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Distinguishing Conscious from Unconscious Perceptual Processes*

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ABSTRACT A widely accepted assumption is that the boundary between conscious and unconscious perceptual processes is most appropriately defined in terms of a threshold for discriminative responding. Although many studies have been based on this assumption, no generally accepted conclusions have emerged concerning whether or not unconsciously perceived visual stimuli lead to semantic analysis. In the present studies, the boundary between conscious and unconscious perceptual processes was equated with a subjectively-defined threshold based on claimed awareness rather than an objective threshold based on discriminative responding. The results of two experiments involving a Stroop-priming task indicated that masked colour words presented above and below a subjective threshold were effective primes for the subsequent naming of colour patches. More importantly, the results also indicated that primes presented above and below a subjective threshold had qualitatively different effects; variations in the proportion of trials on which primes and targets were congruent led to the adoption of a predictive strategy when the primes were presented above the subjective threshold, but no evidence for the adoption of a predictive strategy was found when the primes were presented below the subjective threshold. It is concluded that a subjectively-defined awareness threshold captures the phenomenological distinction between conscious and unconscious experiences and provides a basis for establishing the qualitative differences that distinguish conscious from unconscious perceptual processes.

RÉSUMÉ On suppose généralement que la frontière entre les processus perceptifs conscients et inconscients se définit au plus juste en termes de seuil pour répondre de façon discriminative. Bien que plusieurs études se fondent sur cette prémisse, aucun conclusion générale ne permet de savoir si des stimuli visuels perçus de façon inconsciente mènent ou non à l'analyse sémantique. Dans nos études, la frontière entre les processus perceptifs conscients et inconscients est définie par un seuil subjectif de prise de conscience tel que le rapporte l'individu plutôt que par un seuil objectif déterminé par un mode de réponse discriminatif. Les résultats de deux expériences avec une tâche d'amorce de type Stroop indiquent que les mots masqués de couleur présentés au delà en en deçà du seuil subjectif permettent d'amorcer l'identification verbale ultérieure de taches de couleur. De plus, les résultats montrent que les amorces présentées de part et d'autre du seuil subjectif ont des effets qualitatifs différents; des variations dans la proportion d'essais où amorces et cibles sont congruentes mènent à l'adoption d'une stratégie de prédiction quand les amorces sont présentées au delà du seuil subjectif, mais pas quand elles sont présentées sous le seuil subjectif. Nous concluons qu'un seuil subjectif fondé sur la prise de conscience rend compte de la distinction phénoménologique entre les expériences conscientes et inconscientes; il permet également de rendre compte des différences qualitatives entre les processus perceptifs conscients et inconscients.

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The relationship between perceptual processing and awareness has been the subject of considerable debate for over 30 years. Over this period of time, a pivotal question has concerned whether or not the meaning of visual stimuli is perceived in the absence of awareness or, in other words, in the absence of conscious perceptual processing. Unfortunately, in spite of an extensive number of investigations directed at answering this question (see Dixon, 1971, 1981; Holender, 1986, for reviews), there is still no general agreement concerning whether conscious perceptual processing is necessary for the perception of meaning.

The present studies reflect our attempt to resolve some of the issues that have continually plagued research investigating the relationship between perceptual processing and awareness. Our proposed resolution is based on a distinction between subjective and objective recognition thresholds (Cheesman & Merikle, 1984), and it follows from our previous suggestion that the boundary between conscious and unconscious perceptual processes should be defined in terms of subjective rather than objective thresholds (Cheesman & Merikle, 1985; Merikle & Cheesman, 1986). A *subjective threshold* is the level of discriminative responding at which observers claim not to be able to detect or recognize perceptual information at a better than chance level of performance, whereas an *objective threshold* is the level of discriminative responding corresponding to chance level performance. Given that perceptual awareness or consciousness is a subjective state, we propose that the subjective threshold, or the threshold for *claimed* awareness, better captures the phenomenological distinction between conscious and unconscious perceptual experiences and that the subjective threshold, therefore, provides a better definition of the boundary between conscious and unconscious processes than is provided by the objective threshold.

