Confidence in word detection predicts word identification: Implications for an unconscious perception paradigm

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The present experiments extend the scope of the independent observation model based on signal detection theory (Macmillan & Creelman, 1991) to complex (word) stimulus sets. In the first experiment, the model predicts the relationship between uncertain detection and subsequent correct identification, thereby providing an alternative interpretation to a phenomenon often described as unconscious perception. Our second experiment used an exclusion task (Jacoby, Toth, & Yonelinas, 1993), which, according to theories of unconscious perception, should show qualitative differences in performance based on stimulus detection accuracy and provide a relative measure of conscious versus unconscious influences (Merikle, Joordens, & Stoltz, 1995). Exclusion performance was also explained by the model, suggesting that undetected words did not unconsciously influence identification responses.

For nearly as long as psychology has existed as a science, there have been experimental demonstrations of what some would call perception without awareness (see Adams, 1957, for a review). In many studies investigating the limits of sensory discrimination, participants have been shown to perform at better than chance levels in choosing which of two weights is heavier (Pierce & Jastrow, 1884), for example, or in choosing the identity of a letter (Sidis, 1898), even when they lacked confidence in their judgment. The question of interest is whether such discrimination performance indicates unconscious perception. For example, Bricker and Chapanis (1953) demonstrated that after an incorrect identification, participants can still provide verbal information that eventually leads to the correct identification of the stimulus. In their study, they showed that the number of additional guesses needed to correctly identify a stimulus that was originally misidentified was better than chance. Such behavior would be possible if the participant had perceived par-

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tial information about the stimulus, thus leading to correct identification (see Duncan, 1985, for a similar argument).

Signal detection theory (SDT; Green & Swets, 1966; Macmillan & Creelman, 1991) provides another line of evidence that supports the idea that residual information after an incorrect response can lead to correct identification. For example, Swets, Tanner, and Birdsall (1961) had participants view a sequence of four temporal intervals on each trial, one of which contained a small spot of higher luminance than the background. After an incorrect first response, the researchers collected the participants' next choice for the temporal interval that might have contained the signal. The accuracy of the participants' second choices fit well with the assumptions of SDT, where sensory states are ordered on a continuum. A true sensory threshold is not assumed to exist in SDT, and, if it does exist, it is thought to be well below the mean of the noise distribution (Swets, 1961). SDT thus provided an early insight into the current debate over perception without awareness: A cutoff between conscious and unconscious perceptual states may be difficult or impossible to measure.

A related, methodological argument is that adequately measuring awareness has been one of the greatest difficulties in convincingly demonstrating unconscious perception (Holender, 1986) and unconscious learning (Dulany, 1991, 1997). For example, if one equates the lack of conscious perception with a simple verbal report (e.g., "I didn't see anything!") and subsequently shows that the presented stimulus has influenced participants' behavior in some way, then, via operational definition, unconscious perception has occurred. However, subtle details in the participants' perceptual states could be responsible for their responses in these situations. This issue surfaced during the 1950s in the debate over perceptual defense. In a classic perceptual defense study (McGinnies, 1949), a "taboo" word was presented in such a way to make its detection very difficult. Even when participants claimed they could not detect such words, these words increased their galvanic skin response (a measure of autonomic nervous system arousal). The initial interpretation was that the unconscious mind (in the Freudian sense) was defending the conscious mind against the "taboo" word. However, Eriksen (1960) convincingly demonstrated that participants might have been very reluctant to verbalize their perception of such words (especially to an experimenter) until they were absolutely certain that they identified them. Eriksen also made the very astute observation that if the task is carried out properly, an unbiased verbal report can be just as sensitive as any other measure of perception (such as the indirect measure of the galvanic skin response).

To overcome some of these problems with unconscious perception

research, Cheesman and Merikle (1984) suggested a distinction between the subjective and the objective threshold. They defined the subjective threshold as the participant's own criterion for conscious perception and the objective threshold as a level of stimulation that cannot be perceptually discriminated from the null stimulus (i.e., $d' = 0$). They also suggested that unconscious perception will be found only in experiments that establish the subjective threshold and present stimuli at or below this point yet above the objective threshold.

Merikle and Reingold's (1990) experiments provide an example of the subjective threshold concept and its potential utility. They conducted a series of experiments suggesting that in a concurrent detection and identification task, a measure of awareness (subjective in their experiment because $d' > 0$) can be obtained on every trial if one assumes that, for an unbiased observer, a missed stimulus is not consciously perceived. If performance is influenced after null detection, then this provides evidence of unconscious perception, assuming that any information indicating stimulus presentation would be sufficient to correctly detect the stimulus. In addition to providing a reasonable measure of null awareness, they argued that one must also show qualitative differences in task performance between conscious and unconscious perception. In their initial experiments, participants were asked to indicate on each trial whether a word had been presented (words were presented on half of the trials). After this decision, they were asked to choose which word of two words might have been presented. They found that after "misses" (i.e., word presented, participant decides "no"), word identification performance was above chance. They also showed that this dissociation could not be accounted for by participants adopting conservative detection criteria. Assuming that stimulus detection adequately measures awareness, these results support unconscious perception. Subsequently, they found that after misses, significant above-chance identification occurred only for words (but not for nonwords), which they used to demonstrate qualitative differences in detection and identification between word and nonword stimuli.

As an alternative, numerous psychophysical studies using signal detection methods demonstrate that detection and identification are quantitatively related, such as the detection and identification of Landolt Cs (Benzschawel & Cohn, 1985), simple tones in noise (Green, Weber, & Duncan, 1977), and vowels (Holt & Lotto, 1999). In these experiments, the researchers used a rating scale for the detection task to permit participants to express varying degrees of confidence in detection. Over the course of an experiment, a participant may often have low confidence that a stimulus was presented, but their average confidence on signal + noise trials might be slightly higher than on noise alone trials, which

would be indexed by the participant's perceptual sensitivity (i.e., $d' > 0$). In addition, stimulus information that typically leads to a low confidence rating (or a "no" response in the yes–no detection task) might be sufficient to correctly identify which stimulus (usually from a choice of two) was presented. This ability of a participant to correctly identify stimuli under conditions of detection uncertainty can be displayed geometrically by an independent partitioning of the decision space by separate criteria for detection and identification (Macmillan, 1986; Macmillan & Creelman, 1991). See Figure 1 for a representation of this model, the independent observation model, adapted for the present studies.

Figure 1 represents a top-down view of two signal + noise distributions oriented at a 90° angle (orthogonally) to a noise-alone distribution (in

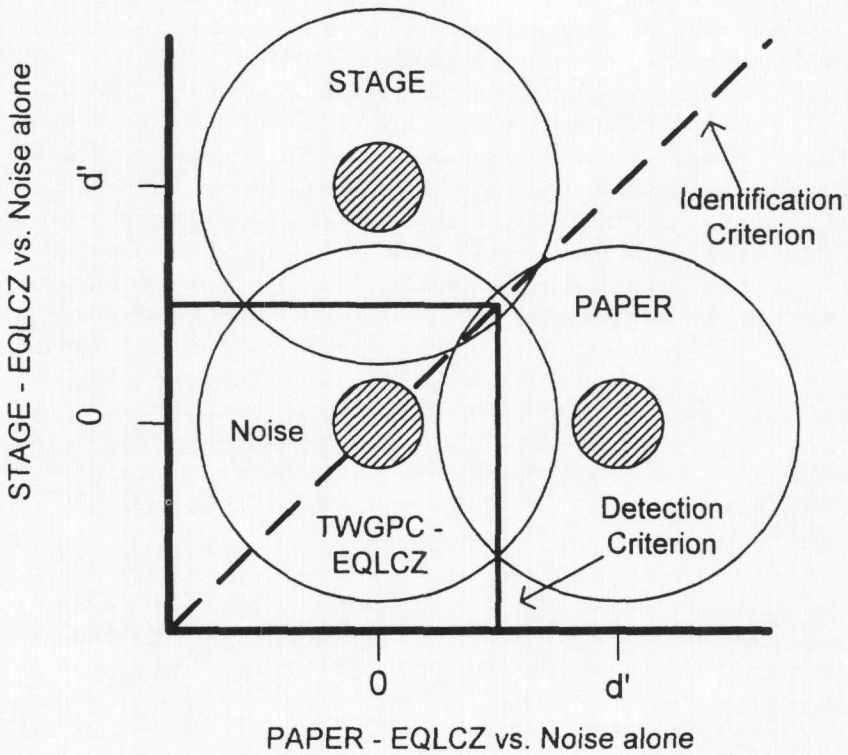

Figure 1. Independent observation model (Macmillan & Creelman, 1991) representing a hypothetical decision space for a particular trial of the concurrent detection and identification task adapted for word stimuli

