 1990). Conditions are first established such that conscious perception, as measured by one task (e.g., subjective report), is eliminated. According to the logic of the paradigm, under these conditions any effects obtained on a second task must be attributable to unconscious perception. Although such discrepancies between effects on behavior and awareness are extremely robust and have been replicated repeatedly in different domains (e.g., Adams, 1957; Cheesman & Merikle, 1986; Marcel, 1983a; Sidis, 1898/1973), their classification as "unconscious" was severely criticized by Eriksen in 1960 and more recently by Holender (1986). Both critics concluded, on the basis of methodological concerns, that the supposed demonstrations of unconscious perception were in fact caused by conscious perception. Important for their conclusion is the method used to measure conscious perception.

How should conscious perception be measured? Although it is generally acknowledged that measures of unconscious perception are sometimes "contaminated" by effects of aware perception, much less attention has been given to the converse case. That is, measures of conscious perception are sometimes contaminated by effects of unconscious perception. In this article, we provide evidence of such contamination by showing that "guessing" is informed by unconscious perception. For measures that are used standardly, informed guessing results in the overestimation of conscious perception. One specific instance of this difficulty is found in Holender's (1986) recent review of the literature on unconscious perception. Holender (1986) stated that "conscious identification can be indicated by overt behavior, for example, by naming the stimulus, discriminating it as familiar, categorizing it, pointing to a matching object, and so on" (p. 1). In fact, it is arguable whether any of those behaviors provides a pure measure of conscious perception.

We report experiments in which we used a process-dissociation procedure (Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993) to better measure conscious perception and to separate the effects of unconscious perception from those of conscious perception. Use of that procedure allowed us to go beyond demonstrating the existence of unconscious perception and on to investigating factors that differentially influence the magnitudes of conscious and unconscious perception. In the course of our discussion, we highlight the similarity of the problems faced when studying unconscious perception and unconscious influences of memory.

The Advantages of Opposition

Most experiments purporting to demonstrate unconscious perception can be described as using "facilitation" paradigms. That is, in those experiments, effects of unconscious processing served to facilitate performance on a task. For example,

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Forster, Booker, Schacter, and Davis (1990) reported evidence indicating that unconscious perception influences stem-completion performance. In their experiment, words flashed for a brief duration were "sandwiched" between words presented for a longer duration (i.e., one before and one after the briefly flashed word), followed by presentation of a word stem that subjects were to complete. On some trials, the flashed word could be used to complete the stem (e.g., elastic; ela----), whereas on other trials it could not (e.g., lattice; ela----). Results showed that flashing a word increased the likelihood of its being given as a completion, even though subjects professed to be unaware that the completion had been flashed. Thus, the findings reported by Forster et al. (1990) revealed a dissociation between effects on a direct measure (subjective report) and an indirect measure (completion performance) of perception.

Of course, those results would not convince the nonbeliever that unconscious perception truly exists. Critics (e.g., Holender, 1986) would argue that subjects actually saw some of the flashed words even though they did not report doing so. The controversy arises because the procedure used by Forster et al. (1990) constitutes a facilitation paradigm; conscious perception of the masked word would produce the same pattern of responding as would unconscious perception. Because both processes can contribute to performance on such tests, it is impossible to determine whether the obtained effects are attributable to conscious processes, unconscious processes, or, as is most likely the case, a combination of the two.

This difficulty is not limited to the perceptual domain. Rather, interpretational problems are encountered whenever a task (e.g., subjective report) is identified with a single process (e.g., conscious perception). Such problems are most obvious in the literature concerned with unconscious influences of memory (Jacoby, 1991; Richardson-Klavehn & Bjork, 1988). According to one currently popular method, conscious recollection is revealed by performance on direct tests of memory (e.g., cued recall), whereas unconscious influences of memory are measured by indirect tests (e.g., stem completion). Rather than equating process with task, Jacoby et al. (1993) used a procedure to separately estimate the two sources of memory contributing to performance of a single task. This technique, termed the *process-dissociation procedure*, is described in detail later with reference to its use for separating conscious and unconscious perception. First, we describe results obtained from the application of the procedure in a memory paradigm.

In the Jacoby et al. (1993) experiments, a list of words was presented for study followed by a test of stem completion. In one condition—the inclusion test condition—subjects were instructed to complete stems with words from the study phase or, if they could not do so, to give the first completion that came to mind. Thus, the inclusion test was akin to a direct test of cued recall. Both conscious recollection and automatic influences of memory would increase the likelihood of a study item being given as a response on an inclusion test. Hence, comparing performance on an inclusion test to baseline, as is common practice, does not provide an accurate estimate of conscious recollection. That estimate is "contaminated" by automatic influences of memory gained from reading the words in the study phase.

Jacoby et al. (1993) incorporated a second condition—the exclusion test condition—in which consciously controlled and automatic influences were placed in opposition. This was accomplished by instructing subjects to complete the stems with words not seen earlier in the study phase. Given these instructions, recollection of study list items would decrease the probability of their being given as a response. In the absence of recollection, however, any automatic influences gained from previously reading the words would increase the likelihood of their being given as a response. Thus, although an above-baseline probability of responding with "old" words on an exclusion test would provide solid evidence for the existence of automatic influences, it would not be an accurate estimate of those influences. In this case, any conscious recollection occurring on the task would contaminate the estimate of automatic influences.

The process-dissociation procedure used by Jacoby et al. (1993) combines performance in an inclusion and an exclusion condition to better estimate the contribution of the two influences of memory to stem-completion performance. In Experiment 1b, they used this procedure to investigate the influence that dividing attention during the study phase had on estimates of consciously controlled and automatic influences of memory. Results revealed that study words read under full attention were given more often on the inclusion test than on the exclusion test. This difference in performance between the inclusion and exclusion tests indicates that some study items were recollected. These recollected items were output on the inclusion test and withheld on the exclusion test, thus yielding a difference between the two tests. By contrast, words studied under divided attention (i.e., while performing a concurrent digit-monitoring task) were given equally often on inclusion and exclusion tests and at a rate that was significantly higher than baseline. This pattern shows that the divided-attention manipulation eliminated recollection of the study words; subjects were not able to respond with study words any more often when told to (inclusion) as compared with when told not to (exclusion). Importantly, automatic influences of memory were not affected by the divided-attention manipulation. Estimates of automatic influences for words read under full attention were nearly identical to those for words read under divided attention, although the two types of study items differed greatly for estimates of recollection.

The aforementioned pattern of results was described by Jacoby et al. (1993) as a "process dissociation" (p. 144). Estimates gained from the process-dissociation procedure showed that one process was radically reduced by a manipulation that left the other process unchanged. Jacoby and his colleagues (e.g., Jennings & Jacoby, 1993; Toth, Reingold, & Jacoby, 1994) have relied on process dissociations of that sort to argue that consciously controlled and automatic influences of memory make independent contributions to performance on tasks such as stem completion. We propose a similar relationship between conscious and unconscious perceptual processes.

The Relationship Between Perception and Memory

What delineates the area of perception from that of memory? Certainly, there is a fine line between the two. Both areas of study could be effectively described as investigating the influences of a prior experience on present performance. Indeed, the similarities between perceptually generated and memorially generated unconscious influences are striking. In each case, a subjective awareness of the initial processing event is absent, although performance may clearly show effects of this event. Although the interval of time between presentation of an item and its test is shorter in investigations of unconscious perception than in investigations of memory, forgetting may occur during that interval. Similarly, visual masking may have the effect of producing a failure in retrieval or recovery of memory for a briefly flashed word (cf. Marcel, 1983b). At the extreme, it is impossible to discriminate between unconscious influences of memory and unconscious perception, and, fortunately, it does not seem terribly important to do so. Awareness at the time an effect operates is more important than any earlier difference in awareness. If one is to avoid a source of influence, one must be aware of that influence when it exerts its effect. In that regard, both unconscious perception and unconscious influences of memory have their effects by means of processes that are not under current volitional control.

Regardless of their similarities, the fields of perception and memory have had distinct histories. In terms of methodology, there appear to be three important elements that differentiate studies of perception from those of memory. Typically, the intervals between "study" and "test" are much shorter when studying perception. In addition, many fewer stimuli (usually only one) are presented prior to the test phase of a perception study. As a final contrast, studies of unconscious perception usually involve some manipulation for reducing the likelihood of awareness at input (i.e., reducing duration). Thus, for unconscious influences of perception, the lack of awareness is induced by the input manipulation. In studies of memory, on the other hand, input is ensured and unconscious influences are instead revealed by lengthy delays between study and test.

Consistent with the previous discussion, we believe that conscious and unconscious influences of perception operate in a manner similar to consciously controlled and automatic influences of memory. Nevertheless, given their separate histories, our chief goal was to demonstrate unconscious influences using a design associated with traditional studies of unconscious perception (i.e., a short study–test interval, few study items, uncertain input). To accomplish this goal, we adopted the stem-completion task used by Forster et al. (1990). Rather than attempting to reveal unconscious perception by preventing awareness of the flashed words, however, we chose to separately estimate the contribution of the two processes to performance by using the process-dissociation procedure (Jacoby, 1991).

The Process-Dissociation Procedure: Separating Effects of Conscious and Unconscious Perception

Our experiments followed the Forster et al. (1990) design whereby a word was flashed for a brief duration immediately prior to the onset of a stem that subjects were to complete. We assumed that conscious and unconscious perception of the flashed words would contribute independently to performance on the stem-completion task. Moreover, like the process of recollection described by Jacoby et al. (1993), we postulated that conscious perception supports intentional control of responding. By contrast, unconscious perception serves to increase the likelihood that the flashed solution will be given as a response, irrespective of intention. To separately estimate the effects of these two perceptual processes, we used the process-dissociation procedure. Thus, instead of instructing subjects to complete the stems with the first word that came to mind, as Forster et al. did, we gave subjects inclusion and exclusion instructions.

In the inclusion condition, conscious perception acts in concert with unconscious perception just as in facilitation paradigms (e.g., Forster et al., 1990; Marcel, 1983a). A stem could be completed with a flashed word either because the subject consciously perceived the flashed word (C), or, because even though conscious perception failed (1 − C), the effects of unconscious perception (U) were sufficient for the flashed word to be given as a completion. That is, conscious perception and unconscious perception serve as independent bases for responding. Stated formally, the probability of completing a stem with a flashed word in the inclusion test condition is as follows:

$$\text{inclusion} = C + U(1 - C) = C + U - UC. \qquad (1)$$

Because conscious and unconscious perception act in concert, a finding that the probability of completing a stem with an old word is above baseline does *not* provide evidence for the existence of unconscious perception. It is the possibility of conscious perception producing such an effect that is the basis for criticisms of supposed demonstrations of unconscious perception (e.g., Eriksen, 1960; Holender, 1986). By the same token, an above-baseline probability of responding with an old word for an inclusion test also does *not* provide unambiguous evidence for the existence of conscious perception. The above-baseline performance might have resulted from guessing that it was informed by unconscious perception.

For the exclusion test condition, subjects were instructed *not* to complete stems with the flashed word or, if they did not see the flashed word, to use the first word that came to mind. Given exclusion instructions, awareness of the presentation of a flashed word results in its being withheld as a response. Consequently, a flashed word should be given as a completion in an exclusion condition only if unconscious perception is sufficient for its being given as a response (U) and the word is not consciously perceived (1 − C). Stated formally, the probability of responding with a flashed word that should be excluded is as follows:

$$\text{exclusion} = U(1 - C) = U - UC. \qquad (2)$$

Placing effects in opposition is a powerful technique for demonstrating the existence of unconscious perception. If, in an exclusion condition, previously flashed words are more likely to be given as completions, compared with baseline, one can be certain that the words were unconsciously perceived; conscious perception would cause the words to be given less often. However, unless conscious perception has been fully eliminated (i.e., C = 0), performance in an exclusion condition underestimates the contribution of unconscious perception. To the extent that conscious perception is not fully eliminated, it offsets any influence of unconscious perception. The process-dissociation procedure corrects for the contamination caused by conscious perception on an exclusion test thus producing more accurate estimates of conscious and unconscious perception.