In many of the recent studies directed at distinguishing conscious from unconscious perceptual processes, the masked-prime paradigm, originally reported by Marcel (1974, 1983a), has been used, and the boundary between conscious and unconscious processes has been defined in terms of an objective threshold for forced-choice recognition or detection (Balota, 1983; Cheesman & Merikle, 1984; Fowler, Wolford, Slade, & Tassinary, 1981; Marcel, 1980, 1983a; McCauley, Parmelee, Sperber, & Carr, 1980; Purcell, Stewart, & Stanovich, 1983). In this type of study, the presentation of a target stimulus is preceded by the presentation of a priming stimulus which is either clearly visible or centrally masked so as to preclude it from awareness, as indicated by chance level performance on a forced-choice recognition or detection task. By defining the boundary between conscious and unconscious processes in terms of an objective threshold, conscious perceptual processing in these studies was equated with an ability to make discriminative responses, and, conversely, unconscious perceptual processing was equated with an inability to make such responses. Although this approach for distinguishing conscious from unconscious perceptual processes has considerable theoretical and empirical appeal (cf. Eriksen, 1960), the recent masked-prime studies in which this approach has been adopted have provided discrepant empirical findings.

In general, two different patterns of results have emerged from these studies involving masked priming stimuli. The results from one group of studies suggest that the meaning of primes is perceived even when it is impossible to decide if these stimuli have been presented (Balota, 1983; Fowler et al., 1981; Marcel, 1980, 1983a; McCauley et al., 1980). This conclusion is based on observations indicating that masked primes, presented below an observer's objective threshold, nevertheless affect decision times to target stimuli. On the other hand, the results from other studies suggest that the meaning of primes is perceived only when they can be recognized or detected at a better than chance level of accuracy (Cheesman & Merikle, 1984; Purcell et al., 1983). These latter studies raise serious questions concerning whether it is possible to perceive the meaning of stimuli presented at or below an observer's objective threshold, and the results of these studies suggest that the masked-prime studies presumed to demonstrate unconscious perceptual processing may contain serious methodological flaws.

The proposed distinction between objective and subjective thresholds provides a possible basis for resolving this apparent discrepancy between the results obtained in these different masked-prime studies. If it is assumed that subjective rather than objective thresholds were inadvertently established in the masked-primed studies which appear to indicate that priming occurs in the absence of discriminative responding (Balota, 1983; Fowler et al., 1981; Marcel 1980, 1983a; McCauley et al., 1980), then the apparently contradictory patterns of results may not be contradictory at all. Our previous research indicates that somewhat higher stimulus energy levels are associated with subjective than with objective thresholds and that considerable perceptual processing, as indicated by discriminative reports, occurs when information is presented at energy levels between the ones defined by these two thresholds (Cheesman & Merikle, 1984). Furthermore, the methods used to establish objective thresholds in the masked-prime studies presumed to demonstrate unconscious perceptual processing are not capable of distinguishing between objective and subjective thresholds (cf. Merikle, 1982); thus, it is entirely possible that subjective rather than objective thresholds were established in these studies. If this did occur, then the apparently contradictory results found in different masked-prime studies may actually be consistent; all masked-prime studies may actually demonstrate that considerable perceptual processing occurs when observers *claim* that they are not aware of a stimulus or, in other words, when stimuli are presented below an observer's subjective threshold.

One implication of defining the boundary between conscious and unconscious perceptual processes in terms of an observer's subjective threshold is that discriminative responding, per se, may provide a completely adequate index of all perceptual processing, both conscious and unconscious. Given that the subjective threshold is associated with a higher stimulus energy level than the objective threshold, the transition from unconscious to conscious perceptual processing, as indicated by the subjective threshold, must necessarily occur at a stimulus energy level associated with above chance discriminative responding. According to the proposed view, stimuli presented above the subjective threshold are consciously processed, whereas stimuli presented at energy levels between the objective and subjective thresholds are unconsciously processed. On the other hand, when discriminative responding indicates a complete absence of perceptual processing, then it may be impossible to demonstrate either conscious or unconscious perceptual processes. This view of the relationship between discriminative responding and perceptual processing is entirely consistent with our previously reported findings indicating that priming and forced-choice recognition are equally sensitive measures of perceptual processing (Cheesman & Merikle, 1984). This view is also consistent with Eriksen's (1960) earlier conclusion that discriminative responding provides as sensitive an indicator of perceptual processing as any other response.