the lower-left hand corner). A test of orthogonality (i.e., independence of stimulus representations) can be made based on the obtained relationship between detection and identification. These three distributions are assumed to be bivariate Gaussian (i.e., in addition to having random variation in the representation of signal strength, there is random variation in the perceptual representation of similarity to the identification choices). In the typical signal detection experiment with two possible targets plus noise, it is assumed after many trials a distribution of sensory representations builds up for each target and noise alone. In our experiment with multiple signals (each repeated only a few times), these distributions might be less idealized than represented in Figure 1. On the other hand, with word stimuli, it is reasonable to assume that there is some sort of preexisting stimulus representation.

In addition, the two signal + noise distributions in Figure 1 would overlap to a slightly greater extent than indicated. Assuming that target words are equally detectable, the distance between the centers of each signal + noise distribution and the noise-alone distribution would be equal, and this distance would also provide an indication of target detectability in noise (e.g., d'). The two perpendicular lines within the figure define a single detection criterion that would separate detection responses into "yes" and "no" regions (presented here for clarity; for a rating scale design, there would be multiple criteria). The diagonal line oriented at a 45° angle represents the identification criterion that would separate identification responses into a region corresponding to each word. From this diagram, identification (in unadjusted d' units) would be better than detection by a factor of $\sqrt{2}$, again assuming two equally detectable, orthogonal signals. An additional implication of the model, which has important implications for unconscious perception theory, is that even when a "no" detection response is made on a signal + noise trial (i.e., a miss), the observer has a better than 50–50 chance of correctly identifying which signal from a choice of two was presented (assuming that overall $d' > 0$). The reason this is likely to occur is that the detection observation would fall below the detection criterion but in a region of space closer to one of the two target stimuli (i.e., more likely on the side of the identification criterion representing the signal that was presented). This view offers an interpretation of correct identification after incorrect detection without needing to claim that unconscious perception has occurred (see also Macmillan, 1986; Macmillan & Creelman, 1991).

When this figure is adapted to rating-scale detection experiments, more conservative criteria would be located higher up and to the right of the detection criterion in Figure 1. A greater proportion of area would fall below the more conservative criteria. Identification perfor-

mance would be more accurate because observations would almost always fall to the side of the diagonal, indicating the correct identification response. As the criterion is made more lenient, the corner formed by the two detection criteria in Figure 1 would be moved more to the lower left-hand portion of the x–y plane, in a region where the two signal + noise distributions would overlap to a greater degree. Identification performance would be less accurate in such a situation (e.g., if the participant believed a word was shown but perceived only the letter "A," his or her performance would be at chance in choosing between "PAPER" and "STAGE").

Signal detection experiments have not been designed to resolve issues of unconscious perception until recently, even though the theoretical basis of SDT is relevant to the study of unconscious perception (e.g., the decision criterion for responding "yes" is not a threshold of awareness; Swets, 1961; see also Green & Swets, 1966). As a demonstration of the utility of the signal detection approach in unconscious perception research, Haase, Theios, and Jenison (1999) conducted a simple experiment using procedures similar to previously published unconscious perception experiments (very short stimulus durations and visual masking) to determine whether the rating scale signal detection method and the corresponding independent observation model (Macmillan & Creelman, 1991) could be used to interpret the typical finding of above-chance identification on "miss" trials. Participants were shown one of two simple visual targets and were asked to rate their confidence (on a 6-point scale) that one of the two targets had been presented. Immediately after the detection decision, participants chose which target was more likely to have been presented (simple identification). Participants' identification performance increased linearly with their detection confidence rating, and identification performance could be predicted from the detection receiver operating characteristic (ROC) curve in accordance with SDT (Green et al., 1977; Starr, Metz, Lusted, & Goodenough, 1975; Swets & Pickett, 1982). These findings suggest that when the participant rates detection confidence on a scale, stimulus information resulting in a "no" decision in a simple yes–no task might sometimes translate into a decision of moderate confidence. At this point it is unclear whether correct identification (or some other measure of performance such as priming) after a missed signal is an indication of unconscious perception or perhaps an indication of conscious perception with low confidence in stimulus detection.

In the present studies, we replicate and extend the findings of Haase et al. (1999) with a larger, more complex, and meaningful stimulus set (words) using an approach similar to that of Merikle and Reingold (1990). In our second experiment, we test for quantitative and qualita-

tive differences in identification performance using an exclusion task. Merikle, Joordens, and Stoltz (1995) suggested that exclusion tasks, where one is instructed not to use the information from a prior stimulus, can be used as a good index of conscious processing. They argue that if, under exclusion task instructions, a participant is influenced by a prior stimulus (e.g., uses this information in a subsequent task), it suggests that the influence was unconscious. The exclusion task often is used as a means, in and of itself, to distinguish between conscious and unconscious processing, perhaps because of the difficulty researchers have encountered in convincingly demonstrating null detection sensitivity. We have set up our exclusion experiment within a dissociation paradigm to compare the responses from detection and identification. Conceptually, the task might be defined as a modified exclusion task, which we feel combines the strengths of both exclusion and dissociation paradigms.

EXPERIMENT 1

METHOD

Participants

Sixteen students (13 women, 3 men; median age = 21 years) from Gordon College participated in the experiment. The participants were enrolled in introductory psychology, human growth and development, or the psychology of adjustment. Participants in both experiments received extra credit for their participation and were treated in accordance with the "Ethical Principles of Psychologists and Code of Conduct" (American Psychological Association, 1992).

Materials and apparatus

The Micro Experimental Laboratory (MEL) software system (Version 2.0 for MS-DOS, 1995) controlled stimulus presentations and collected participants' responses. Stimuli were displayed on a CTX International 14-inch VGA monitor that was attached to an American Megatrends computer (486 SX, 25 MHz, IBM compatible).

Target and distractor stimuli consisted of words obtained from the Kucera and Francis (1967) word frequency norms. The 64 words selected for use in the experiment were five letters long and ranged in frequency from 88 per million ("enemy") to 787 per million ("world"). On each signal + noise trial, one word was designated as the target (i.e., the word actually presented in the detection task) and another word as the distractor (i.e., the other option adjacent to the target word in the identification task). Targets were paired with a distractor of similar frequency, such as "world" (787 per million) paired with "being" (712 per million). Another subset of stimuli was created in which the

target–distractor pairing was reversed so that each previously designated target word served as a distractor, and the word previously used as a distractor was designated as the target. Masking stimuli consisted of nonwords that were formed from five-letter, random arrangements of alphabetical letters with the constraints that they did not form an English word or did not appear too obviously similar to one of the target word pairs. There were eight different backward masks and eight different nonword targets (presented in target field on noise trials). All targets and masks were presented in uppercase and were viewed from a distance of approximately 55 cm (1.6° of visual angle).