The process-dissociation procedure requires the combination of an exclusion condition with an inclusion condition. Given these two conditions, the probability of conscious perception (C) can be estimated as

$$C = \text{inclusion} - \text{exclusion}. \quad (3)$$

Once an estimate of the contribution from conscious perception (C) has been obtained, that of unconscious perception (U) can be estimated by means of simple algebra. The easiest way to do this is by dividing "exclusion" by the estimated probability of a failure in conscious perception (1 − C). Hence,

$$U = \text{exclusion}/(1 - C). \quad (4)$$

The probability of conscious perception provides a measure of consciously controlled processing defined in terms of selective responding. If people were always aware of the flashed word (i.e., C = 1.0), they would always complete the stem with the flashed word in the inclusion condition and never complete the stem with the flashed word in the exclusion condition; selectivity of responding would be complete. In many cases, of course, conscious perception would not be so complete (i.e., would be less than 1.0), and so both types of perceptual process will contribute to overall performance. Unlike conscious perception, unconscious perception is not assumed to support selectivity of responding. The effect of unconscious perception is to increase the probability of responding with an old word regardless of whether doing so is in accord with (inclusion test) or counter to (exclusion test) the intention set by instructions.

We adopt the simplifying assumption that effects of unconscious perception of a flashed word add to the baseline probability of completing a stem with that word. Hence,

$$U = P + B. \quad (5)$$

The use of Equation 4 to estimate unconscious influences, then, results in an estimate (U) that is the sum of the effects of unconscious perception (P) and baseline (B). Effects resulting from unconscious perception of the flashed word can thus be estimated by subtracting a measure of baseline from the estimate of U derived from Equation 4. Given that baselines do not differ across conditions, subtracting baselines will not change the pattern of results. Consequently, when one is interested in showing that unconscious influences differ between conditions, rather than interested in the absolute level of unconscious influences, one does not subtract baselines. It is important that baselines not differ because if they did, U for the inclusion test would not be the same as U for the exclusion test. Consequently, Equation 4 could not be used to gain a measure of conscious perception.

A strong assumption embodied in the equations is that effects of unconscious perception are independent of those of conscious perception. By use of the process-dissociation procedure, our goal was to find variables that would produce dissociations in the estimated effects of conscious and unconscious processes. To validate the use of the procedure, we thought it important to be able to find such dissociations. At first glance, there is an air of circularity to this argument: We were using equations, derived from an assumption of independent processes, to collect evidence to show that the processes were indeed independent. The worry of circularity dissipates, however, when one realizes that the rationale for our approach rests on manipulations that, on a priori and empirical grounds, can be hypothesized to affect one process and not the other. Process dissociations of this sort have been found in investigations of memory (Jacoby, 1991; Jacoby et al., 1993; Jennings & Jacoby, 1993; Toth et al., 1994) and Stroop task performance (Lindsay & Jacoby, in press).

Experiment 1

In Experiment 1, we examined the variable of presentation duration. Like many researchers before us, we hypothesized that reducing the duration of a flashed word would differentially impair conscious but not unconscious perception of that word. In our case, however, we did not have to satisfy the criterion of fully eliminating conscious perception; the effects of conscious perception could be separated from those of unconscious perception with the process-dissociation procedure. This experiment had two objectives: (a) to provide convincing evidence for unconscious perception by showing above-baseline performance in an exclusion condition and (b) to measure, using the process-dissociation procedure, the contribution of conscious and unconscious perception to performance across different presentation durations.

Method

Subjects. Twenty-one subjects enrolled in an introductory psychology course at McMaster University served in the experiment for course credit. Data from 1 subject had to be discarded because of a programming error. Subjects were tested individually.

Materials and design. A pool of 588 five-letter words was used for construction of the test materials. From this pool, 120 words were selected as "critical items" and divided into 10 groups of 12 words each. These groups of critical items were equated in terms of word frequency (Thorndike & Lorge, 1944). As described shortly, the other 468 words were used to fulfill the remaining requirements of the experimental conditions. In addition, 44 random letter strings were constructed for use in nonword trials. Two sets of stimuli, each containing an equal number of critical items, filler words, and random letter strings, were composed for use in the two different test conditions (inclusion vs. exclusion). Test instructions were manipulated within subjects such that the experiment consisted of two blocks of test trials.

Each test trial was made up of three stimuli presented in succession, followed by a three-letter word stem. The first and third stimuli of the sequence were always words. These words acted as forward and backward masks for the second stimulus item in the sequence, which was either a word or a random letter string. Because this procedure made a sort of "sandwich," we call the second stimulus item the *sandwiched item* throughout the rest of this article. Word stems were produced by replacing the last two letters of a five-letter word with underscores. All of the word stems used had at least 2 five-letter solutions (e.g., tab _ _ could be table, tabby, or taboo).

On critical trials, the three-letter word stem was drawn from one of the items in the critical groups. There were three different types of critical trials produced by manipulation of the sandwiched item in the sequence: (a) match trials, in which the sandwiched item was a word that completed the word stem (i.e., "scalp" for the stem *sca* _ _); (b) nonmatch trials, in which the sandwiched word did not complete the stem (e.g., "fatal" for the stem *sca* _ _); and (c) nonword trials, in which the sandwiched item was a random letter string (e.g., "oeddv" for the stem *sca* _ _). Nonword trials provided a means for assessing stem-completion performance when the sandwiched item was not meaningful. Long-duration nonword trials were omitted from the design so as to disguise the existence of nonword trials. Thus, five different conditions were produced from the combination of the three trial types and the presentation duration (short vs. long) of the sandwiched item.

On filler trials, a word that could complete the stem always occurred in either the first or third position in the sequence; the sandwiched word was never a completion for the word stem. These trials were included in the design so that attention would be somewhat distributed across the three flashed stimuli. Six types of filler trials were produced from the factorial combination of solution word position (first vs. third), sandwiched item type (word vs. letter string), and duration of sandwiched item (short vs. long). The three factors were not fully crossed because two of the eight possible combinations—the two long-duration letter-string conditions—were excluded from the design. These two types of filler trials were excluded for the same reason as described previously for the critical trials.

Five list formats were constructed by rotating each group of critical items through each of the five different critical trial conditions. Filler items were not rotated through conditions. This design produced a test list of 60 critical and 30 filler trials for each of the two test blocks. Thus, a total of 180 test trials were presented in the entire experiment.

In addition to the 180 test trials, 3 practice trials were placed at the beginning of each test block. The practice trials consisted of 1 long-duration match trial, 1 short-duration nonmatch trial, and 1 short-duration nonword trial.

Procedure. The experiment was programmed using the software package *Micro Experimental Laboratory* (Schneider, 1990). All stimuli were presented by means of a Zenith Data Systems computer interfaced with a Zenith VGA color monitor. Stimuli appeared as white lowercase letters on a black background. The character size of the stimuli was approximately 2.5 mm × 4 mm. The subjects were seated at a distance of approximately 45–55 cm from the screen.

Experimental trials consisted of the following sequence of events: (a) presentation of a fixation point for 2 s; (b) presentation of a premasking word for 50 ms; (c) presentation of the sandwiched item, either a word presented for 50 ms (short) or 500 ms (long) or a random letter string presented for 50 ms; (c) presentation of a postmasking word for 500 ms; (d) a delay of 500 ms in which the screen was blank; and (f) presentation of a word stem that the subject was to complete. All events occurred in the same location in the center of the screen.

Instructions (inclusion or exclusion) were given at the beginning of each of the two test blocks. Half of the subjects received inclusion instructions first and the other half received exclusion instructions first. All subjects were informed that they would be shown the first three letters of a word (i.e., a word stem) and were asked to generate a five-letter word that would be a completion for that stem. In addition, they were told that prior to the appearance of the word stem a sequence of either two or three words would be flashed briefly on the screen and that this sequence would sometimes contain a completion to the stem.

Inclusion instructions emphasized that the word stem *should* be completed with one of the words from the sequence flashed immediately prior to its appearance. Subjects were instructed that if none of those words completed the stem, then they should respond with the first word that came to mind that was an acceptable completion for the stem.

Exclusion instructions emphasized that the word stem should not be completed with a word from the sequence flashed immediately preceding the stem. If a completion word did occur in the preceding sequence, then they were to produce an alternative completion for the stem. As in the inclusion instructions, if no completion word occurred in the sequence preceding a stem, subjects were to respond with the first word that came to mind that was an acceptable completion for the stem. Before the start of each block, subjects were asked to repeat the instructions so as to ensure that the instructions were clearly understood.

Responding on the stem-completion task was verbal. Subjects were given 7.5 s to solve the word stem. If the subject gave a solution within the allotted time, the experimenter recorded the solution and initiated the next trial sequence. If, after 7.5 s, no solution had been given, the computer generated a tone that signaled the experimenter to initiate the next trial.

For each stem, there was one particular "target" solution. This solution corresponded to the sandwiched word that was presented on match trials. Thus, *table* would be a target completion to *tab* _ _ but *taboo* would not because *table* occurred as the sandwiched word during match trials for the stem *tab* _ _. For all experiments, analyses were performed on the probability of completing critical stems with their target solution, and, unless otherwise specified, the significance level for all tests was set at the .05 level. Also, main effects were not reported when higher order interactions were significant. For all experiments, data from nonmatch and match trials were analyzed separately.

Results and Discussion

The mean probabilities of responding with a target word when inclusion instructions were given were .38, .34, and .34 for nonword, 50-ms nonmatch, and 500-ms nonmatch trials, respectively. Under exclusion instructions, the mean probabilities for those same trials were .36, .35, and .33, respectively. Data from nonword and nonmatch trials were analyzed in a 3 × 2 repeated measures analysis of variance (ANOVA) that included the variables of duration (50-ms nonword, 50-ms nonmatch, and 500-ms nonmatch) and instruction (inclusion vs. exclusion). Results from that analysis revealed no significant effects. The mean of the nonmatch trials (.34) was taken as the "baseline" probability for giving the target word as a completion and was used for comparison with match trials.

Evidence for the existence of unconscious perception. Table 1 shows a summary of the completion data from match trials. Results from the exclusion test condition provide unambiguous evidence of the existence of unconscious perception. In particular, the probability of completing a stem with the target word on short-duration trials ($M = .50$) was found to be significantly higher than that of baseline ($M = .34$), $t(19) = 3.66$, $SE = .04$. That high probability of producing flashed words as responses on exclusion trials was caused by unconscious perception, not by a failure to understand and follow instructions. This was demonstrated by the finding that when words were presented for a longer duration so as to make their conscious perception highly likely, subjects had little difficulty excluding the words. On long-duration trials, stems were completed with their target words at a rate that was reliably lower than that of baseline (.10 vs. .34), $t(19) = 8.13$, $SE = .03$. Thus, the increased probability of responding with words flashed for a brief duration (50 ms) could not be explained as being produced by conscious perception because conscious perception had the opposite effect. Although performance in the exclusion test condition provided strong evidence for the existence of unconscious perception, it underestimated the magnitude of unconscious influences. This underestimation was a result of the effects of unconscious perception being partly offset by effects of conscious perception.

The clear evidence of unconscious perception gained by use of the exclusion test condition could not have been revealed by use of standard self-report procedures. The inclusion test condition corresponded to a direct test of perception akin to those standardly used to measure awareness. For the inclusion test, presentation of a completion word increased the likelihood of its being given as a response over baseline (.34), regardless of whether the word was presented for a short ($M = .63$) or a long ($M = .96$) duration. Both increases were highly significant, $ts(19) = 7.41$ and 30.90, $SEs = .04$ and $.02$, respectively. Results on the inclusion test may be interpreted as showing that subjects consciously perceived many of the words that were flashed for a short duration. To correct for guessing, baseline (.34) would be subtracted from the probability of responding with the target completion (.63). Doing so, the probability of conscious perception would be estimated as being .29. However, estimating conscious perception in that way ignores the contribution of unconscious perception and indeed defines unconscious perception out of existence.

The difference between performance in the inclusion test condition and baseline undoubtedly overestimated the probability of conscious perception. If the probability of consciously perceiving words flashed for a short duration were .29 and unconscious perception did not play a role, the probability of responding with an old word in the exclusion condition should have been below, not above, baseline. Conscious perception of the flashed words would allow them to be either included or excluded, whichever was dictated by instructions. As evidence for this assumption, the ability to control responding was clearly demonstrated for words flashed at a longer duration. A better measure of conscious perception is provided by the difference between performance in the inclusion and exclusion test conditions. It is that measure that is used in the process-dissociation procedure.