Unfortunately the empirical problem of distinguishing conscious from unconscious processes is not solved by simply changing the definition of awareness. Many criticisms can be directed at any approach that equates awareness solely with a subjective threshold. The most obvious criticism is that any measure of awareness based on subjective confidence alone allows each observer to establish his or her own criteria for awareness (cf. Merikle, 1983, 1984). Furthermore, as noted by Eriksen (1960), there can never be any empirical validation of the measure itself, since differences in subjective confidence cannot be distinguished empirically from response bias. Thus, if the awareness threshold is simply equated with the subjective threshold, disagreements concerning perception without awareness will never be resolved because of the impossibility of establishing the validity of the subjective threshold as an adequate measure of awareness.

Given these problems with defining awareness solely in terms of a subjective threshold, at least one additional criterion must be used to distinguish conscious from unconscious processes. Fortunately, the solution to this definitional problem has been expressed several times (Dixon, 1971, 1981; Shevrin & Dickman, 1980), although the proposed solution has had surprisingly little empirical impact. Simply stated, the additional criterion needed to distinguish conscious and unconscious perceptual processes is a demonstration that a particular independent variable has a qualitatively different effect when information is consciously perceived than when the same information is unconsciously perceived. The demonstration of qualitative differences provides much stronger support for the distinction between conscious and unconscious processes than is provided by an approach based solely on evidence indicating that perceptual information is processed both above and below a particular threshold. In fact, if qualitative differences cannot be established, then it is probably impossible to reach general agreement as to the most appropriate definition of awareness.

A major weakness in the approach exemplified by many of the recent studies presumed to provide evidence for unconscious perceptual processes is that the experimental data have consisted only of demonstrations indicating that priming is produced by stimuli presented above and below a particular awareness threshold (Balota, 1983; Fowler et al., 1981; Marcel, 1983a). Thus, the conclusiveness of the reported data depends entirely upon the adequacy with which the awareness thresholds in these studies were defined and measured, and it is the absence of any general consensus concerning the adequacy of the threshold measures used in these studies that has led to the disagreements concerning the importance of the reported findings for the perception-without-awareness hypothesis (Henley, 1984; Merikle, 1982, 1984; Purcell et al., 1983).

To overcome the problems associated with these recent approaches to the study of unconscious perceptual processes, the approach adopted in the present studies was based on first defining an awareness threshold in terms of an observer's subjective threshold and then attempting to establish that the same perceptual information presented above or below this threshold has qualitatively different behavioural effects. If it can be demonstrated that perceptual information presented below the subjective threshold has a qualitatively different effect than perceptual information presented above the subjective threshold, then strong support would be provided for the claim that the subjective threshold defines the transition between two different perceptual states which may be equated with conscious and unconscious perceptual processing.

The idea that qualitative differences in perceptual processing occur as a function of claimed awareness was tested in the present experiments by using a Stroop colour-word priming task in conjunction with a manipulation that varied the proportion of trials on which the colour-word prime reliably predicted the colour-patch target. In a Stroop task involving the presentation of congruent, control, and incongruent trials, the usual procedure is to administer a block of trials in which each type of trial occurs equally often (i.e., 33.3% of the trials). Under these conditions, both facilitation (control minus congruent trials) and inhibition (incongruent minus control trials) occur. However, it has been demonstrated that both facilitation and inhibition increase when the proportion of congruent trials is increased (Glaser & Glaser, 1982; Taylor, 1977). Thus, for example, if congruent word-colour combinations occur on 66.7% of the trials and control and incongruent trials each occur on 16.7% of the trials, both facilitation and inhibition are greater than is found when each trial type occurs equally often.

Probability effects, such as the one described above, have been investigated using a variety of tasks, and the results of these studies generally have been interpreted to indicate that observers adopt voluntary processing strategies which utilize the predictive information provided by the primes (Lowe & Mitterer, 1982; Neely, 1977; Posner & Snyder, 1975a, b; Taylor, 1977). According to this view, tne increased facilitation and inhibition that occurs on a Stroop task when congruent word-colour combinations are presented on a large proportion of the trials is due to the fact that observers become selectively biased towards the most probable response, based on the identity of the prime. This is a reasonable strategy for the task, given that it should facilitate performance on the large proportion of trials involving congruent colour-word combinations, and only disrupt performance on the small number of trials involving incongruent word-colour combinations.