Procedure

Each participant was seated comfortably in front of the computer monitor in a well-lit room. Before the experimental trials, participants were given practice at detecting briefly presented words that were followed by nonword masks. Instructions were written on the screen, which the experimenter read to the participant. Participants were asked whether they had any questions after the task was explained.

Practice trials consisted of four blocks of rating scale detection. The extremes of the scale were defined to the participant as 1 (*absolutely sure no word was presented*) to 6 (*absolutely sure that a word was presented*). The probability of target presentation (signal + noise) was .50. In the first block of trials ($n = 12$), the duration of the target word was 132 ms, followed by a 50-ms nonword mask. On trials where words were not presented (noise trials), a nonword was presented in the target field for the specified target duration, followed by a nonword mask, which differed from the target field nonword. The target field duration was reduced to 67 ms in the second block of trials ($n = 16$) and was further reduced to 33 ms in the third and fourth blocks of practice trials ($n = 16$ in each block). The duration of the nonword mask remained at 50 ms for all trials. The two words used during the practice detection task ("night" and "place") were not used in the experimental trials.

After the practice trials, the experimenter explained the procedure for the experimental trials (see Table 1 for an outline of each experimental trial). The experimental procedure was similar to the practice trials with two important exceptions. In the experimental trials, participants were asked to make a simple identification response as to which word might have been presented. During each detection rating, two words were shown adjacent to each other above the rating scale. One of those two words would have been presented on a signal + noise trial. The participant was asked to rate his or her confidence on the 1- to 6-point scale that either of these two words had been presented. After this response, participants were asked to choose which word might have been shown (simple 1-of-2 identification). The word pair was displayed to ensure that the correct choice was presented equally often on the left and right during the identification task. The procedure of including the possible target words on the detection task was similar to Merikle and Reingold's (1990) procedure for Experiment 2. Another reason for including the possible target words on the detection task is that the independent observation model (Macmillan & Creel-

Table 1. Sequence of experimental trials

Event	Display	Duration
Warning tone	Blank	1,000 ms
Fixation	— —	1,000 ms
Display field (word/nonword)	"GROUP"	33 ms
Backward mask	"KWDYB"	50 ms
Detection rating (possible words displayed next to each other horizontally, above rating scale)	1–6 rating scale	Until response
Identification	"POINT GROUP"	Until response
Intertrial interval	Blank	500 ms

man, 1991) assumes that the target stimuli are known on the detection task. The other change from the practice procedure was made to the rating scale for the experimental trials. In a pilot study, we found that some participants were uncomfortable expressing higher levels of confidence in their performance given the difficulty of the task. Therefore, we labeled 1 as *guessing that no word was presented* and 6 as *guessing that a word was presented.* The scale values of 2 and 3 were defined as indicating less confidence that no word was presented (compared with a 1); the scale values of 4 and 5 were defined as indicating less confidence that a word was presented (compared with a 6). We felt that this change in the verbal scale anchorings as defined for the practice trials was important so that participants would use the extreme ratings, at least on some of the trials, and thus use the entire extent of the rating scale (i.e., to encourage unbiased responding).

The duration of the target field was set at 33 ms. In a previous study, we tested this procedure at a 16-ms duration and found that approximately half of the participants had d's for detection that were not substantially different from zero (Haase & Fisk, 1998). Therefore, we increased the target duration to make the task easier. We also made clear to participants that they would be prompted for an identification response after every trial even if they were convinced that no word was displayed. Obviously, there is no correct identification response on nonword (noise) trials; however, the detection rating is used as a measure of the false alarm rate (e.g., responding 6 frequently on such trials would indicate a bias toward saying "yes"). We also instructed participants to make their identification responses carefully even if they believed no word was shown because they could still be correct at identifying the word. Once these instructions were explained, participants had little difficulty making a identification response on each trial. On noise trials, word pairs that were presented as options for the identification task were randomly selected from the same word pairs used on the signal + noise trials. Before the experimental trials, there were eight practice trials (using the same stimulus pool as in the experimental trials) to ensure that the participant understood the task. If the participant did

not have any questions, he or she was instructed to proceed through five blocks of trials, with 64 trials per block. Trials within each block were selected at random from a file containing 128 stimulus pairs. Half of the stimulus pairs in the file contained a word in the target field and the other half contained a nonword in the target field, thus yielding a .50 probability of target presentation. Participants were free to rest or take a short break between blocks to prevent fatigue. The entire experimental session lasted approximately 1 hr.

The detection rating scale used in this experiment may not be directly comparable to the yes–no task used by other experimenters (e.g., Merikle & Reingold, 1990). Therefore, a second group of observers (n = 12, 10 men, 2 women, median age = 19) was tested on a yes–no detection task in place of the 1–6 rating scale. To ensure similarity across this study, we instructed observers that a "no" response could mean that they were guessing that no word was shown and that a "yes" response could mean that they were guessing that a word was shown. This was done to be consistent with the procedures of the 1–6 rating scale detection task and to minimize conservative bias. All other conditions for this group were the same as described earlier.

We replicated the finding of interest, namely, that after miss trials, identification performance, $M = .598$, was significantly above chance, $t(11) = 4.33$, $p < .05$, $SE = .0225$. After hits, identification performance was quite accurate, as would be expected, $M = .816$, $SE = .040$. Overall detection performance was similar to our Experiments 1 and 2, $d' = 1.029$, $SE = .184$, $c = -.127$, $SE = .062$.

RESULTS AND DISCUSSION

The results were analyzed using methods based on SDT (Green & Swets, 1966; Macmillan & Creelman, 1991) and mean identification performance conditional on detection rating category. The .05 level of significance was adopted for all statistical tests. All statistical tests reported for this experiment are one tailed because the prediction is for above-chance identification performance as a function of confidence rating.

In terms of overall detection performance, we report a measure of sensitivity that is appropriate for rating scale designs, especially when the z-score (normalized) plot of hit and false alarm rates shows nonunit slope (Macmillan & Creelman, 1991; Swets & Pickett, 1982). This estimate of perceptual sensitivity, d_a, results in a value similar in magnitude to the more familiar d' from the yes–no detection task. Participants could discriminate between word and nonword trials, as shown by their moderate level of perceptual sensitivity, $d_a = 0.744$ (pooled yes–no estimate of $d' = 0.802$), slope = .755. A measure of bias called c_2 (Macmillan & Creelman, 1991) was also determined from the normalized ROC curve, with $c_2 = +.099$ (averaged across the five normalized ROC criteria). The c_2 value indicates the amount of bias from zero in standard deviation units (negative values indicate liberal bias; positive values indicate conservative bias).

Of interest for the issue of unconscious perception is participants' identification performance conditional on rating category. As can be seen in Figure 2, identification performance increases monotonically as a function of detection rating category. To compare performance on this task to the yes–no tasks used in previous unconscious perception studies, one would have to collapse identification performance on the 1–3 ratings to obtain an estimate of performance on "miss" trials. First, we consider the 1–3 ratings separately. For the lowest confidence in word presence rating (i.e., the 1 rating), identification performance, $M = .495$, $n = 10$, was not reliably different from chance, $t(9) = -.23$, $SE = .022$. For the 2 rating, identification performance, $M = .529$, $n = 11$, was also not reliably above chance, $t(10) = .67$, $SE = .043$. In contrast to the 1 and 2 ratings, identification performance for the 3 rating, $M = .613$, $n = 14$, was significantly above chance, $t(13) = 2.90$, $SE = .039$. Each participant's mean identification performance was based on a minimum of 10 observations.