Table 1
Observed Probabilities of Completing Word Stems With Target Words on Match Trials Across Instruction and Duration in Experiment 1

	Instruction			
	Inclusion		Exclusion	
Duration	P	M^a	P	M^a
50 ms	.63	(.61)	.50	(.51)
500 ms	.96	(.95)	.10	(.15)

Note. The mean rate of completion on nonmatch trials was .34.
[a] These numbers represent observed probabilities of completing word stems with target words after removing the data from 6 subjects who achieved perfect performance in the inclusion and exclusion conditions.

Table 2
Estimates of the Contribution of Conscious Perception and Unconscious Perception to Stem Completion Performance in Experiment 1

Duration	Conscious perception	Unconscious perception
50 ms	.10	.58
500 ms	.80	.76

Note. Data from 6 subjects were excluded from these estimates because an estimate for unconscious perception could not be calculated (see the text).

Estimating effects of conscious and unconscious perception. The process-dissociation procedure was used to estimate the separate effects of conscious and unconscious perception. Estimates of the two types of effects were computed for each subject using Equations 3 and 4, along with performance on inclusion and exclusion tests for match trials. For 6 subjects, performance in the inclusion and exclusion test conditions was perfect (i.e., 1.0 and 0.0, respectively) when words were presented for a long duration. Their data had to be discarded for purposes of analyses because, for them, the estimate of unconscious perception was undefined; the use of Equation 4 would entail dividing by zero. The mean estimates for the remaining 14 subjects are shown in Table 2. Reducing the duration of the sandwiched word drastically decreased the probability of conscious perception and, to a lesser extent, that of unconscious perception. Separate one-tailed t tests showed both effects to be significant, $ts(13) = 13.28$ and 1.86, $SEs = .05$ and $.10$, respectively. We used one-tailed t tests because, on a priori grounds, we expected that any effect of decreasing duration would be to decrease conscious and unconscious perception.

It was perfect responding on the long-duration trials that made it impossible for us to estimate the effects of unconscious perception for some subjects. For the long-duration trials, the generally high level of accuracy including or excluding earlier-presented words shows that subjects followed instructions. Why did not all subjects show perfect performance when words were presented for a duration (500 ms) that allowed awareness of their presentation? One possibility is that because of a lapse in attention, subjects might not have consciously perceived some of the long-duration words and consequently failed to exclude those words. In Experiments 2 through 4, we examined the effects of dividing attention on conscious and unconscious perception. A second possibility is that, although consciously perceived, subjects might have sometimes forgotten the word that had been presented and, for that reason, failed to follow instructions. Given that the filler trials forced them to pay attention to the first and third items of the "sandwich," this hypothesis seems reasonable. To claim that forgetting played some role is to suggest that the results we take as showing unconscious perception sometimes arose from unconscious influences of memory (cf. Jacoby et al., 1993). Indeed, our contention is that the two types of influences are closely related and may even share common mechanisms.

Unconscious perception, as well as conscious perception, decreased with decreases in presentation duration. At some level, this should not be surprising. If a masked word were presented for 1 ms, neither the effects of unconscious perception nor conscious perception would result. However, that both conscious and unconscious perception are tied to presentation duration does make clear the difficulties faced by those who have tried to demonstrate the existence of unconscious perception by traditional means. To show effects of unconscious perception while holding the probability of conscious perception at zero requires that one find a presentation duration that is sufficiently long to allow unconscious perception and sufficiently short to disallow conscious perception. The range of presentation durations that satisfy these dual constraints is probably a narrow one and different across subjects, levels of practice, and so forth. Because the target range of presentation durations is small and moving, it is unlikely that many supposed demonstrations of unconscious perception actually hit that target.

By using the process-dissociation procedure, we could avoid the necessity of hitting such small moving targets and instead separately estimate the contributions of conscious and unconscious perception to performance. However, to validate the use of that procedure, it was necessary to find some variable that, for example, would reduce the probability of conscious perception but leave the effects of unconscious perception unchanged (a "process dissociation"). It should be possible to find such process dissociations if conscious and unconscious perception do in fact serve as *independent* bases for responding. In Experiment 2, we examined the effects of dividing attention during the presentation of the flashed word. On the basis of the results of experiments examining unconscious influences of memory (Jacoby et al., 1993), we expected divided attention to reduce the probability of conscious perception but to leave invariant the effects of unconscious perception.

Experiment 2

Experiment 1 supplied strong evidence for unconscious perception using the traditional variable of duration. In this experiment, we examined the effect of another variable, attention, which has been used less commonly in studies of unconscious perceptual processes. There were many reasons for manipulating attention. First, Joordens and Merikle (1992) manipulated attention, rather than presentation duration, to replicate Jacoby and Whitehouse's (1989) finding of an influence of unconscious perception on false recognition. Furthermore, results from Experiment 1 show that lengthening the presentation duration of a word produced increases in both conscious and unconscious perception. Thus, larger effects of unconscious perception may be attainable by presenting stimuli for longer durations, but under conditions of divided attention. Finally, there is an ecological argument for manipulating attention to, rather than duration of, the stimuli: Divided attention is much more likely to occur in a nonlaboratory setting, and, as others have argued, may in fact be the normal state of affairs (e.g., Jacoby, Toth, Lindsay, & Debner, 1992; Neumann, 1984).

The procedure that we used to divide attention was similar to a procedure used by Wolford and Morrison (1980). Flashed words were flanked by a pair of numbers, and, in the divided-attention condition, subjects were required to add those numbers. The phenomenological experience in this task is often reported as being one of not "seeing" the flashed word because of attending to the presented numbers. The experience is much like that of visually fixating on an object while engaged in heavy intellectual work unrelated to the object. Are such unattended objects perceived unconsciously but not consciously?

Method

Subjects. Thirty-six subjects enrolled in an introductory psychology course at McMaster University served in the experiment for course credit. Data from 4 subjects had to be discarded because those subjects failed to follow instructions as evidenced by a high likelihood (> .40) of responding with the target solution under full-attention, exclusion conditions. Subjects were tested individually.

Materials and design. A pool of 128 different multiple-solution, three-letter word stems were selected for use in the experiment. The stems were chosen from a larger pool of five-letter words that had been used in earlier stem-completion experiments done in our laboratory. The 128 stems were used to create eight sets of 16 stems, with each set being equated on the probability of a stem being completed with its target word. In addition to the word stems, 320 five-letter words were used as pre- and postmasks and as sandwiched words for nonmatch trials.

The design incorporated four blocks of 32 trials each. These blocks corresponded to the factorial combination of two within-subjects variables: attention (divided vs. full) and instructions (inclusion vs. exclusion). Within each block there were 16 match trials and 16 nonmatch trials. Trials within each block were ordered randomly with the exception that no more than 3 trials from the same condition were presented in a row. Rotating the word groups through each possible combination of conditions produced eight different test formats.

An additional 32 three-letter stems were selected for use on practice trials. These practice trials required 80 five-letter words for use as pre- and postmasks and sandwiched items. Eight practice trials (4 match and 4 nonmatch) were placed at the beginning of each test block. Hence, there were 40 trials in each test block, which yielded a total test length of 160 trials.

Attention to the sandwiched word was manipulated using a secondary task. For this task, pairs of digits were placed on either side of the sandwiched word (e.g., 4 scalp 5) and the word stem (e.g., 3 sca _ _ 4). Digits from 1 to 9 were paired so as to produce sums ranging between 5 and 12. The sums were chosen randomly with the exception that identical digits did not flank the same word (i.e., if the sum was 10, the flanking digits could not be 5 and 5).

Procedure. The experimental apparatus and procedure were the same as those used in Experiment 1 with the following exceptions: Because nonword trials and nonmatch trials exhibited no differences in Experiment 1, we used only nonmatch trials here. Thus, the sandwiched stimulus was always a word.

Experimental trials consisted of the following sequence of events: (a) presentation of a fixation point for 2 s; (b) presentation of a premasking word for 500 ms; (c) presentation of the sandwiched word flanked by digits for 150 ms; (d) presentation of a postmasking word for 500 ms; (e) a delay of 500 ms in which the screen was blank; and (f) presentation of a word stem flanked by digits. All events occurred in the same location on the screen. It is important to note that the digits flanking the sandwiched word were not pre- or postmasked.

The experiment was conducted in four blocks. Half of the subjects received divided-attention instructions for the first two blocks and full-attention instructions for the last two blocks. The other half of the subjects were given instructions in the reverse order. Within each attentional condition, all subjects received exclusion instructions for the first block and then inclusion instructions for the second block. Exclusion instructions emphasized that the stem should not be completed with the sandwiched word. Thus, if subjects saw that the sandwiched word was a completion to the stem, then they were to come up with a different solution. By contrast, inclusion instructions emphasized that the stem should be completed with the sandwiched word if it was appropriate (i.e., a match trial). In both instructional conditions, subjects were told that if the sandwiched word was not a completion for the stem, then they should respond with the first solution word that came to mind.

On each trial the subject had to perform a secondary task prior to completing the word stem. This task consisted of reporting the sum of a pair of digits presented during each trial (Wolford & Morrison, 1980). In the divided-attention condition, subjects were required to report the sum of two digits flanking the sandwiched word before completing the stem. This condition was labeled *divided attention* because during the presentation of the sandwiched word, attention was split between the word and its flanking digits. Given that the divided-attention condition called for a sum to be reported prior to completion of the stem, we felt it necessary that the full-attention condition also include a summation task. Hence, the full-attention condition required that the sum of two digits flanking the word stem be reported prior to stem completion. In this condition, full attention could be devoted to the sandwiched word at the time of its presentation.

Responding on both tasks was verbal. Subjects reported the sum as soon as the stem appeared on the screen and then attempted to solve the stem. Feedback was given when errors were made on the addition task. Subjects were given 7.5 s to report the sum and complete the stem. In all other ways, responding was the same as in the first experiment.

Results and Discussion

Errors on the secondary task were analyzed by a 2 × 2 × 2 repeated measures ANOVA, with variables of trial type (match vs. nonmatch), attention (full vs. divided), and instruction (inclusion vs. exclusion). This analysis showed a reliable main effect of attention, $F(1, 31) = 22.82$, $MS_e = 0.027$, with more errors being made in the divided-attention condition than in the full-attention condition ($Ms = 3.0\%$ and 1.0%, respectively). This finding is not surprising given that the digits to be summed in the divided-attention condition were on the screen for a much shorter period of time. No other main effects or interactions were found to be significant.

The mean probability of responding with a target word on nonmatch trials given inclusion instructions was .32 and .33 for the full-attention and divided-attention conditions, respectively. Given instructions to exclude, those same probabilities were .32 and .34, respectively. Data from nonmatch trials were analyzed in a 2 × 2 repeated measures ANOVA, with the variables of attention (divided vs. full) and instruction (inclusion vs. exclusion). Results from that analysis revealed no significant effects. Consequently, mean performance on all nonmatch trials (.33) was taken as the baseline probability of giving the target word as a completion and was used for comparison with match trials.

Table 3

Observed Probabilities of Completing Word Stems With Target Words on Match Trials Across Instruction and Attention in Experiment 2

	Instruction			
	Inclusion		Exclusion	
Attention	P	M^a	P	M^a
Divided	.85	(.84)	.42	(.43)
Full	.96	(.95)	.09	(.12)

Note. The mean rate of completion on nonmatch trials was .33.
[a]These numbers represent observed probabilities of completing word stems with target words after removing the data from 8 subjects who achieved perfect performance in the inclusion and exclusion conditions.

Evidence for the existence of unconscious perception. The completion data for match trials are shown in Table 3. As in Experiment 1, results from the exclusion test condition provided unambiguous evidence of the existence of unconscious perception. Although instructed not to complete the stems with the target words, subjects responded with target completions reliably more often than baseline when attention to the presentation of the word was divided (.42 vs. .33), $t(31) = 2.84$, $SE = .03$. Yet, when full attention was devoted to the presentation of the words, subjects completed stems with their target completions less often than baseline ($M = .09$ vs. .33), $t(31) = 11.30$, $SE = .02$. These effects were comparable in magnitude to those produced by the manipulation of duration used in Experiment 1.