The unique aspect of the present approach is the additional assumption that observers may be able to initiate a predictive strategy only when they are consciously aware of the identity of the primes. This assumption is consistent with views such as those expressed by both Posner and Snyder (1975a, b) and

Underwood (1982) who equate the attentional processes underlying strategy effects with consciousness. If this assumption is correct, then a predictive strategy should be adopted in the Stroop priming task only when observers are aware of the words used as primes. On the other hand, when observers claim to have no awareness of the words, then it should be impossible for them to initiate any strategy to predict a future event such as the presentation of a particular colour patch. A demonstration that predictive strategies are limited to situations in which observers are consciously aware of the primes, as defined by the subjective threshold, would indicate that conscious and unconscious processes are qualitatively different, and it is this type of finding that is needed to support a distinction between conscious and unconscious perceptual processes.

EXPERIMENT 1

The purpose of this experiment was to replicate previous findings indicating that changes in the proportion of congruent trials on a Stroop task influence the relative magnitudes of facilitation and inhibition. For this reason, all primes were clearly visible. In addition, there were two probability conditions. In one condition, congruent, control, and incongruent trials were presented equally often, so that the presentation of a colour word could not be used to predict whether the name of the subsequent target would be the same or different. In the other condition, congruent prime-target combinations occurred on 66.7% of the trials, whereas incongruent and control combinations each occurred on 16.7% of the trials. Thus, in this condition, presentation of each colour word predicted the name of the target on four out of every five trials. Based on previous research involving Stroop tasks (Glaser & Glaser, 1982; Taylor, 1977), the increase in congruent-trial probability from .333 to .667 was expected to decrease congruent-trial naming latency and to increase incongruent-trial naming latency, while leaving control-trial performance relatively unaffected.

Method

Subjects: Twenty volunteers recruited from the University of Waterloo received $5.00 for participating in a single session. All subjects had normal or corrected-to-normal visual acuity and claimed to have normal colour vision.

Apparatus and Materials: The stimulus materials were displayed on an Electrohome colour monitor that was interfaced to an Apple II Plus microcomputer via an Electrohome Supercolor board. The monitor was viewed through a hood that physically divided the screen into separate left-eye and right-eye fields; fusion of these fields was aided by viewing the display through a set of rotating prisms. The viewing distance was 65 cm and the luminance of each field measured 32 cd/m^2 when the light beige background colour (colour No. 91) was displayed.

A button box placed in front of the subject was used to initiate display presentations and to record responses on the detection trials. Colour naming latencies were measured by the microcomputer from colour onset to the activation of a voice key. Display timing and msec response accuracy were coordinated using a John Bell Engineering 6522-VIA interfaced to the microcomputer (see De Jong, 1982; Merikle, Cheesman, & Bray, 1982).

Each stimulus display consisted of five separate components: a white fixation rectangle, a colour word (BLUE, GREEN, RED, or YELLOW) or control prime (XXXXX), two pattern masks, and a rectangular colour-patch target (blue, green, red, or yellow). The fixation rectanglé was presented centrally and measured 2.2 cm (1.9°)[1] horizontal by 1.1 cm (1.0°) vertical. The primes could appear either above or below the fixation rectangle and were constructed from white uppercase letters using the standard 5 × 7 character font provided by the microcomputer. The dimensions of each letter were approximately 0.4 cm (0.4°) horizontal by 0.6 cm (0.5°) vertical, and the vertical distance from the centre of the fixation rectangle to the centre of the prime was 1.4 cm (1.2°). Each pattern mask was comprised of two rows of 14 white, uppercase letters presented in the same character font as the primes. The 28 characters were selected randomly with replacement from the following population: A, B, E, G, H, M, N, Q, R, S, and W. The masks formed separate rectangles measuring 6.6 cm (5.8°) horizontal by 1.3 cm (1.1°) vertical, and both masks were displayed on each trial in order to overlap spatially each possible prime location. The colour patches were centred within the fixation rectangle and measured 1.0 cm (0.9°) horizontal by 0.4 cm (0.4°) vertical.