One could reasonably argue that for the 3 confidence rating, participants had a conscious impression of at least part of the words with a moderate level of confidence and subsequent ability to correctly identify them above chance. This would be possible, for example, if the participant perceived what he or she thought may have been "PA" yet responded with a low value for word detection confidence (e.g., 3). On the subsequent identification task, if the choices were "PAPER" and "STAGE," it would be very reasonable for the participant to choose "PAPER" given the perception of the letters "PA" (see also Duncan, 1985, for a similar argument). However, this result would have been obscured if the present experiment had been conducted as a simple yes–no detection task. As a demonstration of the likely results had this experiment been conducted in a yes–no fashion, we pooled the identification data conditional on the 1–3 ratings, which probably would have mapped onto "no" detection decisions in a yes–no task. Collapsing across ratings 1 to 3 demonstrates that identification performance, $M = .562$, was significantly above chance, $t(15) = 1.94$, $SE = .032$, essentially replicating the findings of Merikle and Reingold (1990, Experiments 1 and 2). Taken together with the results of our yes–no detection experiment, it appears reasonable that some of the "no" responses in the yes–no task would be classified along a continuum if such a scale were available to the participant.

We next examine the ROC generated from the present experiment. From a multipoint ROC, there are several ways to summarize the overall detection performance and relate it to identification performance. The first characterizes the estimate of perceptual sensitivity and is labeled d_a, which we reported earlier. From this measure, an estimate of

the area under the ROC, A_z, can be used to predict overall identification performance (Macmillan & Creelman, 1991; Swets & Pickett, 1982). In addition to these measures of performance, we present the joint ROC–IOC (identification operating characteristic) in Figure 3. Here, the recognition theorem of Starr et al. (1975) is used to obtain measures of predicted identification performance at each ROC point. The predicted values for identification were generated by a piecewise approximation of the integral describing the relationship between detection and identification (see Green et al., 1977, footnote 1):

$$p_m(R\&C|\lambda_i) = p(R|S,\lambda_i) - [(m-1)/m] \int_0^{p(R|N,\lambda i)} [1 - p(R|S,\lambda)]/[1 - p(R|N,\lambda)]\, dp(R|N,\lambda)$$

where

m = the number of choices on the identification task (two in the present studies)
$p_m(R\&C|\lambda_i)$ = the joint probability of the rating and a correct identification response for a given detection criterion, λ_i
$p(R|S)$ = the probability of the rating, given signal + noise presentation
$p(R|N)$ = the probability of the rating, given noise-alone presentation

Put simply, the recognition theorem, generated from multiple hit and false alarm pairs at different detection criteria, functions very similarly to the area theorem, generated from a single hit and false alarm rate pair (see Green et al., 1977, Appendix).

For example, the first predicted IOC point is calculated by computing $[1 - p(R|S)]/[1 - p(R|N)]$ based on the hit $[p(R|S)]$ and false alarm $[p(R|N)]$ rates at that criterion. The hit rate at this criterion corresponds to the proportion of signal + noise trials responded to with rating 6. Once this ratio (R-lambda, Green et al., 1977) is computed, it is multiplied by the false alarm rate at that same detection criterion, which results in an approximation of the area under that portion of the ROC. This value is then multiplied by 0.5 (for $M = 2$) and subtracted from the hit rate at that criterion, which yields the predicted value for identification performance at that criterion. Another way to understand this theorem is to imagine the case in which detection performance is quite good at this criterion (e.g., .80, a high hit rate, and .20, a low false alarm rate). When R-lambda (.25 in this example) is multiplied by the false alarm rate, an even smaller value results (.05 in this example), and thus a very small value is subtracted from the hit rate, indicating that nearly all the hits will be correctly identified (the proportion of signal + noise trials correctly identified and responded to with rating 6 would be $.80 - [.5 \times .05] = .775$ in this example). This value is not the proportion correct identification because the theorem requires that the data be cumulated across all detection criteria. However, if one were to divide the

predicted value by the hit rate at that criterion, the resulting value would give a prediction for correct identification performance (.775/.80 = .969). This makes intuitive sense in that a highly detectable signal should be easily identifiable (given the assumption of equally detectable, orthogonal signals). As the false alarm rate increases (and the integral cumulates), a larger value is subtracted from the hit rate and identification performance decreases relative to previous criteria. At the most lenient, final criterion, the signal may not be perceived to be very different from the noise, is thus less clear, and thus is harder to identify.

The last point on the IOC can also be predicted by the area theorem (proportion correct identification prediction from recognition theorem = .750, prediction from area under normalized ROC = .70). The top curve is the generally more familiar curve for detection performance, with the two remaining curves being identification performance as a function of detection criterion. One IOC curve represents the predicted values, and the other represents the obtained values from our experiment. The predicted and obtained values agree remarkably well, with a better fit than reported by Haase et al. (1999). There are several possible reasons for the improvement in fit over Haase et al. First, detection performance in that study was not quite as good, possibly because of the shorter, 16-ms stimulus duration and use of both forward and backward masking. Second, there were only two target stimuli in that study that varied slightly (but not statistically) in target detectability. If one uses the predicted identification value, A_z, as the last cumulative prediction, then the overall fit is even better. The recognition theorem uses the ROC point (1,1), along with the previous point, to predict the proportion correct identification. The ROC point (1,1) contains no information that participants could distinguish between word and nonword trials. If a value close to this upper right-hand corner point was used (e.g., estimated from the smooth ROC curve), then the predicted and obtained values for identification would be closer at this point.

A more detailed inspection of the IOC is needed to understand how SDT can provide an alternative explanation to what is often argued to be unconscious perception. The identification data plotted on the IOC curve are cumulative proportions of the joint probability of responding with a particular detection rating category and correctly identifying the target word. For example, consider trials in which the participants had a low false alarm rate (conservative detection criterion, first ROC point). The proportion of word trials responded to with the highest confidence rating (6) equaled .275. The proportion of word trials given this rating and correctly identified was .25. This translates to a proportion correct identification of .909 at this detection criterion (.25/.275). This value

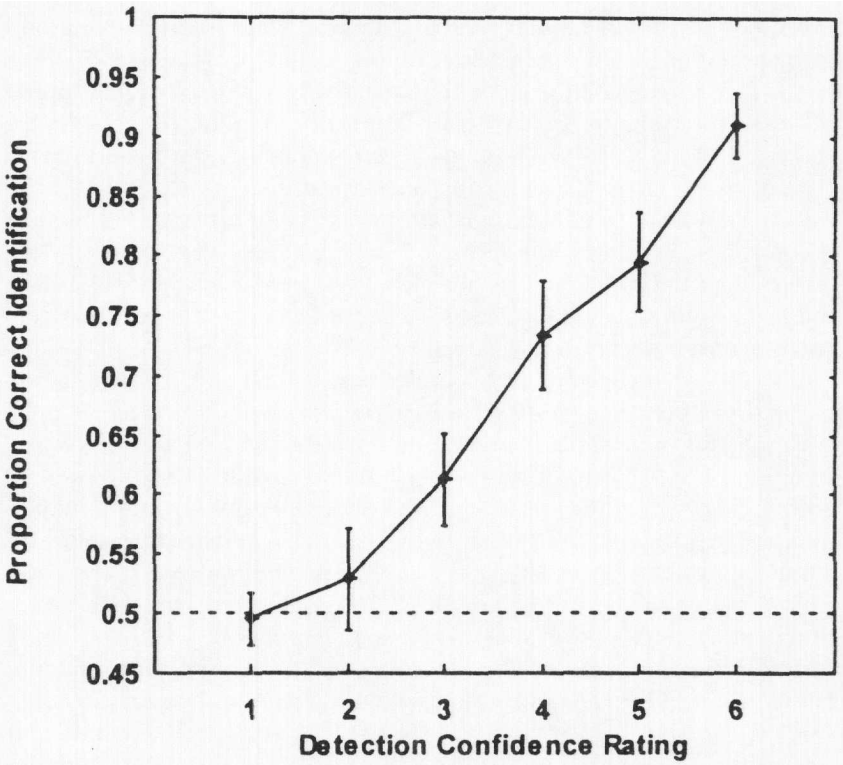

Figure 2. Proportion correct identification conditional on rating category, Experiment 1. Confidence ratings range from 1 (lowest confidence in word presentation) to 6 (highest confidence in word presentation). For ease of task performance 1 was defined as "guessing that no word was presented" and 6 was defined as "guessing that a word was presented." The values 2 and 3 were defined as indicating less confidence that no word was shown (compared to a 1). Likewise, the values 4 and 5 were defined as indicating less confidence that a word was shown (compared to a 6). Error bars represent the standard error of the mean.