For the inclusion test, presentation of a target word increased the probability of its being used as a completion over baseline regardless of whether attention to its presentation was full (.96 vs. .33) or divided (.85 vs. .33). Both increases were reliable, $ts(31) = 51.27$ and 22.16, $SEs = .01$ and $.02$, respectively. Again, subtracting baseline from performance in the inclusion test condition would overestimate the probability of conscious perception. This overestimation results from a failure to take effects of unconscious perception into account.

Estimating effects of conscious and unconscious perception. Estimates of the probabilities of conscious and unconscious perception were calculated in the same manner as in Experiment 1. For 8 subjects, performance in the inclusion and exclusion conditions was perfect (i.e., 1.0 and 0.0, respectively). Their data had to be discarded from the following analyses because estimates of unconscious perception could not be calculated. Analysis of the remaining 24 subjects showed that dividing attention to the sandwiched word drastically reduced conscious perception, $t(23) = 9.37$, $SE = .04$, but that it left the effects of unconscious perception unchanged ($t < 1$, $SE = .06$; see Table 4).

Similar to reducing presentation duration (Experiment 1), dividing attention produced a radical reduction in conscious perception. However, unlike the manipulation of duration, the manipulation of attention left invariant the effects of unconscious perception. The process dissociation produced by manipulating attention provides strong support for the assump-

Table 4

Estimates of the Contribution of Conscious Perception and Unconscious Perception of Stem-Completion Performance in Experiment 2

Attention	Conscious perception	Unconscious perception
Divided	.41	.75
Full	.83	.76

Note. Data from 8 subjects were excluded from these estimates because an estimate for unconscious perception could not be calculated (see the text).

tion that conscious perception and unconscious perception make independent contributions to stem-completion performance. In addition, the results corroborate those of others who have found a similar process dissociation within the area of memory (Jacoby et al., 1993).

Experiment 3

Experiment 3 was identical to Experiment 2, except that the presentation duration of the sandwiched word was reduced from 150 ms to 100 ms. In Experiments 1 and 2, several subjects performed perfectly on inclusion and exclusion tests and their data therefore could not be used to estimate the contributions of conscious and unconscious perception. Reducing the presentation duration of the sandwiched word should lower performance in the full-attention condition to a level such that estimates can be gained for all subjects in the experiment.

Method

Subjects. Nineteen subjects enrolled in an introductory psychology course at McMaster University served in the experiment for course credit. Data from 3 subjects had to be discarded because those subjects had a high likelihood (>.25) of responding with the target solution under full-attention, exclusion conditions. The criterion was deliberately lowered in this experiment because we wanted to be certain that subjects could perform the task as instructed. From the standpoint of demonstrating unconscious perception, this was an extremely conservative move because subjects with high exclusion scores would be more likely to show large effects of unconscious perception. Subjects were tested individually.

Materials and design. The materials and design for this experiment were identical to those of Experiment 2.

Procedure. In this experiment, a Zenith VGA monochrome (white) monitor was used for presentation of all stimuli. Because the stimuli presented in Experiment 2 were also white on black, the displays were virtually identical.

The procedure was identical to that of Experiment 2 with the following exceptions: The sandwiched word was presented for 100 ms in order to make conscious perception more difficult. Also, the two full-attention blocks were always done before the two blocks of divided attention.

Results and Discussion

An analysis of errors on the secondary task revealed a reliable main effect of attention, $F(1, 15) = 8.13$, $MS_e = 0.027$; more errors were made in the divided-attention condition than in the full-attention condition (Ms = 4.1% and 1.2%, respectively). There was also a significant main effect of trial type, $F(1, 15) = 5.00$, $MS_e = 0.008$; nonmatch trials produced more errors than did match trials (Ms = 3.4% and 1.9%, respectively). No other main effects or interactions were significant. As in the previous experiment, the main effect of attention was expected, although we cannot explain the significant effect of trial type. Given the low percentage of errors overall, however, we do not believe that this finding affects our conclusions.

The mean probabilities of responding with a target word on nonmatch trials for the inclusion test were .33 (full attention) and .35 (divided attention). For the exclusion test, those same probabilities were .27 (full attention) and .33 (divided attention). ANOVA results revealed no significant effects. Consequently, mean performance on all nonmatch trials (.32) was taken as the baseline probability of giving the target word as a completion and was used for comparison with match trials.

Evidence for the existence of unconscious perception. Table 5 shows a summary of the completion data for match trials. Results from the exclusion test condition provide striking evidence for the existence of unconscious perception. When words were presented for a brief duration and attention was distracted, those words were highly likely to be used as completions even though doing so would be countered by any conscious perception of the presented words. The probability of responding with a flashed word for the exclusion test was much higher than baseline (.60 vs. .32), $t(15) = 5.77$, $SE = .05$. That finding stands in contrast to the results from trials on which full attention was devoted to the presentation of the sandwiched words. After full attention, subjects completed stems with flashed words less often than baseline ($M = .16$), $t(15) = 8.98$, $SE = .02$. Performance in the full-attention condition showed that subjects were following instructions by excluding consciously perceived words.

For the inclusion test, flashed words were likely to be given as a completion, regardless of whether full attention was devoted to their presentation (.71 for divided attention and .90 for full attention). Performance in both conditions was significantly higher than baseline, $ts(15) = 11.56$ and 28.83, $SEs = .03$ and .02, respectively. As in earlier experiments, performance in the inclusion test conditions by far overestimated the probability of conscious perception because of the effects of unconscious perception.

Estimating effects of conscious and unconscious perception. Estimates of the contributions of conscious and unconscious perception were calculated as in the first two experiments. Because of the reduction in presentation duration, none of the

Table 5

Observed Probabilities of Completing Word Stems With Target Words on Match Trials Across Instruction and Attention in Experiment 3

	Instruction	
Attention	Inclusion	Exclusion
Divided	.71	.60
Full	.90	.16

Note. The mean rate of completion on nonmatch trials was .32.

Table 6
Estimates of the Contribution of Conscious Perception and Unconscious Perception to Stem-Completion Performance in Experiment 3

Attention	Conscious perception	Unconscious perception
Divided	.11	.68
Full	.75	.66

subjects attained perfect performance and consequently it was possible to gain estimates for all subjects. Dividing attention during the presentation of the sandwiched word substantially reduced the probability of conscious perception but left the effects of unconscious perception invariant (see Table 6). That is, the manipulation of full versus divided attention had a large effect on conscious perception, $t(15) = 10.97, SE = .06$, but its influence on unconscious perception did not approach significance ($t < 1, SE = .06$). Thus, these results replicate the pattern of results found in Experiment 2.

Experiment 4

In the previous three experiments, words were used to mask the flashed, sandwiched word. Although the subjects were instructed to ignore these words in Experiments 2 and 3, it is possible that these irrelevant words induced a type of memory load and were thus responsible for the effects obtained. Although we would argue that the source of these unconscious influences is immaterial, we were interested in showing that a "memory load" is not necessary to obtain the effect. Thus, in this experiment, we used random letter strings as masks so that the target word was the only word presented prior to onset of the stem.

A second methodological change introduced in this experiment concerned the instructions. Whereas in the previous experiments we used a blocked format to implement the inclusion-exclusion instructions, we used a mixed format in this experiment. This format was instantiated so that subjects would not know, prior to each trial, whether the trial would be an inclusion or an exclusion trial. In this way, any deliberate attentional effects brought about by knowledge of the trial type (i.e., not paying attention on exclusion trials) can be ruled out.

Method

Subjects. Sixteen subjects enrolled in an introductory psychology course at McMaster University served in the experiment for course credit. Subjects were tested individually.

Materials and design. The materials and design of this experiment were identical to Experiment 2 with the following exceptions: Some of the stimuli (including stems and solutions) were changed. In addition, four pseudorandom letter strings were created such that there was somewhat of an alternation of ascenders and descenders in the string (e.g., gpkjklqfp). Letters were chosen so as to avoid overlap with the target word as much as possible. The appearance of the letter strings as pre- or postmasks was randomly determined on each trial.

Procedure. An IBM-compatible VGA color monitor was used for presentation of all stimuli. The stimuli were presented as in Experiment 2 (white on black) except that (a) the presentation duration of the target was reduced to 83 ms, (b) the duration of the pre- and postmasking letter strings was reduced to 300 ms, and (c) the stems were displayed in either red or green. The color of the stem was used to signal the instruction: Green stems were a cue for inclusion instructions and red stems were a cue for exclusion instructions. In addition, a card was placed below the computer screen that reminded subjects that a green stem meant that they were to use flashed words as completions, whereas a red stem meant that they were not to use flashed words as completions. All other aspects of the procedure were identical to Experiment 2.

Results and Discussion

A 2 × 2 × 2 analysis of errors on the secondary task revealed a reliable main effect of attention, $F(1, 15) = 6.02, MS_e = 0.006$; more errors were made in the divided-attention condition than in the full-attention condition ($Ms = 4.9\%$ and 1.8%, respectively). No other main effects or interactions were significant.

The mean probabilities of responding with a target word on nonmatch trials for the inclusion test were .34 (full attention) and .31 (divided attention). For the exclusion test, those same probabilities were .33 (full attention) and .40 (divided attention). Analysis of these data by a 2 × 2 ANOVA revealed no significant effects. Consequently, mean performance on all nonmatch trials (.35) was taken as the baseline probability of giving the target word as a completion and was used for comparison with match trials.

Evidence for the existence of unconscious perception. Table 7 shows a summary of the completion data for match trials. As in the previous three experiments, the exclusion test provided solid evidence for the existence of unconscious perception. When attention was diverted from the briefly presented words, those words were often used as completions. The probability of responding with a flashed word for the exclusion test was higher than baseline (.48 vs. .35), $t(15) = 3.41, SE = .04$. That finding stands in contrast to the results from trials on which full attention was devoted to the presentation of the flashed words. After full attention, subjects completed stems with flashed words less often than baseline ($M = .20$), $t(15) = 4.39, SE = .03$. Performance in the full-attention condition showed that subjects were excluding consciously perceived words as instructed.

For the inclusion test, flashed words were likely to be given as completions, regardless of whether full attention was devoted to their presentation ($Ms = .54$ for divided attention and .82 for full attention). Performance in both conditions was significantly higher than baseline, $ts(15) = 5.24$ and 22.18, $SEs = .04$ and $.02$, respectively.

Table 7
Observed Probabilities of Completing Word Stems With Target Words on Match Trials Across Instruction and Attention in Experiment 4

Attention	Instruction: Inclusion	Instruction: Exclusion
Divided	.54	.48
Full	.82	.20

Note. The mean rate of completion on nonmatch trials was .35.

Table 8
Estimates of the Contribution of Conscious Perception and Unconscious Perception to Stem-Completion Performance in Experiment 4

Attention	Conscious perception	Unconscious perception
Divided	.06	.51
Full	.62	.50

Estimating effects of conscious and unconscious perception. Estimates of the contributions of conscious and unconscious perception were calculated as in the previous experiments. Importantly, because none of the subjects attained perfect performance, it was possible to obtain estimates for all subjects. Dividing attention during the presentation of the flashed word substantially reduced the probability of conscious perception but left the effects of unconscious perception invariant (see Table 8). That is, the manipulation of full versus divided attention had a large effect on conscious perception, $t(15) = 16.88$, $SE = .03$, but its influence on unconscious perception did not approach significance ($t < 1$, $SE = .07$).

The results from this experiment replicate the pattern of results found in Experiments 2 and 3. Although we did not rule out "forgetting" explanations, the use of a single word flashed only 1 s prior to the stem does make a memory-load explanation unlikely. These findings, in addition to those of the previous three experiments, confirm that unconscious influences of perception contribute considerably to performance on a stem-completion task. Moreover, these unconscious influences are proposed to operate independently of any consciously controlled responding occurring on the task.