Design: The overall experimental design was a 3 (prime-target relationship) by 2 (congruent-trial probability) within-subjects factorial. The three prime-target relationships were congruent, incongruent, and control. On congruent trials, the prime had the same name as the target, whereas on incongruent trials, the prime and target had different names. The primes on control trials simply consisted of the series of 5 Xs. In one probability condition, congruent, incongruent, and control trials were presented equally often, so that each prime-target relationship occurred on 33.3% of the trials. For the other probability condition, congruent trials were presented on 66.7% of the trials, while incongruent and control trials each occurred on 16.7% of the trials. Colour-naming performance for both probability conditions was evaluated during a single session, and the order in which these conditions were administered was counterbalanced across subjects.

For each probability condition, the stimulus displays were presented in blocks of 48 trials with each of the four targets appearing equally often. Within any trial block, prime-target pairs corresponding to each prime-target relationship were presented in the relative proportions prescribed by the particular probability condition. The congruent trials consisted of the eight unique combinations formed by pairing the four colour patches with the same colour-word prime presented either above or below the fixation rectangle. Similarly, eight different control trial combinations were formed using the control prime. Thus, regardless of the probability condition, complete sets of congruent and control prime-target combinations were administered within every trial block. Since the factorial combination of four targets, three primes, and prime presentation either above or below the fixation rectangle yielded 24 unique incongruent trial combinations, more than one trial block was required to display all the incongruent prime-target combinations. In this case, the incongruent items were sampled exhaustively across trial blocks before any prime-target combination was repeated.

The 48 trials assigned to each trial block were presented randomly with two constraints. First, targets of the same colour were never presented successively. Second, after any particular trial, the number of occurrences of the most frequently presented target never exceeded by more than two the number of occurrences of the least frequently presented target.

In order to ensure that the primes were clearly visible during the experimental trials, a series of detection trials involving lexical decisions was administered prior to the colour-naming trials. The stimuli for these trials consisted of the four primes (BLUE, GREEN, RED, and YELLOW) and four nonword variants of the primes (BUEL, GENER, ERD, and YOLLEW). Each nonword variant was selected to be maximally confusable with its corresponding colour word. The stimuli were presented in blocks of 48 trials consisting of three repetitions of the eight stimuli at the two spatial locations. Within each block, the 48 stimulus displays were presented randomly with the constraint that the same stimulus never appeared three times in succession.

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[1]The visual angle subtended by each stimulus dimension is provided within parentheses following each linear measurement.

Procedure: Each subject was tested individually during one 90-min session.

Detection Trials. Prior to the colour-naming trials, several blocks of detection trials involving word-nonword decisions were administered. The subjects were informed that on each trial a colour word or nonword variant would be presented either above or below the fixation rectangle and that they should accurately indicate whether a word or nonword had been presented by pressing the appropriate button. In order to equate the viewing conditions of the detection trials with those of the colour-naming trials, the subjects were also instructed to maintain fixation on the centrally presented rectangle at all times during each trial. In addition, the subjects were asked to provide an estimate of their detection performance after every block of 48 trials. They were told that performance would be 50% correct with complete guessing and that, therefore, their estimates should range between 50% and 100% correct.

At the beginning of each trial, the fixation rectangle was presented to both eyes and remained in view throughout the trial. The subjects fixated the centre of the rectangle and initiated a trial sequence by pressing the start button. After a delay of 250 msec, a colour word or nonword was presented to the left eye for 16.7 msec. Following a constant prime-mask stimulus onset asynchrony (SOA) of 250 msec, the pattern masks were presented to the right eye for 200 msec. After a response button was pressed, the screen went blank for approximately 500 msec before the fixation rectangle for the next trial was presented.

Upon completion of each block of 48 trials, the subjects' performance estimates were recorded, and the pattern masks were changed by selecting a new set of letters. In addition, if subjects indicated that their performance was errorless, they were asked if the stimuli were clearly visible. Additional trial blocks were administered until both the observed and estimated performances were 100% correct, and subjects claimed that all targets were clearly visible.

Colour-Naming Trials. The subjects were instructed to fixate the centre of the fixation rectangle continually during each trial and to name, as quickly as possible, the colour patch that appeared within the fixation rectangle. Before each probability condition was administered, the subjects were informed as to the relative proportions of each trial type, but they were cautioned to respond only to the colour patch and to avoid naming the word.