is very close to the value plotted in Figure 2 above the 6 rating category. For the remaining ROC points, one would have to examine the noncumulative proportions at each of these criteria to obtain a measure of correct identification performance. Now consider the fourth ROC point, where the probability of using the rating on signal trials $P(R|S)$ = .746, and the probability of using the rating on noise trials $P(R|N)$ = .505. These are cumulative proportions. The noncumulative proportions

entering into this point correspond to the 3 rating category responses (which showed above-chance identification). Here, the proportion of word trials given this rating was .14. The proportion of word trials in which this rating was used and the word was correctly identified was .083. This translates into an identification performance of .593 and is similar to the average of participant average identification performance at the 3 rating of .613 (see Figure 2). Because the obtained values were close to the predicted values, the model predicts above-chance identification performance even when confidence in detection is low. Identification will not be above chance if detection performance is near chance (Green et al., 1977), which generally was shown by Haase and Fisk (1998). This interpretation and analysis is not consistent with the view (e.g., Marcel, 1983a) that one could obtain unconscious perception effects in the absence of stimulus detection, possibly at a d' near zero, which has been difficult to demonstrate empirically (see Holender, 1986, and accompanying peer commentary).

Intuitively, when participants respond with a high confidence level (e.g., 5 or 6), it is reasonable to assume that they could clearly see that a word was displayed and thus were highly successful at identifying which word it was. In this sense, it is perhaps unsurprising that detection and identification are highly related in a quantitative fashion. What is revealing, however, are the data for signal + noise trials when the participants have lower confidence that a word was shown. Theories of unconscious perception claim that when there is no subjective confidence that a word was shown, the participant may have unconsciously processed the word to a sufficient degree for correct identification at an above-chance level. This interpretation suggests that detection and identification may not be closely related under difficult viewing conditions. However, our results show that the pattern relating detection and identification is quantitative throughout the entire range of detection performance and there does not appear to be any clearly marked cutoff point where one could say unconscious perception is taking place. The best attempt one could make is to obtain significant above-chance identification performance when the participant had no confidence that a word was presented and no ability to discriminate it from noise trials, which again seems theoretically and empirically unlikely (Green et al., 1977; Haase & Fisk, 1998; Holender, 1986).

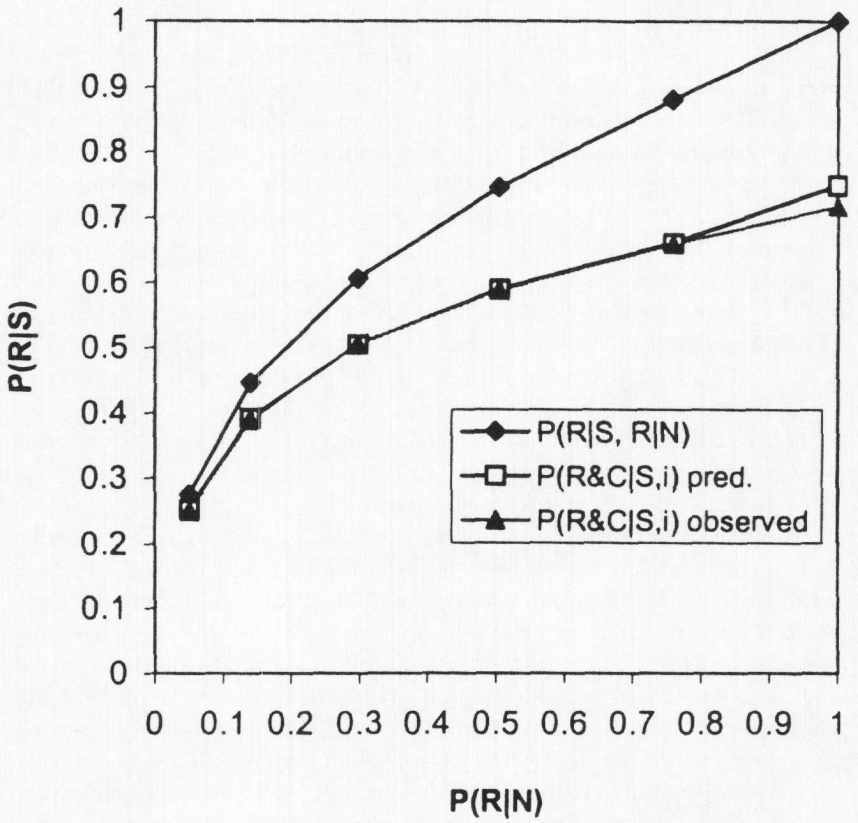

Figure 3. ROC/IOC, Experiment 1. The receiver operating characteristic (ROC) curve plots the hit rate as a function of the false alarm rate. For a rating scale detection task, the hit rate (plotted on the *y*-axis) is defined as $P(R/S)$, the probability of the rating category selected, given that a signal was presented. Likewise, $P(R/N)$ is the probability of the rating given noise. $P(R\&C/S)$ is the joint probability of the rating category and correctly identifying the signal given a signal trial. These values are also plotted on the *y*-axis, and the curve is named the identification operating characteristic (IOC) curve. The predicted values of the IOC generated from the detection ROC fall very close to the obtained identification proportions

EXPERIMENT 2

Despite the aforementioned reasons for arguing against an interpretation of unconscious perception, some investigators have recently chosen a different approach that involves predicting qualitative differenc-

es in task performance between consciously and unconsciously perceived stimuli. Some might argue that performance in the simple detection–identification task could be a combination of conscious and unconscious perceptual processes (Jacoby et al., 1993). In fact, Merikle and Reingold (1990) bolstered their argument for using the detection–identification paradigm as a tool in studying unconscious perception by providing converging evidence that showed qualitative differences in subsequent task performance after misses and hits. They showed that only familiar stimuli (words) could be identified at an above-chance level after misses as well as hits. Nonwords, on the other hand, could not be identified above chance after misses, even though they could be after hits.

Another such demonstration of qualitative differences is Merikle, Joordens, and Stoltz's (1995) study. They suggested that when a stimulus is consciously perceived, the participant can use that information intentionally to exclude its influence on a subsequent task. On the other hand, stimulus information influences performance on a subsequent task regardless of one's intentions when the stimulus is unconsciously perceived. Thus, "successful exclusion reflects greater conscious than unconscious influences and failures to exclude reflect greater unconscious than conscious influences" (Merikle et al., 1995, p. 423). We decided to incorporate such an exclusion task in the detection–identification paradigm. The task was identical to Experiment 1, except that we asked the participants to identify the word that was *not* presented. If uncertain detection is the result of unconscious processes, then participants should be more likely to choose the word that was presented to them and be incapable of excluding its influence. Thus, one might argue that participants could perform the exclusion task successfully only when they have high confidence that a word was shown. If conscious perception fails (and unconscious perception is spared) at the lower confidence ratings on signal + noise trials, participants should perform significantly below chance on the exclusion task because they will be unconsciously influenced by the presented word despite task instructions to exclude it. Thus, one might argue that this task can provide insight into whether stimulus detection is based more on conscious or unconscious processes.