General Discussion

The experiments reported here as evidence of unconscious perception are highly similar to experiments reported by Jacoby et al. (1993) as evidence of unconscious influences of memory. In each case, a stem-completion task was used to assess the influence of a prior processing event. The similarity between the two sets of experiments is a reflection of the relatively fine line that is drawn between memory and perception. From a historical viewpoint, however, there is no question that ours is a study of perception. Some of the most notable investigations of unconscious perception to date have involved the presentation of a single pattern-masked target followed by an immediate test (e.g., Balota, 1983; Cheesman & Merikle, 1986; Marcel, 1983a). Therefore, we feel justified in reporting our results as evidence of unconscious perception. Furthermore, we are equally comfortable discussing our results in terms of previous research on both unconscious perception and unconscious influences of memory.

Experiment 1 revealed that briefly flashed, pattern-masked words can produce unconscious influences on stem-completion performance. This experiment is consistent with many traditional studies of unconscious perception whose purpose was to eliminate conscious perception of a target through a reduction in the presentation duration (e.g., Marcel, 1983a). In our case, however, use of the process-dissociation procedure (the exclusion condition in particular) made elimination of conscious perception unnecessary. Thus, we avoided the age-old criticism that attributed supposedly unconscious influences to residual conscious perception (Eriksen, 1960; Holender, 1986). We have also shown (Experiments 2 through 4) that effects produced by presenting words for a brief duration can be mimicked by dividing attention during the presentation of those words (cf. Joordens & Merikle, 1992). That is, inattention to an event can yield unconscious perception just as can the occurrence of an event in a perceptually difficult setting. In each of these experiments, unambiguous evidence of the existence of unconscious perception was provided by an exclusion test condition. Such evidence cannot be explained as truly resulting from conscious perception because conscious perception would produce an opposite result.

Results from the exclusion test conditions are sufficient to demonstrate the existence of unconscious influences, but those results underestimated the magnitude of unconscious effects. Because presentation conditions were not such as to totally eliminate conscious perception, unconscious influences were partly offset by conscious perception. To separately estimate the contributions of conscious and unconscious perception to performance, we used the process-dissociation procedure. This procedure is based on the assumption that conscious and unconscious perception provide independent bases for responding. Using this procedure, we uncovered a difference between the effects of reducing duration and dividing attention that would have gone unnoticed by other measures of conscious and unconscious influences (e.g., direct and indirect tests). Specifically, we found that decreasing the presentation duration of the flashed words (Experiment 1) decreased the probability of both conscious and unconscious perception. Further support for that conclusion was found in Experiments 2 through 4, in which reductions in the estimates of conscious and unconscious perception paralleled the reductions in presentation duration across those three experiments. Effects derived from manipulation of presentation duration stand in contrast to effects of dividing attention. Experiments 2 through 4 demonstrated that dividing attention during the presentation of flashed words radically reduced the probability of conscious perception, although effects of unconscious perception were left unchanged. This latter finding of a dissociation between estimates of conscious and unconscious perceptual processing is important for several reasons.

Dissociations of conscious and unconscious influences lend support to the assumption that the two processes operate independently. Although some have argued that our reasoning is circular in that our evidence for independence was gained from a metric that was based on the assumption of independence, we disagree. True, the dissociation of conscious and unconscious influences found within any single experiment is important, but of far more importance is the converging evidence demonstrated by Experiments 2 through 4. We doubt that such consistent findings would be obtained if the two processes were not independent. The argument is strengthened even more when one considers that dividing attention produces the same dissociation between consciously controlled and automatic influences of memory (Jacoby et al., 1993; Jennings & Jacoby, 1993), processes that we consider to be analogous to those of conscious and unconscious perception. Thus, from our view, the process dissociation induced by dividing attention is robust across a range of situations, including different stimuli, different testing conditions, and even different paradigms. In addition, other process dissociations have been found in investigations of unconscious influences of memory (Jacoby, 1991; Jacoby et al., 1993; Jennings & Jacoby, 1993; Toth et al., 1994) and investigations of Stroop interference (Lindsay & Jacoby, in press).

Conscious Perception and Measures of Awareness

Use of the process-dissociation procedure has important advantages over self-report measures of conscious perception. First, directly asking a person to report a flashed word may direct attention toward that word, making perception conscious, whereas if not asked to report, conscious perception may not occur. More important, the process-dissociation procedure takes into account the likely possibility that performance on direct tests is contaminated by effects of unconscious perception. For stem-completion experiments, a standard way of measuring conscious perception would be to subtract baseline performance from performance on the inclusion test. For each of our experiments, that standard measure of conscious perception would substantially overestimate conscious perception. This is because unconscious perception adds to correct guessing and therefore the true probability of guessing is underestimated by baseline performance. Signal-detection theory is of no help for measuring conscious perception because it does not distinguish between effects of conscious perception and those of unconscious perception (cf. Eriksen, 1960).

One of the most common criticisms of supposed demonstrations of unconscious perception concerns criterion differences (e.g., Eriksen, 1960; Holender, 1986). For example, perceptual defense has been generally dismissed as arising from subjects' hesitancy to report awareness of the presentation of a taboo word. Appeals to criterion differences treat unconscious perception only as a weaker form of conscious perception. By contrast, we have shown that conscious and unconscious perception serve as independent bases for responding. The results from our experiments join a growing body of evidence indicating that conscious and unconscious influences have qualitatively different effects on behavior (Cheesman & Merikle, 1986; Jacoby, 1991; Jacoby & Whitehouse, 1989; Joordens & Merikle, 1992; Marcel, 1980, 1983a; Weiskrantz, 1986). For example, Weiskrantz (1986, pp. 152–155) argued that blindsight cannot be understood as resulting from only a quantitative difference in a single criterion for responding (i.e., signal-detection theory). Rather, he suggested that normal visual functioning results from the operation of two independent visual pathways, one of which is dysfunctional in the case of blindsight.

The Relation Between Conscious and Unconscious Perception

The measure of conscious perception provided by the process-dissociation procedure is a commonsense one that is based on the assumption that awareness of the presentation of an item allows intentional control of responding. If subjects "see" a flashed word, they can either use that word as a response (inclusion test) or avoid using that word as a response (exclusion test) as dictated by instructions. This estimate of conscious perception is important in its own right and is crucial for estimating influences of unconscious perception by means of the process-dissociation procedure. What if one were to assume, however, that the two perceptual processes were not independent? For example, what if conscious processing occurred only for items that were also processed unconsciously?

The relationship mentioned earlier as an alternative to the independence model is known as a *redundancy model* (Jones, 1987). The redundancy model holds that only a subset of the stimuli processed unconsciously are also processed at the conscious level. For the redundancy model, because conscious processing occurs only in the presence of unconscious processing, the inclusion test serves as an estimate of unconscious perception. Generate–recognize models of cued-recall performance serve as an example of a redundancy model of the relation between conscious and unconscious influences of memory. Jacoby et al. (1993) compared a generate–recognize model with a model that was based on the assumption of independence and gave reasons for preferring the assumption of independence.

We believe that the assumption of independence for the relation between conscious and unconscious perception is more plausible than is that of redundancy. First, to say that an inclusion test provides an estimate of unconscious perception is to make a factor-pure assumption that seems particularly curious against the backdrop of controversy, surrounding claims of unconscious perception. As indicated earlier, a common criticism has been that performance on indirect tests of perception is contaminated by conscious perception (e.g., Holender, 1986; Reingold & Merikle, 1990). Against that backdrop, it seems farfetched to claim that a direct test (an inclusion test) serves as a pure measure of unconscious influences if it is admitted that an indirect test does not do so.

Perhaps the strongest argument for independence comes from the data. Experiments 2–4 revealed that dividing attention left the contribution of unconscious perception to performance unchanged. Similar findings of invariance have been reported in studies of memory (Jacoby et al., 1993; Jennings & Jacoby, 1993). Two points should be made about these results. First, if conscious and unconscious processes are actually redundant, findings of invariance gained by mistakenly assuming independence could occur only by chance and should be difficult to replicate. It strains credibility that, given their number, our findings of invariance are happy accidents. Second, we emphasize the fact that the variables (e.g., attention) for which we have found invariance in our estimates of the unconscious component are ones that have been classically associated with automatic processing. These invariances would not be found if the inclusion condition were used as a pure measure of unconscious perception.

What if the truth lies someplace between the redundancy model and the independence model? That is, what if conscious and unconscious influences are correlated but the correlation is not a perfect one? If the two are correlated, our estimate of conscious perception would be unaffected. That this is true is most easily understood by considering the equations for the inclusion and exclusion test conditions. Adding a term to each of those equations to represent the correlation between conscious and unconscious influences would simply result in that term being subtracted out when conscious perception was estimated. By contrast, any correlation between conscious and unconscious influences would bias estimates of unconscious perception. If there are occasions when stimuli are processed consciously in the absence of concurrent unconscious processing, the redundancy model will overestimate the level of unconscious perception. Such overestimation has been the reason for rejecting supposed demonstrations of unconscious perception that rely on performance on indirect tests and seems even more likely when a direct test of perception is used. By contrast, reliance on the independence model will underestimate unconscious influences to the extent that conscious and unconscious perception are correlated. Thus, the independence model generates estimates that are more conservative than those gained by relying on the redundancy model. The findings of invariance can be taken as showing that any correlation between conscious and unconscious influences is not large. Furthermore, given a choice between underestimating or overestimating unconscious influences, we would prefer the former on the same grounds that a Type II error is preferred over a Type I error when hypothesis testing: Failures to find "real" effects are generally considered to be of less cost than is treating "null" effects as real ones. Because of its controversial nature, this is especially true in the case of unconscious perception.

Perception, Memory, and Behavior

Unconscious perception may be best treated as a member of a larger class of phenomena, all of which reflect automaticity. The notion of automaticity sounds much more innocuous than does that of unconscious perception. Even critics grant a role for automaticity or habit in the form of effects on performance without awareness of the source of those effects (e.g., Eriksen, 1960). For both automaticity and unconscious perception, behavior is largely initiated by the stimulus environment without the intervention of conscious intention (however, see Jacoby et al., 1992). We contend that, under the right stimulus conditions, even a single prior presentation of an item can produce what is, in effect, a habit (i.e., an automatic influence of perception or of memory; Jacoby et al., 1992).

Although the effects of brief visual presentations have been given great prominence, they are probably less common than attentional factors as causes of unconscious influences that are unaccompanied by conscious perception. As described earlier, dividing attention during the occurrence of an event can produce results that are similar to those produced by brief visual presentations (Joordens & Merikle, 1992). Indeed, much larger unconscious influences can probably be produced by manipulations of attention than by flashing items for a brief duration. When attention is focused on attaining a high-level goal, lower level processes that support that goal may be carried out largely without awareness (Neumann, 1984). That is, as long as the high-level intention is being actualized, the lower level processes that enable it are largely automatic. One implication of these ideas is that people are especially susceptible to unconscious influences when they are "in flow" and so are not analytically monitoring sources of influence (cf. Jacoby et al., 1992; Wicklund, 1986). This highlights the positive nature of unconscious processing: automatic uses of memory (skills) and of perception (environment) are essential for expert performance.

Although a useful tool, there really is nothing special about presenting items in perceptually difficult ways such as briefly flashing an item. Indeed, the overemphasis on "hidden" presentation of messages might have obscured much more important effects of attention. For example, consider the controversy surrounding the effects of subliminal "backmasked" messages that are supposedly embedded in some rock music (Vokey & Read, 1985). There may be more to fear from supraliminal messages in "background music" than from any subliminal messages hidden in that music. The backgrounding of music, akin to dividing attention, may make one more open to the lyrics as a source of unconscious influences and persuasion. The human race may have more to fear from the ill effects of "backgrounding" than those of "backmasking."

Regardless, it is the possibility of unconscious perception that has captured the layperson's interest. The reason for that interest is the fear that unconscious perception techniques can be used to gain control over thought and behavior. Much of the work of experimental psychologists has been aimed at countering sensationalistic claims about the effects of unconscious perception. We, too, give little credibility to such claims. However, we agree with the layperson that the issue of control of thought and behavior is the *real* reason for interest in unconscious perception. The process-dissociation procedure centers on that issue. By emphasizing the question of control, we provide a measure of conscious perception that has important advantages over the direct tests of awareness that have traditionally been used.