The sequence of events on each trial was similar to the event sequence on the detection trials. The subjects pressed the start button and, following a delay of 250 msec, a colour-word or control prime was presented to the left eye for 16.7 msec. The prime-mask SOA was equal to 250 msec, and both pattern masks were presented to the right eye for 200 msec. Prime presentation was also followed by the presentation of a colour-patch target after a 66.7 msec prime-target SOA. The target remained in view until the subject named the colour, at which point the entire screen went blank. There was a further delay of approximately 500 msec before the fixation rectangle for the next trial appeared.

For each probability condition, 4 blocks of 48 trials were administered. The first block of trials served as practice, and the remaining three blocks of trials provided the experimental observations. After every block of 48 trials the pattern masks were changed by selecting a new set of letters. Subjects were given a 3-min rest after each block of trials and approximately 10 min intervened between the two probability conditions.

Results

Mean naming latencies for correct trials and percentage errors are presented in Table 1 for each condition. The data in Table 1 are based on a maximum of 48 observations/subject/condition when congruent trial probability was .33, and maximums of 96, 24, and 24 observations/subject/condition for congruent, incongruent, and control trials, resectively, when congruent trial probability was .66.

The means in Table 1 indicate that as congruent trial probability increased from .33 to .66, naming latency for both control and incongruent trials increased while

TABLE 1
Mean Naming Latencies and Percentage Errors in Experiment 1

Prime-Target Relationship	Congruent Trial Probability .33 RT	.33 %E	.66 RT	.66 %E
Congruent	454	0.5	441	0.4
Control	494	2.0	500	2.3
Incongruent	576	13.1	602	19.0

congruent trial naming latency decreased. This pattern of results suggests that the increased probability of congruent trials promoted subjects to utilize the additional predictive information provided by the primes.

The naming latencies were evaluated by a 3 (prime-target relationship) by 2 (congruent-trial probability) analysis of variance. The analysis revealed a significant main effect for prime-target relationship, $F(2, 38) = 74.96, p < .001$, and a nonsignificant main effect for congruent trial probability, $F(1, 19) = 0.93$, $p > .20$. Of more importance, though, was the significant interaction between these factors, $F(2, 38) = 11.56, p < .001$, indicating that performance for the three prime-target relationships changed differentially as congruent trial probability increased from .33 to .66. Planned comparisons indicated that naming latency increased significantly for incongruent trials, $t(38) = 4.59, p < .01$,[2] showed a marginally significant decrease for congruent trials, $t(38) = 2.21$, $p < .10$, and did not change significantly for control trials, $t(38) = 1.07, p > .20$. Thus, the naming latency data confirm that an increase in congruent prime probability produces an advantage on congruent trials with a corresponding cost to performance on incongruent trials.

The error data summarized in Table 1 were also evaluated by a 3 $\times$ 2 analysis of variance. This analysis revealed significant main effects for prime-target relationship, $F(2, 38) = 51.56, p < .001$, and congruent trial probability, $F(1,19) = 6.87, p < .025$, as well as a significant interaction between these factors, $F(2, 38) = 6.18, p < .01$. Planned comparisons showed a significant increase in errors with increased congruent trial probability for incongruent trials, $t(38) = 4.39, p < .01$, but no significant differences for either congruent or control trials, both ts < 1. This pattern of results is consistent with the naming latency data in showing that the most robust effect of the probability manipulation involves the incongruent trials. Furthermore, the error data indicate that speed-accuracy trade-offs were not a factor in the experiment, as naming latency and error rates were positively correlated.

Discussion

The results of this experiment indicate that the probability effect reported by other investigators (Glaser & Glaser, 1982; Taylor, 1977) was successfully replicated.

[2]Each comparison was based upon the pooled error interaction term, and Type I error rates were corrected using the Bonferroni t procedure.

Increased congruent-trial probability produced a marginal decrease in naming latency on congruent trials and a considerable increase in naming latency on incongruent trials. This particular pattern of results indicates that the cost to processing on incongruent trials produced by the increase in congruent-trial probability outweighed the benefit which occurred on congruent trials (cf. Posner & Snyder, 1975b). Thus, in general, congruent-trial probability has its most pronounced effect on the naming of targets preceded by incongruent colour words.