METHOD

The method for Experiment 2 was nearly identical to that of Experiment 1. The same word pairs, distractors, nonword masks, and timing durations were used. The only change was in the task instructions for the participants, who were instructed to identify the word that was *not* presented, hence the exclusion task.

The detection task was identical (e.g., "rate your confidence from 1 to 6 that a word was presented") to Experiment 1. We predicted that the exclusion task would be harder for participants to perform because the task was somewhat confusing (i.e., determine whether you detected a word, then choose the word that you do not think was shown). In addition, we were concerned that participants might occasionally lapse in their attention to the task and choose the word that they saw by mistake, which would decrease the participants' ability to exclude (Visser & Merikle, 1999). However, as will be apparent shortly, participants were very capable at performing this task. A few subtle response differences emerged; one was that 52.4% of the observers used four or fewer detection rating categories, which was higher than Experiment 1 (37.5%). Other subtle differences are reported in the Results section.

Participants

Twenty-one students (15 women, 6 men; median age = 20 years) from introductory psychology or human growth and development courses at Gordon College participated in Experiment 2. None of these students participated in Experiment 1.

RESULTS AND DISCUSSION

As in Experiment 1, participants could discriminate between word and nonword trials. The estimate of detection performance was $d_a = .976$ (slope = .782), and the estimate of criterion placement was $c_2 = -.017$. Figure 4 plots the mean identification performance as a function of detection rating category. In this experiment, both below and above-chance identification performance have relevance for experimental hypotheses, so the following tests were two tailed. As in Experiment 1, identification performance (i.e., exclusion success) was not reliably different from chance for low confidence ratings at the 1, $M = .522$, $t(9) = .50$, $SE = .044$, and 2, $M = .504$, $t(10) = .12$, $SE = .033$, rating levels. However, as in Experiment 1, identification performance for the 3 rating, $M = .588$, was reliably above chance, $t(15) = 2.75$, $SE = .032$. It should be noted that more participants contributed data for the 3 rating than for the 1 or 2 ratings, as was the case in Experiment 1.

To examine the accuracy of the 3 confidence rating on the ROC–IOC curve, we look at the noncumulative proportions corresponding to the fourth ROC point in Figure 5, $P(R|S) = .815$; $P(R|N) = .512$. The proportion of word trials that participants rated 3 was .099, and the joint proportion of word trials and correct identification for this rating was .057. This translates to a proportion correct identification of .576, which is consistent with the .588 average of participant averages presented earlier and shown in Figure 4.

We also collapsed the identification data across the 1–3 ratings to get

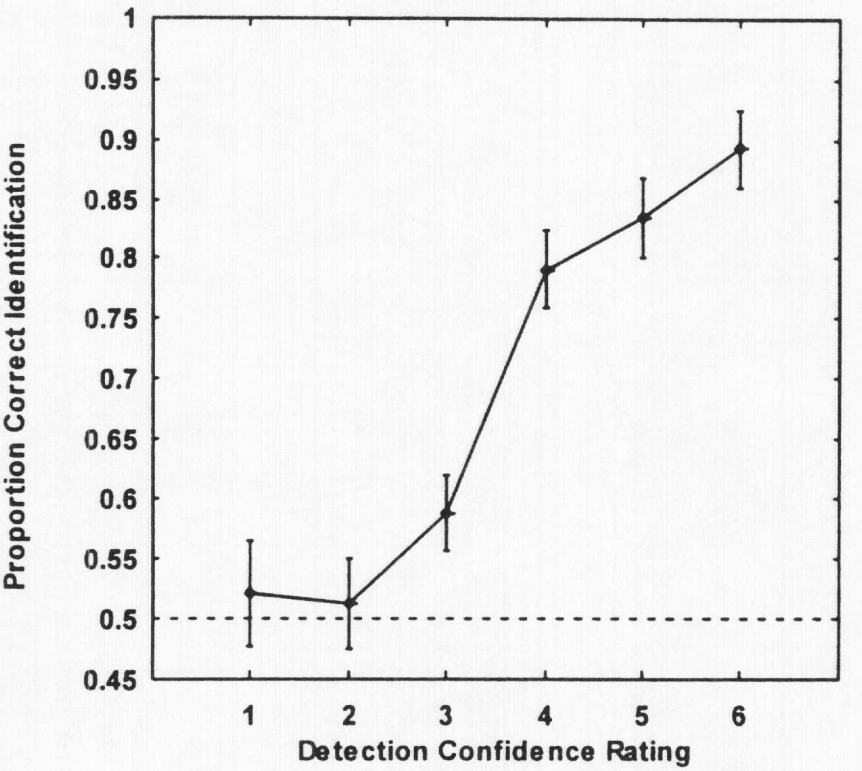

Figure 4. Detection conditional on rating category, Experiment 2 (exclusion task). The *y*-axis plots the probability of correctly excluding (on the identification task) the displayed word (on the detection task)

an estimate of results had this been a yes–no detection task. As in Experiment 1, identification performance, $M = .560$, was significantly above chance when the low confidence rating categories of 1–3 are combined, $t(20) = 2.61$, $SE = .023$. In sum, participants could still successfully perform the exclusion task on signal + noise trials even when they had low confidence (e.g., 3 rating) that a word was presented. At the lowest confidence ratings (e.g., 1 and 2), participants could not exclude, but identification did not appear to be influenced by the stimuli either, with stimulus identification falling to random levels. The pattern of results was very similar to those of Experiment 1, and Figure 5 shows, again, that identification performance can be predicted accurately from the detection ROC curve. The largest discrepancy is at the last point in the upper right-hand corner (as was the case in Figure 3).

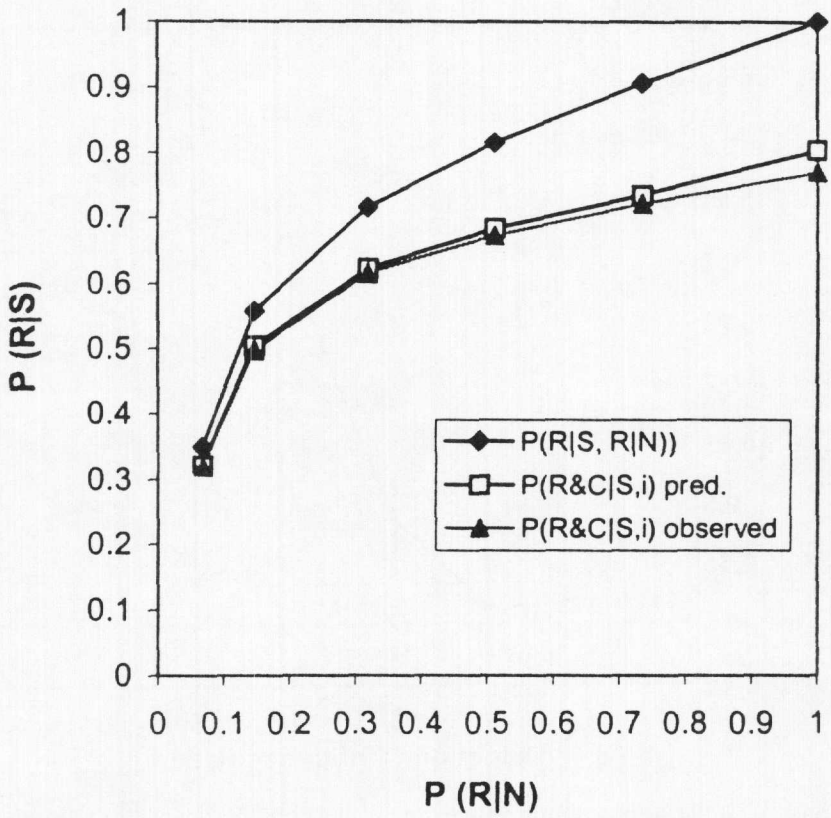

Figure 5. ROC/IOC, Experiment 2 (exclusion task)

Another way to estimate this value is to report an estimate of area under the ROC based on the sensitivity parameter d_a. This value, A_z, is .76, which falls very close to the actual value of .77 obtained in the experiment.