For unconscious perception, what we find exciting is that our change in strategy opens the way to go beyond attempts to demonstrate the existence of unconscious influences by allowing us to explore factors that affect their magnitude. What is the difference between the structures and processes underlying conscious and unconscious perception? Why does divided attention reduce conscious perception while leaving unconscious perception invariant? We cannot yet fully answer these questions, but by providing a means of separating conscious and unconscious influences, we hope to have placed the answers to such questions within reach.

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Conscious and Unconscious Perception: An Episodic Account

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Abstract

In three experiments, the process-dissociation procedure was used to estimate the contribution of conscious and unconscious perception to performance on a stem-completion task. Increasing delay or changing the visual similarity between a briefly flashed word and a test of stem completion reduced estimates of unconscious perception while those of conscious perception remained intact. These experiments complement those of Debner and Jacoby (1994) in which estimates of conscious perception were reduced while estimates of unconscious perception remained intact. Such results support the assumption that conscious and unconscious processes provide independent contributions to performance (Debner & Jacoby, 1994; Jacoby, Toth & Yonelinas, 1993). Discussion focuses on the relation between variables affecting each perceptual process and prior theorizing with respect to direct and indirect tests of perception and memory. The data are interpreted within a theoretical framework based on conscious and unconscious retrieval of prior processing episodes.

One of the most controversial areas of study in the past century has been that of unconscious perception. Ironically, the controversy derives from a more fundamental problem: defining conscious perception. While some researchers (e.g., Sidis, 1898/1973) have chosen to define conscious perception in subjective terms (e.g., the point where subjects claim they can no longer perceive a stimulus), others (e.g., Eriksen, 1960) have chosen more objective definitions (e.g. the point where detection performance is no longer above chance). Not surprisingly, one often finds dramatically different patterns of results depending on the particular definition chosen (Adams, 1957; Cheesman & Merikle, 1986; Eriksen, 1960; Reingold & Merikle, 1990).

Forster, Booker, Schacter and Davis (1990) used a stem-completion paradigm to examine effects of unconscious perception. Subjects were given word stems and told to complete them with the first word that came to mind. Prior to presentation of the stem to solve, however, a word was flashed for a brief duration. On some trials, this word was a completion to the stem, on other occasions it was an unrelated word (i.e., baseline). Forster et al. found that flashing a solution greatly increased its likelihood of being given as a response compared to baseline. They claimed that this facilitation was due to unconscious processing of the flashed words. This claim was based on the fact that subjects could not identify the words when flashed. However, this logic does not satisfy the critics. In this paradigm, a "facilitation" paradigm, conscious perception of the flashed words would produce the same effects as unconscious perception: both would increase the likelihood that the flashed solution would be given as a response. In fact, whenever a facilitation paradigm is used, no conclusion can be drawn as to which perceptual process is responsible for the observed effects.

Unconscious Perception and the Process-Dissociation Procedure

Using the same stem-completion paradigm, Debner and Jacoby (1994) reported a procedure that overcame these interpretational problems. Here I briefly describe the procedure used by Debner and Jacoby. Those who want more detail about the procedure and/or the results should consult the original paper.

To make interpretation of the results clear-cut, Debner and Jacoby (1994) placed effects of conscious and unconscious perception in opposition. Instead of instructing subjects to complete stems with the first completion that came to mind, they instructed subjects not to complete stems with the flashed words. When viewing conditions were made difficult (e.g, brief durations, divided attention), responding with the flashed word in this "exclusion" test condition was above baseline. That is, even though instructed not to complete the stems with the flashed solution, subjects did so ***more often than baseline***. It was not that subjects disregarded the instructions; those same subjects performed exactly as instructured (i.e. rarely gave flashed solutions as completions) when the flashed solution was more visible (e.g, long duration, full attention). With exclusion instructions, conscious perception cannot be invoked as an explanation for the increased usage of the flashed word; the effect of conscious perception was to drive performance below baseline. Thus, performance in the exclusion test condition provided unambiguous evidence for the existence of unconscious perception.

Besides demonstrating the existence of unconscious perception, Debner and Jacoby (1994) also reported a procedure, the process-dissociation procedure, for estimating the contribution of conscious and unconscious perception to performance. On the exclusion test, awareness of the presentation of a flashed word resulted in its being withheld as a response; conscious perception offset the influences of unconscious perception. More formally, a flashed word should be given as a completion in an exclusion condition only if unconscious perception is sufficient for its being given as a response (U) and the word is not consciously perceived (1-C):

$$\text{Exclusion} = U(1-C). \qquad (1)$$

To estimate the contribution of unconscious and conscious perception to performance, Debner and Jacoby (1994) compared performance on an exclusion test with that of an inclusion test. For the <u>inclusion</u> test, subjects were instructed to complete stems with flashed words or, if they did not see the flashed word, to complete stems with the first appropriate word that came to mind. Notice that for the inclusion condition conscious perception acts in concert with unconscious perception, just as in facilitation paradigms (e.g., Forster et al., 1990). A stem could be completed with a flashed word either because the subject consciously perceived the flashed word (C), or, in the absence of conscious perception (1-C) because effects of unconscious perception (U) were sufficient for the flashed word to be given as a completion:

$$\text{Inclusion} = C + U(1-C). \quad (2)$$

Given these two conditions, the probability of conscious perception (C) can be estimated as:

$$C = \text{Inclusion} - \text{Exclusion}. \quad (3)$$

Once an estimate of the contribution from conscious perception (C) has been obtained, that of unconscious perception (U) can be estimated by means of simple algebra. The easiest way to do this is by dividing "Exclusion" by the estimated probability of a failure in conscious perception (1-C). Hence:

$$U = \text{Exclusion}/(1-C). \quad (4)$$

<u>Dissociations of Conscious and Unconscious Influences</u>

A strong assumption embodied in the previous equations is that effects of unconscious perception are independent of those of conscious perception. Therefore, it should be possible to find factors that influence the likelihood of one process, but leave the other process unchanged. In fact, several investigations of memory and perception have utilized the process-dissociation procedure to reveal dissociations between estimates of conscious and unconscious influences.

Most relevantly, Debner and Jacoby (1994) illustrated that dividing attention to a briefly presented word impaired conscious perception of those words, but left effects of unconscious perception intact. Jacoby and colleagues have also shown that attention, levels of processing, and aging produce dissociations of recollection and automatic influences of memory similar to those reported by Debner and Jacoby (Jacoby & Hay, 1993; Jacoby, Toth & Yonelinas, 1993; Jennings & Jacoby, 1993; Toth, Reingold & Jacoby, 1994). Taken together, these results go far toward justifying the assumption that conscious and unconscious processes are independent; across several different situations, consciously-controlled influences were shown to be impaired, but unconscious influences remained invariant (Jacoby, Yonelinas & Jennings, in press). The present experiments served two purposes: 1) to provide additional support for the independence assumption by demonstrating changes in estimates of unconscious perception while leaving estimates of conscious perception unchanged and 2) to extend what is known about the processes of conscious and unconscious perception. All of the experiments reported here used the same general procedure as Debner and Jacoby (1994) in which each trial involved a briefly flashed word followed immediately by a stem-completion task. This task allowed assessment of conscious and unconscious perception of the flashed word based on the contribution of each of those processes to performance.

Experiments 1a and 1b

Experiments 1a and 1b were designed to produce process dissociations through manipulation of the interstimulus interval (ISI) between the target word and onset of the stem. Automatic effects of unconscious perception may be limited to, or strongest for, only a very short period of time after encoding (Humphreys, Besner & Quinlan, 1988). Conscious perception on the other hand may be capable of producing relatively longer-lasting effects. Evidence supporting this hypothesis has been observed in a few instances (Chalfonte, 1989; Forster & Davis, 1984; Forster et al., 1990; Humphreys et al., 1988). Chalfonte (1989), for example, found anagram solution times to be facilitated by prior presentation of the solution <u>below</u> subjective threshold but only for very short ISIs (100 ms). Yet, for anagram solutions presented <u>above</u> subjective threshold, there was substantial and equal facilitation for all ISIs examined (up to 5000 ms). Similarly, Forster and Davis (1984) showed that lexical decision times to a target word were speeded by a masked presentation of the word immediately prior to lexical decision. No evidence for facilitation was obtained, however, when a lag of 9 s (which also included 17 additional stimuli) was instantiated.

In the following two experiments, the process-dissociation procedure was used to obtain separate estimates of the contribution of conscious and unconscious perception to stem completion performance across different ISIs. Experiments 1a and 1b were identical except that in Experiment 1a all stimuli appeared in upper case whereas in Experiment 1b all stimuli appeared in lower case.

Method

Subjects. In Experiment 1a, 25 subjects enrolled in an introductory psychology course at McMaster University participated for course credit. Data from 1 subject were discarded because of a failure to follow instructions. In Experiment 1b, an additional 19 subjects participated. Data from 1 subject were discarded for failure to follow instructions. Data from two other subjects were discarded because they deviated from mean performance by more than 4 standard deviations.

Materials and Design. Each test trial was made up of three words presented in succession, followed by a three-letter word stem. The first and third words acted as forward and backward masks for the second word. As this procedure made a sort of "sandwich", the second item will be called the "sandwiched item" throughout the rest of the paper. Word stems were produced by replacing the last two letters of a five-letter target word (e.g., table) with underscores (e.g., tab__). Besides the target completion, all of the word stems had at least one other five-letter completion (e.g., tab__ - tabby or taboo).

Two different types of trials were produced by manipulation of the sandwiched item in the sequence: 1) match trials, where the sandwiched item was the target completion for that word stem (i.e., "table" for the stem tab__); 2) nonmatch trials, where the sandwiched word did not complete the stem (e.g., "cluck" for the stem tab__).

A pool of 128 different multiple-completion, three-letter word stems were used in the experiment. From this pool, eight sets of 16 stems were created, each set equated on the probability of a stem being completed with its target. In addition to the word stems, 320 five-letter words were used as pre- and post-masks, and as sandwiched words for nonmatch trials.

The design incorporated two blocks of 64 trials. These blocks corresponded to the two instructional conditions (inclusion vs. exclusion). Each block contained 16 trials of each combination of trial type (match vs nonmatch) and ISI (1 s vs 6 s). Trials were ordered such that 8 trials of the same ISI (4 match and 4 nonmatch) appeared in a row. Thus, each 64-trial block was composed of 8 groups of 8 trials, each group alternating between the 1 s ISI and the 6 s ISI. The 4 match and 4 nonmatch trials composing each group of 8 trials were ordered randomly, with the restriction that there be equal numbers of match and nonmatch trials in the initial position of each group. Rotating the words through all possible combination of conditions produced eight different test formats.

An additional 32 three-letter stems were used on practice trials. These practice trials required 80 five-letter words for pre- and post-masks, and sandwiched items. Sixteen practice trials (4 match and 4 nonmatch at each ISI) were placed at the beginning of each test block. Hence, there were 80 trials in each test block which yielded a total test length of 160 trials. In Experiment 1a, stimuli were presented in upper case, whereas in Experiment 1b, stimuli were presented in lower case.

For purposes of a secondary summation task to be described later, pairs of digits were placed on either side of the sandwiched word (e.g., 4 scalp 5) and the word stem (e.g., 3 sca__ 4). Digits from 1 to 9 were paired so as to produce sums ranging between 5 and 12. The sums were chosen randomly with the exception that identical digits could not flank the same stimulus (i.e., if the sum was 10, the flanking digits could not be 5 and 5).

Procedure. The experiment was programmed using the software package Micro Experimental Laboratory (Schneider, 1990). All stimuli were presented by means of an IBM-compatible computer interfaced with a VGA color monitor. Stimuli appeared as white letters on a black background. The character size of the stimuli was approximately 2.5 x 4 mm. The subjects were seated approximately 45-55 cm from the screen.

Experimental trials consisted of the following sequence of events: 1) presentation of a fixation point for 1 s; 2) presentation of a premasking word for 500 ms; 3) presentation of the sandwiched word flanked by digits for 100 ms; 4) presentation of a postmasking word for 500 ms; 5) a delay of 500 ms (1 s ISI) or 5500 ms (6 s ISI) in which the screen was blank; and 6) presentation of a word stem flanked by digits. All events occurred in the same location on the screen.

The experiment was conducted in two blocks. All subjects received exclusion instructions for the first block and then inclusion instructions for the second block. Subjects were informed that they would be shown the first three letters of a word (i.e., a word stem) and asked to generate a five-letter completion (without using names or plurals). They were also told that, prior to the appearance of the word stem, a sequence of three words would be flashed briefly on the screen and that the middle word of this sequence would sometimes be a completion to the stem. Exclusion instructions stressed that the stem <u>should not</u> be completed with the sandwiched word. Thus, if the sandwiched word was a completion to the stem they were to respond with an alternative completion. In contrast, inclusion instructions emphasized that the stem <u>should</u> be completed with the sandwiched word if it was appropriate (i.e., a match trial). In both test conditions, subjects were told that if the sandwiched word was not a completion for the stem, or if they did not see the sandwiched word, then they should respond with the first completion that came to mind. Subjects were also informed that the interval between the flashed words and the stem would vary, alternating between groups of short intervals and groups of long intervals. Before the start of each block, subjects were asked to repeat the instructions so as to insure that the instructions were clearly understood.

On each trial subjects also performed a secondary task prior to completing the word stem. This task consisted of reporting the sum of the two digits that flanked the sandwiched word (Wolford & Morrison, 1980). Such a "divided attention" task was necessary in order to keep overall performance at a reasonable level (Debner & Jacoby, 1994). Subjects reported the sum as soon as the stem appeared on the screen and then attempted to solve the stem. Feedback was given when errors were made on the secondary summation task. Responding on both the summation task and the stem completion task was verbal. Subjects had a total of 7.5 s to perform both tasks.

For all experiments, analyses were performed on the probability of completing stems with their target completion and, unless otherwise specified, the significance level for all tests was set at $p < .05$. Data from nonmatch and match trials were analyzed separately.

Results: Experiment 1a

Errors on the secondary task were minimal. Overall, subjects averaged 3.5% error on the summation task which is consistent with results from previous experiments. For example, Debner and Jacoby (Experiment 3, 1994) reported an error rate of 3.4% for the divided attention condition.

The mean probability of responding with a target word on nonmatch trials under inclusion instructions was .29 and .27 for 1 s and 6 s ISIs, respectively. Given exclusion instructions, those same probabilities were .31 and .26, respectively. Data from nonmatch trials were analyzed in a 2 x 2 ANOVA which included the within-subject factors of ISI (1 s vs 6 s) and instruction (inclusion vs exclusion). Results revealed no reliable differences between conditions. The mean of the nonmatch trials (.28) was taken as the "baseline" probability for giving the target word as a completion and was used for comparison with match trials.

Table 1 shows the completion data from match trials as well as the estimates of conscious and unconscious perception derived from the match trials. In the inclusion condition, subjects were much more likely to complete stems with the target completions compared to baseline. This was true for both the 1 s ISI (.65 vs .28) and the 6 s ISI (.52 vs .28). T-tests showed both increases to be reliable, $t(23) = 9.09$, $SE = .04$, and $t(23) = 6.08$, $SE = .04$, respectively. These results are not surprising; one would likely interpret such results as evidence that subjects were consciously perceiving the flashed words (Eriksen, 1960). Nevertheless, results from this condition cannot be interpreted as arising solely from conscious perception (Debner & Jacoby, 1994). It is quite possible that the effects were due to unconscious influences of the flashed word.

Insert Table 1 about here

The exclusion test condition provides evidence that unconscious perception did in fact contribute to performance. In that condition, the probability of completing a stem with the target word was also found to be reliably above baseline even though subjects were instructed not to complete stems with the flashed completion. Again, this pattern was found for both the 1 s ISI (.44 vs .28) and the 6 s ISI (.37 vs .28), $t(23) = 5.22$, $SE = .03$ and $t(23) = 2.76$, $SE = .03$, respectively.

The results produced in the inclusion and exclusion conditions could not be due to conscious perception alone. If performance in the inclusion condition had been driven solely by conscious perception, then consciously perceived items would have been withheld in the exclusion condition and performance would have been below, not above, baseline (Debner & Jacoby, 1994). Thus, the finding of above-baseline performance in the exclusion condition provides solid evidence for unconscious perception. Yet, some conscious perception of the flashed words must have taken place because inclusion test performance was higher than exclusion test performance. Had conscious perception been fully eliminated, subjects would not have been able to respond differentially on the two tests.

Estimates of conscious and unconscious perception. The process-dissociation procedure was used to estimate the separate contributions of conscious and unconscious perception to performance. Estimates of the two processes were computed for each subject using Equations 3 and 4 along with performance on match trials in inclusion and exclusion test conditions. The mean estimates of conscious and unconscious perception for all subjects appear in Table 1. Separate ANOVAs were carried out on each set of estimates to examine the effects of ISI. Analysis of the estimates of unconscious perception revealed a reliable effect of ISI, $F(1,23) = 10.83$, $MSe = .01$. When the stem appeared after a 1 s delay, effects of unconscious perception were much higher than when the delay was lengthened to 6 s ($Ms = .58$ and .46, respectively). In contrast, analysis of the effect of ISI on estimates of conscious perception was not significant, $F(1,23) = 1.01$, $MSe = .04$. The contribution of conscious perception to performance remained intact as the ISI was increased from 1 s to 6 s ($Ms = .20$ and .15, respectively).

Results: Experiment 1b

Subjects made very few errors on the secondary task, averaging 3.6% errors. This error rate was comparable to that of Experiment 1a and previous experiments (Debner & Jacoby, 1994).

For the inclusion condition, the mean probability of responding with a target word on nonmatch trials was .31 and .30 for 1 s and 6 s ISIs, respectively. Those same probabilities for the exclusion condition were .31 and .31, respectively. Results of a 2 x 2 ANOVA with within-subject factors of ISI and instruction revealed no reliable effects. The mean of the nonmatch trials (.31) was taken as the "baseline" probability for giving the target word as a completion and was used for comparison with match trials.

Table 2 shows the completion data from match trials. As in Experiment 1a, the probability of completing a stem with the target word in the inclusion condition was significantly higher than baseline (.31). This pattern was found at both the 1 s ISI (.71 vs .31) and the 6 s ISI (.58 vs .31), $\underline{t}(15) = 9.62$, $\underline{SE} = .04$, and $\underline{t}(15) = 7.04$, $\underline{SE} = .04$, respectively.

Importantly, the same pattern of results was found on the exclusion test. For both ISIs, target words were given as completions on the exclusion test more often than baseline. T-tests indicated these increases above baseline to be significant. For the 1 s ISI (.46 vs .31), $\underline{t}(15) = 2.87$, $\underline{SE} = .05$, and for the 6 s ISI (.37 vs .31), $\underline{t}(15) = 2.15$, $\underline{SE} = .03$.

Insert Table 2 about here

Estimates of conscious and unconscious perception. Estimates of conscious and unconscious processes were computed for each subject as in Experiment 1a. The mean estimates of conscious and unconscious perception for all subjects appear in Table 2. A one-way ANOVA on the estimates of unconscious perception revealed a reliable effect of ISI, $F(1,15) = 12.65$, $MSe = .01$. Effects of unconscious perception were much higher when the delay was 1 s ($M = .64$) compared to when the delay was 6 s ($M = .49$). In contrast, the same analysis on the estimates of conscious perception revealed no reliable effects of ISI, $F(1,15) = 0.61$, $MSe = .01$. The contribution of conscious perception to performance remained intact as the ISI was increased from 1 s to 6 s (Ms = .24 and .21, respectively).

Discussion

Experiments 1a and 1b revealed important dissociations between conscious and unconscious perceptual processes. As ISI increased from 1 s to 6 s, the contribution of conscious perception to performance remained invariant although the contribution of the unconscious component declined. Previously, I reported a manipulation (divided attention) that produced large effects on the contribution of conscious perception to performance while leaving that of unconscious perception unchanged (Debner & Jacoby, 1994). The data from the current experiments demonstrate that it is possible to obtain the opposite dissociation as well. Such dissociations provide strong support for the assumption that conscious and unconscious processes operate independently.

The effects of ISI revealed in these experiments are consistent with findings from previous research examining temporal effects of masked targets (e.g., Chalfonte, 1989; Forster & Davis, 1984). In all cases, increasing the ISI between the masked study word and test stimulus decreased the effect a masked study word had on performance. The present experiments suggest that such effects are caused by declining effects of unconscious perception over time. At some point, of course, both conscious and unconscious perception must be affected by manipulations of ISI. However, at longer delays, any effects seen on the conscious component might be more appropriately attributed to forgetting rather than to a failure in conscious perception. In fact, the slight (nonsignificant) decrease in estimates of conscious perception seen in Experiments 1a and 1b may have resulted from such factors.

As will be elaborated in the General Discussion, the decline of unconscious perception across time is attributed to the contextual sensitivity of unconscious processes. The idea that a temporal delay may be associated with contextual changes is not a novel proposition within psychology. Indeed, such a "contextual drift" account has been incorporated into explanations of short-term memory effects and negative priming effects (Gorfein, 1987; Gorfein & Schulze, 1975; Neill, Valdes, Terry & Gorfein, 1992).

To assess the contextual sensitivity hypothesis more directly, in the second experiment I manipulated perceptual similarity between study and test. Based on Experiments 1a and 1b, it was expected that the greater the visual similarity between study and test, the higher the contribution of unconscious perception to performance. Conscious processes, on the other hand, should be more resistant to minor perceptual changes. Thus, manipulation of perceptual similarity should produce a process dissociation identical to the one found in the first two experiments.

Experiment 2

Performance on memory tests is often enhanced by a match between study and test conditions. Roediger and Blaxton (1987), for instance, found that word fragments were completed with previously-studied completions at a higher rate when typography was kept constant between study and test as opposed to when typography was changed. Also, the influence of specific visual features appears to be dependent on the type of test (Madigan, McDowd & Murphy, 1991; Roediger & McDermott, 1993). Indirect tests of memory (e.g., fragment-completion) have generally shown more sensitivity to manipulations of perceptual characteristics than direct tests (e.g., cued recall; Allen & Jacoby, 1990; Roediger, Weldon & Challis, 1989). Indirect tests on which effects of typography have been demonstrated include rereading normal and inverted sentences (Jacoby, Levy & Steinbach, 1992; Kolers, Palef & Stelmach, 1980), semantic comparison (Woltz, 1990), perceptual identification (Jacoby & Hayman, 1987) and word-fragment completion (Roediger & Blaxton, 1987).

Although indirect tests often reflect a mix of conscious and unconscious processes (Jacoby, 1991; Reingold & Merikle, 1990; Richardson-Klavehn & Bjork, 1988), the consensus is that they primarily reflect unconscious processing. If the consensus opinion is correct, then visual similarity effects probably operate via unconscious processing. Indeed, Jacoby et al. (1993) used the process-dissociation procedure to reveal an effect of visual similarity on automatic influences of memory. My contention is that unconscious processes of memory and perception reflect the operation of similar processes (Debner & Jacoby, 1994; Jacoby, Toth, Lindsay & Debner, 1992). On this assumption, the effect of perceptual characteristics found for automatic influences of memory in stem completion should also apply in a perceptual paradigm. The manipulation of visual similarity employed in Experiment 2 involved typecase: sandwiched words were presented in either upper or lower case followed by word stems printed in either the same or different case.

Method

Subjects. Thirty-four subjects enrolled in an introductory psychology course at McMaster University served in the experiment for course credit. Subjects were tested individually. Data from 2 subjects were discarded because those subjects failed to follow instructions.

Materials and Design. The materials were identical to those of the first two experiments. The design incorporated two blocks of 64 trials each. These blocks corresponded to the two instructional conditions (inclusion vs. exclusion). Each block consisted of 16 trials of each combination of trial type (match vs nonmatch) and the visual similarity between the sandwiched word and the stem (same case vs different case). Trials were ordered randomly within each of the two test blocks. As a counterbalancing measure, half of the subjects were shown the "word sandwich" in lower case while the other half received upper case.

Sixteen practice trials were given at the start of each test block just as in the first two experiments.