According to the exclusion task hypothesis, if unconscious perception is occurring at the lower confidence detection ratings (i.e., target stimuli that are not detected very accurately), participants should produce below-chance identification because of an inability to exclude the targets during identification. The reason this is assumed to occur is that if participants are having difficulty consciously detecting stimuli, then they should have difficulty consciously excluding their presumed influence. However, the results indicate that participant identification performance does not fall below .50 for any of the detection confidence ratings (Figure 4) and thus do not provide qualitative support for the ex-

clusion task hypothesis. Furthermore, post hoc inspection of the data showed that out of 21 participants across the three lowest confidence rating categories, only 19% of the data categories resulted in exclusion performance at or below .45 correct (based on a minimum of five observations), compared with 23% when a similar analysis is performed on Experiment 1 data. This demonstrates that there was no greater likelihood of below-chance performance in Experiment 2, even though this difference is predicted by the exclusion task hypothesis.

Two subtle aspects of the data from this experiment are worthy of further examination. First, Figure 4 shows some deviation from the more linear pattern found in Figure 2. This apparent difference is marginally significant at best, given the following analysis. Participants' identification proportions from the 4 rating and 3 rating were subtracted from each other. The resulting difference scores were compared across Experiments 1 and 2. Although the average difference between the 3 and 4 ratings was greater in Experiment 2, $M = .198$, $SE = .035$, $n = 16$, compared with Experiment 1, $M = .109$, $SE = .049$, $n = 12$, it was not significant, $t(26) = 1.52$, $p = .07$, even with a powerful one-tailed test. Second, the individual participant fits of the model (Table 2) were not as accurate as predicted (and less accurate than in Experiment 1), even though the overall results in Figure 5 show a very comparable fit to Figure 3 and a better overall fit than in Haase et. al (1999). Table 2 contains selected participants from both experiments who used the detection ratings with sufficient frequency. Some participants used only four of the six ratings, which makes generating the predicted values from the ROC less precise.

Unconscious perception proponents might suggest that the reason the predicted identification values were generally higher than the observed identification values was that at least some of the time, participants were unable to exclude the influence of the presented word. For example, Participant 11 was accurate at excluding the displayed word for the 6 ratings (93% correct, based on 41 trials) but was less able to do so at the 1 rating (43% correct, based on 21 trials). So, at least for some participants, perhaps the task of excluding became too difficult when perception was uncertain, or, one might argue, they were slightly influenced by the words unconsciously because their exclusion performance was below chance. Others (e.g., Holender, 1986) might argue that the percept on the 1 trial ratings was more fleeting and thus more easily forgotten, which might have passively but not unconsciously influenced the participant's identification choice, especially given the high level of response conflict in the exclusion task.

Future research may be necessary to disentangle these disparate interpretations, especially whether one is aware of things that influence

Table 2. Individual sensitivity (d_a), bias (c_2), proportion correct identification ($p(c)$), and observer difference scores for selected observers between predicted and observed identification proportions at detection criterion

Participant	d_a	c_2	$p(c)$	Criterion 5	4	3	2	1	Overall
Experiment 1									
1	0.709	.121	.699	−.003	−.006	−.012	−.002	−.013	.002
4	0.830	.090	.788	−.006	−.025	−.019	−.019	−.035	−.002
5	0.833	.235	.786	.017	.011	.008	−.005	−.048	−.014
6	1.028	−.245	.778	−.005	−.032	.019	.015	.012	.014
11	0.016	.467	.532	−.019	−.024	−.012	−.029	−.024	.027
15	0.469	.499	.624	.004	.004	.009	.006	.023	.075
Experiment 2									
4	1.156	.039	.781	−.005	.003	−.001	.002	.020	.057
8	0.565	−.190	.647	.012	.014	.004	.022	.021	.062
11	1.079	.359	.703	.015	.017	.022	.049	.083	.126
12	2.095	−.057	.872	.024	.029	.042	.070	.070	.075
15	1.267	−.162	.826	−.001	.014	.027	.019	.026	.035
18	0.231	−.318	.546	−.003	−.020	.005	.021	.029	.042
19	0.147	.557	.541	.022	.026	.037	.019	.000	.072
20	1.223	−.009	.843	.002	.016	.013	−.012	−.026	.008

Note. The difference score at the far right represents the difference score for overall identification (upper right IOC point).

behavior outside of conscious control. However, one must consider that most observers were able to exclude the displayed word consistent with their level of detection performance. In addition, some participants (e.g., Participants 15 and 20) did show better correspondence between predicted and observed values. Participant 15 was very accurate in identification at the 6 rating (96%, 51 trials) but was not very accurate at exclusion and did not show evidence of being influenced by the presented word on the lower ratings (2 rating, 60%, 10 trials; 1 rating 50%, 6 trials). Another possibility is that participants who had more difficulty detecting words would be more likely to have problems excluding the presented words on the identification task and might show below-chance performance. Six of the 21 participants had generally poor detection performance, $d_a = 0.220$, $c_2 = -.203$. Again, below-chance performance would indicate an influence of the stimulus to be excluded, and, with the exception of the 3 rating, these participants did not show such an effect (6 = 65.3% correct, 5 = 64.7%, 4 = 62.0%, 3 = 44.3%, 2 = 56.2%, 1 = 59.8%). These are rough estimates in that some participants' means only had five observations contributing to the percentage-correct value. When the low confidence ratings were collapsed for these partici-

pants, the mean exclusion performance (.515) does not appear to be different from chance performance, $SE = .02$. In sum, there seems to be very little evidence to support unconscious perception in the present experiment, even when the unconscious perception hypothesis is given the benefit of the doubt.

It is important to consider why these results differed from Merikle et al.'s (1995) findings, which showed that participants were influenced by stimuli that they were instructed to exclude. In their task, participants were presented target words between two 500-ms duration pronounceable nonword strings, with the target words being presented at six stimulus durations (0, 29, 43, 57, 71, or 214 ms). Exclusion performance was assessed by a stem completion task in which the first three letters of the target word were presented and the participant was instructed to form an English word other than the one he or she had been previously presented by typing in one to five letters. Participants were able to successfully exclude the previously shown target word only when the target word stimulus duration was 214 ms. On the 43- and 57-ms trials, participants were more likely to complete the word stem with the target (displayed) word compared to baseline (i.e., proportion of trials that participants completed the stem with the target word at the 0-ms duration control condition). Performance was not different from baseline on the 29- and 71-ms target word duration trials. One possible explanation for the difference in results between this study and the present experiments is that the tasks were somewhat different (e.g., forced-choice identification vs. stem completion). A second explanation is that a lapse in attentiveness might cause the participant to inadvertently complete the stem with the target word instead of excluding it. A few such errors might inflate the proportion of target words used to complete the stem, especially because the task was one of production rather than forced choice. A similar effect could have occurred to some small degree in our forced-choice experiment. In our task, participants were given the word options on both the detection and identification task, which would reduce this possibility.

The results from our exclusion task mirror Visser and Merikle's (1999) study, in which they offered participants a motivational incentive (increased pay with increased exclusion performance) in one condition of their experiment. At the brief stimulus duration of 50 ms, participants given a motivational incentive showed no greater likelihood of completing a word stem with the displayed word (compared to baseline) that they were instructed to exclude. In the no-incentive condition, participants were less able to exclude the influence of the displayed word on the exclusion task (similar to the results of Merikle et al., 1995).