Procedure. The experimental apparatus was the same as in Experiments 1a and 1b. Experimental trials consisted of the following sequence of events: 1) presentation of a fixation point for 1 s; 2) presentation of a premasking word for 500 ms; 3) presentation of the sandwiched word flanked by digits for 100 ms; 4) presentation of a postmasking word for 500 ms; 5) a delay of 500 ms in which the screen was blank; and 6) presentation of a word stem flanked by digits. The word stem appeared either in the same case or a different case as the sandwiched word. All events occurred in the same location on the screen. Subjects performed the secondary task and responded as described in the first two experiments.

Results and Discussion

Errors on the secondary task were minimal. The overall error rate for this experiment was 3.2%, comparable to all previous experiments using these conditions.

The mean probabilities of responding with a target word on nonmatch trials given inclusion instructions were .31 when the stem was presented in the same case as the flashed word and .34 when the stem was presented in a different case. Under exclusion instructions those same probabilities were .32 and .33. Data from nonmatch trials were analyzed in a 2 x 2 ANOVA with within-subject factors of visual similarity (same vs different) and instruction (inclusion vs exclusion). Results from that analysis revealed no significant effects. The mean of the nonmatch trials (.32) was taken as the "baseline" probability for giving the target word as a completion and was used for comparison with match trials.

Table 3 summarizes the completion data from match trials. When given inclusion instructions, subjects produced target completions at a rate much higher than baseline (.32). This was true regardless of whether the typecase was kept constant between study and test (.70 vs .32), $\underline{t}(31) = 12.38$, $\underline{SE} = .03$, or was different between study and test (.62 vs .32), $\underline{t}(31) = 8.75$, $\underline{SE} = .03$. The same pattern of responding was found on the exclusion test. Target completions were given reliably more often than baseline when the typecase was the same (.48 vs .32), t(31) = 3.98, SE = .04 and also when the typecase was different (.40 vs .32) t(31), = 2.23, SE = .03.

Insert Table 3 about here

Estimates of conscious and unconscious perception. Estimates of the contribution of conscious and unconscious perception to performance were computed for each subject as in the previous experiments. The mean estimates of conscious and unconscious perception for all subjects are presented in Table 3. Separate ANOVAs were carried out on each set of estimates to examine the effects of visual similarity. For the estimates of unconscious perception, there was a significant effect of visual similarity, F(1,31) = 16.07, MSe = .01. When the sandwiched word and the stem appeared in the same visual format, effects of unconscious perception were higher than when they appeared in different formats (Ms = .63 and .52, respectively). For estimates of conscious perception, no effect of visual similarity was obtained, F(1,31) = 0.15, MSe = .01. The contribution of conscious perception to performance was identical whether the visual format was the same or different (Ms = .23 for both).

General Discussion

The results from these three experiments provide converging evidence for the assumption of independence adopted in the process-dissociation procedure. Across two different manipulations, the contribution of conscious perception to stem-completion performance remained stable, while that of unconscious perception decreased significantly. These dissociations complement other dissociations demonstrating dramatic reductions in estimates of conscious perception coupled with invariance in estimates of unconscious perception (Debner & Jacoby, 1994). Further, results from these perception experiments parallel those from memory experiments which exhibit process dissociations between consciously-controlled and automatic influences of memory (Jacoby, 1991; Jacoby et al., 1993; Jacoby, Yonelinas & Jennings, in press; Jennings & Jacoby, 1993; Toth et al., 1994).

The present experiments illustrated that unconscious perceptual effects decreased rapidly (Experiment 1) and were sensitive to subtle changes in visual detail from study to test (Experiment 2). The conclusion drawn from these studies is that effects of unconscious perception are fragile in comparison to effects of conscious perception which remained remarkably stable across these same manipulations. Yet, manipulations of attention have been shown to have an opposite effect on the two processes: dividing attention radically reduces the contribution of conscious perception to performance but leaves effects of unconscious perception unchanged (Debner & Jacoby, 1994).

These findings corroborate previous research in the memory area indicating that perceptual variables (e.g., typography) have effects on indirect tests but little or no effect on direct tests (Roediger & McDermott, 1993). Attentional variables, by contrast, historically have been associated with conscious processes and not automatic, unconscious processes. Indeed, the hallmark of an automatic process is that it can be carried out regardless of other attentional demands (Hasher & Zacks, 1979; Posner & Snyder, 1975). Thus, perceptual variables affect automatic processes and attentional variables affect consciously-controlled processes. This observation, along with the fact that manipulation of these variables consistently produces invariances, lends credence to the assumption that conscious and unconscious processes are independent.

Logogens vs. Episodes. By showing declining effects over time (Experiments 1a and 1b), some (e.g., Morton, 1969) might claim that unconscious perception reflects the activation of an abstract lexical representation (i.e., logogen). As time passes, the activation level of the logogen decays and the prior presentation of the solution becomes less influential. The data from Experiments 1a and 1b are consistent with such an interpretation. By contrast, the failure to find effects on the conscious perceptual component causes problems for a logogen model. One has to explain how conscious perception (generated from activation levels reaching some threshold?)

could remain constant over the same interval in which unconscious perception declines. It is possible to get around this problem by proposing a separate system/process (conscious perception) that is initiated after the logogen has reached some threshold. This type of model represents a redundancy relation between conscious and unconscious perception; conscious perception only takes place when unconscious perception has occurred. Redundancy models of the relation between conscious and unconscious processes have been called into question previously and so will not be discussed here (Jacoby et al., 1993; Jacoby, Toth, Yonelinas & Debner, in press).

Further difficulties for the logogen hypothesis are caused by Experiment 2 where a change in typecase produced a reduction in estimates of the unconscious component but not the conscious component. The effect of typecase on unconscious perception makes a strict logogen hypothesis untenable: logogens are abstract representations and therefore should be indifferent to small changes in visual detail such as typecase. The results from Experiment 2 indicate that whatever the representation is that is activated by the flashed word, it must be sensitive to perceptual features. Thus, to account for these data one must propose that logogens (or whatever representations are activated) do in fact encode perceptual information, or, that a separate mechanism is responsible for the typecase effects. Of course, the absence of typecase effects on the conscious component are again problematic. All in all, while an abstractionist account is not ruled out, it would have to be made overly complex in order to handle all of the data.

Suppose instead that the uptake of information from the environment is akin to what Marcel (1983b) described as "a nondisjointed flow (it does not segment into events, objects, episodes); it codes all aspects of what impinges at every level and in every code with which the organism is equipped..." (p. 243). By my view, conscious and unconscious perceptual processes operate on this flow of information in qualitatively different, independent ways. Conscious perception may result from "imposition of a particular segmentation and structure on what is otherwise unsegmented..." (p. 243). This segmentation may allow certain information to be given special status, a status which supports selective responding. By contrast, unconscious perception binds together "all aspects of what impinges" so that for unconscious influences to occur one must "get back into the flow." Subsequent processing serves as a cue for retrieval of any prior processing episodes that may have occurred. As a result, prior processing episodes affect current performance to the extent that they are retrieved, retrieval being affected by the similarity between past and current processing (Morris, Bransford & Franks, 1977).

One important difference between conscious and unconscious processes concerns contextual segregation: conscious processes are foregrounded whereas unconscious processes are backgrounded. That is, conscious processes <u>isolate</u> task-relevant information from background context unlike unconscious processes which <u>integrate</u> information with the background context. Given the stem completion task used here, for example, the identity of the flashed word is relevant to performance but not the case in which the word is presented.

The generation of unconscious or automatic responses may be akin to the notion of direct parameter specification put forth by Neumann and colleagues (e.g., Neumann, 1984, 1990; Neumann & Klotz, in press). This mechanism allows responses to be made automatically provided that enough parameters for action are designated by the task (and stimuli). A parallel can be drawn between contextual information and parameter specification. If an unconscious processing episode is retrieved by the stem and that episode contains sufficiently overlapping contextual information, then a response may be made. Thus, in the absence of consciously controlled processing, actions may be guided entirely by previous experience with the stimulus. Important to my argument, however, is the fact that unconscious influences do not support selective responding. Automatic responses are generated as a result of prior processing which may be in accord with or in opposition to conscious intention (Jacoby & Hay, 1993).

An "episodic" account provides a natural explanation for effects of typecase and ISI on estimates of unconscious perception. To the extent that the stem (and processing of it) differs from the flashed word, then retrieval of a prior processing episode will be less likely. This holds true for both conscious and unconscious processes. Given that unconscious processing of the flashed word is inextricably bound to context, small changes in surface characteristics would have a substantial effect on the contribution of unconscious perception to performance. The same may be said for temporal delay. Unconsciously produced processing episodes are less likely to be retrieved after a delay because of contextual changes that may take place over the delay (Neill et al., 1992). Nevertheless, if conscious processes operate in such a way that irrelevant features are backgrounded, then conscious processes would appear less sensitive to perceptual variables (Jacoby, Levy & Steinbach, 1992). Furthermore, the nature of the task is such that conscious perception of the flashed word allows it to be kept in memory (via rehearsal) over the delay until the stem appears. In this particular case, it is perhaps less frequent that a consciously perceived word must be retrieved in the true sense of the word. Possibly for longer delays or with intervening items, one might find an effect of perceptual variables on conscious perception.

A recent proposition in the memory area emphasizes the importance of perceptual factors during automatic retrieval of prior episodes (Jacoby, Levy & Steinbach, 1992; Jacoby et al., 1993; Levy, Di Persio & Hollingshead, 1992; Toth et al., 1994). According to these authors, repetition effects result from reinstatement of prior processing episodes which contain both conceptual and perceptual information. Episodes may be accessed directly, as in conscious recollection, or automatically, as in the service of another task (Jacoby, Levy & Steinbach, 1992). One hypothesis of the episodic view is that automatic retrieval is more sensitive to perceptual characteristics than is consciously-controlled access. This hypothesis contrasts with those that have claimed perceptual sensitivity to be limited to early stages of skill acquisition (Masson & Freedman, 1990). To the extent that unconscious perceptual processes can be mapped onto automatic influences of memory, the data from the current experiments would certainly support an episodic account.

Conclusions

A major theme of this article is that the processes of unconscious and conscious perception act as qualitatively different, independent processes. As a result, I have both here and elsewhere (Debner & Jacoby, 1994) demonstrated process dissociations in which one process was reduced while the other was left intact. This is the essence of independence. Moreover, the variables that have been shown to affect conscious perception (attention and duration) are ones that have classically been associated with awareness. Likewise, the argument was made that variables which affect unconscious perception (duration, delay and visual similarity) are also reflective of past theorizing on the topic of automaticity. While there is clearly more work that needs to be done is this area, it is my opinion that the most parsimonious account for all the data involves an approach whereby conscious and unconscious processing episodes are created and retrieved. Differences in the characteristics of conscious and unconscious processes (i.e., control, hyperspecificity) are a direct result of the way information is stored in those episodes.

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Table 1

Experiment 1a. Observed Probabilities of Stem Completion[a] in Inclusion and Exclusion Test Conditions with Estimates of Conscious Perception (CP) and Unconscious Perception (UP).

	Instruction		Estimates	
	Inclusion	Exclusion	CP	UP
1 s ISI	.65	.44	.20	.58
6 s ISI	.52	.37	.15	.46

Note. The baserate, derived from nonmatch trials, was .28 (see text). All stimuli in this experiment were presented in uppercase.

[a]The data in this table represent mean probabilities of responding with the target completion on match trials.

Table 2

Experiment 1b. Observed Probabilities of Stem Completion[a] in Inclusion and Exclusion Test Conditions with Estimates of Conscious Perception (CP) and Unconscious Perception (UP).

	Instruction		Estimates	
	Inclusion	Exclusion	CP	UP
1 s ISI	.71	.46	.24	.64
6 s ISI	.58	.37	.21	.49

Note. The baserate, derived from nonmatch trials, was .31 (see text). All stimuli in this experiment were presented in lowercase.

[a]The data in this table represent mean probabilities of responding with the target completion on match trials.

Table 3

Experiment 2. Observed Probabilities of Stem Completion[a] in Inclusion and Exclusion Test Conditions with Estimates of Conscious Perception (CP) and Unconscious Perception (UP).

	Instruction		Estimates	
Visual Similarity	Inclusion	Exclusion	CP	UP
Same	.70	.48	.23	.63
Different	.62	.40	.23	.52

Note. The baserate, derived from nonmatch trials, was .32 (see text).

[a]The data in this table represent mean probabilities of responding with the target completion on match trials.

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