GENERAL DISCUSSION

These experiments add to a growing body of evidence suggesting that correct identification after uncertain detection (low confidence or missed signals in a yes–no task) is not necessarily an indication of unconscious perception. Furthermore, the results from our exclusion task cast doubt on the hypothesis that words detected with low confidence were unconsciously perceived because participants could intentionally use this information to make the correct exclusion responses, albeit at a less accurate rate. This also suggests that there are situations in which qualitative differences (on a subsequent task) between low detection performance and high detection performance may not always be reliably obtained, as many researchers have argued (Merikle & Reingold, 1990; Merikle et al. 1995; Marcel, 1980). Our data suggest that stimulus detection and identification are quantitatively related throughout the tested range of responses, which is consistent with previous studies using signal detection methods (Benzschawel & Cohn, 1985; Green et al., 1977). Thus, there is no clear indication of a cutoff point or transition between conscious and unconscious perception. In other words, the independent observation model we use to predict identification performance from detection performance does not require a distinction between conscious and unconscious processing to explain the data. Our results are also consistent with the view that stimuli that are difficult to detect are not likely to have a strong influence on behavior (Moore, 1982; Synodinos, 1988).

The present paradigm could be extended to additional stimulus configurations. One manipulation previously used in signal detection experiments is to violate the orthogonality (independence) of target stimuli, which results in the observed values for identification falling well below the predicted values (see Green et al., 1977). What might be interesting in this context is a manipulation of the visual (orthographic) similarity between the alternatives in the identification task. Presumably, this would make the task harder in that detection performance might be fairly good; however, determining which word was presented might be more difficult (e.g., identification of *house* vs. *horse*). This manipulation would also be interesting because it might address the question of what is actually perceived in the detection task under difficult viewing conditions. Even if one is able to perceive only part of a word, there might be enough information to identify the correct word from the distractor alternative. Specifically manipulating orthographic similarity could objectively tease out this process. Also, Merikle and Reingold (1990) proposed that when participants correctly identified words that were not detected, this indicated unconscious activation of word nodes

in memory. This process, if carried out by unconscious perceptual processes, might be less affected by orthographic similarity if nodes at the word level are distinct.

There are other possible conditions in which there would be less of a relationship between detection and identification. For example, Haase (1994, Experiment 3b) reported an experiment similar to our Experiment 1, in which participants detected and identified words. The stimulus parameters were somewhat different in that on nonword trials (noise trials), there was a blank field before the backward mask. Word trials (signal + noise trials) contained a word in this first display field. Participants were quite good at discriminating word from nonword trials (approximate $d' = 1.7$) at a stimulus duration of 50 ms. However, identification performance was quite poor, not exceeding chance on the first three detection ratings and averaging only about .60 on the highest three detection ratings. With such high performance in stimulus detection, identification performance was predicted to be much better. However, it is possible that participants were basing their detection decisions on low-level stimulus information (such as absence of a blank field or a change in luminance across word vs. nonword trials). This information probably would be insufficient for high-level word identification, especially because the identification choices were not provided during the detection portion of the trial.

The masking also might have produced temporal integration of mask and target (Turvey, 1973), which would also make identification more difficult. This could be especially likely when the stimuli are of high spatial frequency (such as small, thin characters displayed on a computer screen). For example, Theios and Amrhein (1989) showed that lower spatial frequency patterns are easier to identify than higher spatial frequency patterns during masked, tachistoscopic presentations. Similar effects can be found in "low-level" vision. Watson, Thompson, Murphey, and Nachmias (1980) observed that at detection threshold, high spatial frequency gratings did not provide enough information to identify direction of motion. However, for gratings low in spatial frequency, the direction in which the stimulus was moving (identification) was reported as accurately as it was detected. Merikle and Reingold (1990) presented stimuli in a way that would minimize peripheral, temporal integration at the retina (target to one eye, masks to the other eye). In the experiments reported here, we minimized these problems by not having a blank field on noise trials and perhaps also by providing the identification choices on the detection portion of the trial. In a sense, the detection task was not the traditional detection of stimulus presence versus stimulus absence but rather detection of stimulus information present in the word choices relative to the nonword ("noise") stimuli.

At least in this restricted situation, word detection and subsequent identification are highly related, even at low levels of detection confidence (and performance).

Another example where the relationship between stimulus detection and stimulus identification might fail is in people with damage to striate cortex. Azzopardi and Cowey (1998), using a similar detection identification paradigm, showed that people with damage to striate cortex showed much better two-alternative forced-choice performance than their detection performance would have predicted. In contrast, normal participants' performance showed a strong connection between detection and recognition. This particular study is important in that the researchers ruled out earlier, critical interpretations of blindsight that suggested that the observed dissociation between detection and identification could be explained by conservative criterion placement. It is likely that at least some demonstrations of blindsight resulting from brain damage are different from the types of dissociations found in normal observers when tested at threshold. Azzopardi and Cowey also provided evidence that the blindsight dissociation occurred only for static and not for moving targets.

Future experimentation on the relationship between detection and identification might address recent claims of unconscious perception effects at detection $d' = 0$. For example, Snodgrass, Shevrin, and Kopka (1993) found that identification performance differed from chance under particular instructions and task preferences even when overall identification d' was not different from zero. This finding was replicated by Van Selst and Merikle (1993). Similarly, Greenwald and his colleagues (Draine & Greenwald, 1998; Klinger & Greenwald, 1995) showed unconscious processing effects (semantic priming, association judgments) at near zero values of d'. What must be resolved is whether our results would obtain when both the detection task and identification and priming task are measured concurrently instead of in separate tasks and to what extent, if any, detection performance would relate to subsequent task performance. It is often the case that in separate tasks, identification is better than would be predicted from detection (see Gescheider, 1997, p. 147; Macmillan & Creelman, 1991, p. 134), which could account for unconscious perception effects and stimulus effects when separate yes–no detection produces null sensitivity.

Another avenue for research in unconscious perception would be to use the present paradigm while manipulating the participant's attention. Some researchers have speculated that unconscious perception effects should be obtained outside the focus of attention to the same degree that they occur during focused attention (e.g., Marcel, 1983b; but see Greenwald, 1992; Haase, 1994; Kahneman & Treisman, 1984, for chal-

lenges and questions of this assumption). Although the method did not permit separate bias estimates or guarantee absence of eye movements to "unattended" locations, Haase (1994, Experiment 4) showed that stimuli presented at unattended locations resulted in a drop in both detection and identification performance and that the relationship between detection and identification was, again, quantitative.

The results from numerous signal detection experiments show that participants' perceptual states and responses change lawfully as stimulus parameters vary if they are given reasonable training on their task (Link, 1992; Green & Swets, 1966; Macmillan & Creelman, 1991). In fact, the application of signal detection methods has demonstrated greater sensitivity of perceptual systems than was previously acknowledged (Snodgrass, Levy-Berger, & Haydon, 1985). Perhaps this suggests that there may be not be much to gain in assuming unconscious (cognitive) perceptual analysis between physiological processes and the resulting symbolic outputs (or behaviors) resulting from those processes. This would be consistent with the view (Dulany, 1991, 1997; Searle, 1992) that symbolic representations are not likely to be unconscious. In fact, a rather bold hypothesis follows from this work: If even under very brief, masked stimulus presentations, evidence of unconscious processing cannot be convincingly demonstrated, then, by default, the scope of conscious awareness may be more broad than is currently recognized in contemporary cognitive theory. Granted, SDT does not need to distinguish between conscious and unconscious perception in explaining data. So perhaps cognitive theories should take one of two approaches to consciousness: Avoid any reference to whether processes are conscious or unconscious (Lupker, 1986) or more thoroughly measure awareness and its relationship to performance before claiming that cognitive contents are unconscious.

Notes

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