The present results are consistent with an interpretation suggesting that the increase in congruent-trial probability led observers to use the identity of the primes to anticipate the presentation of particular targets. Although it is not possible to specify the exact process mediating the strategy induced by the increase in congruent-trial probability, given that the probability effect was replicated, it is possible to use this variant of a Stroop task to establish if induced strategy changes are limited to conditions in which observers are aware of the primes.

EXPERIMENT 2

The question of primary interest in this experiment concerned whether or not the strategy effects observed in Experiment 1 would occur when observers claimed to have no awareness of the primes. As discussed previously, it is reasonable to expect that observers can implement a strategy based upon the expectation of a future event only when they are aware of a prime. If this assumption is correct, then no evidence for strategy effects should be found when primes are presented below the awareness threshold. On the other hand, given that awareness was defined in terms of a subjective threshold, an overall Stroop effect should occur even when the primes are presented below this threshold. Thus, when primes are presented below the subjective threshold, priming should occur, but this priming should not vary with changes in the proportion of congruent trials, as occurs when primes are clearly visible.

Two major procedural changes distinguish this experiment from the previous one. First, prior to the priming trials, several blocks of detection trials were administered to establish each observer's subjective threshold. Subjective thresholds were defined in terms of the prime-mask SOA at which an observer consistently claimed to detect the primes at a chance level of accuracy. The second procedural change introduced in the present study was that subjective threshold and suprathreshold conditions were intermixed within each block of priming trials. By randomizing the presentation of the two threshold conditions within each trial block, it was possible to ensure that any observed strategy difference across the two threshold conditions was induced on a trial-by-trial basis and did not result from a general strategy applicable only to a particular threshold condition.

Method

Subjects: Each of 16 volunteers, ranging in age from 19 to 29, received $30 for participating in the study.

Apparatus and Materials: Both the apparatus and stimulus materials were identical to those used in Experiment 1.

Design: The overall design was a 3 (prime-target relationship) by 2 (congruent-trial probability) by 2 (threshold condition) factorial. The only change, relative to Experiment 1, was that performance was evaluated under two threshold conditions. These threshold conditions were designated as suprathreshold and subjective threshold. Under the suprathreshold condition, a constant prime-mask SOA of 250 msec was used, and this condition served as a replication of Experiment 1. Under the subjective threshold condition, the prime-mask SOA was equal to the longest word-mask SOA at which subjects consistently claimed that their word-nonword decision performance approximated a chance level of accuracy.

Colour-naming performance at each level of congruent-trial probability was assessed during a separate session, and the presentation order for these sessions was counterbalanced across subjects. Within each session, colour-naming trials for both threshold conditions were randomly intermixed. Initially, separate blocks of 48 trials were constructed for each threshold condition in exactly the same manner as Experiment 1. The trials within these blocks were then intermixed and presented randomly within a single 96-trial block using the same constraints employed in Experiment 1.

Procedure: Each subject participated in four 1-hour sessions. During the first two sessions, the word-mask SOAs reflecting subjective threshold were determined. The final two sessions involved the presentation of the colour-naming trials.

Detection Trials. The subjects were provided with the same detection trial instructions as in Experiment 1. In addition, after each trial block, subjects were also asked to indicate which colour words, if any, they felt were easily detected. This information was used to fine tune the adjustment of the prime-mask SOAs at the subjective threshold.

The sequence and timing of events for each trial was changed only slightly from the detection trials of the previous experiment. The colour word or nonword was presented to the left eye for 16.7 msec, and following the prime-mask SOA the pattern masks were presented to the right eye for 200 msec. In order to equate detection performance across the four primes so as to establish accurately the subjective threshold, the prime-mask SOA was varied independently for each word-nonword pair.

After every block of 48 trials, each pattern mask was changed, and subjects provided both their performance estimates and an indication of the stimuli they saw clearly. Feedback concerning detection performance was not provided.

In the first detection session, subjects were familiarized with the 250-msec suprathreshold prime-mask SOA, and rough estimates of the prime-mask SOAs necessary for the subjective threshold condition were established. Once subjects obtained 100% correct detections and indicated that the colour words were clearly visible at the 250-msec SOA, the prime-mask SOAs were reduced by 50 msec per trial block until detection performance fell below 100% correct. Thereafter, the prime-mask SOAs for individual word-nonword pairs were adjusted by either 16.7 or 33.3 msec depending upon the subjects' estimates of their performance and self-reports concerning the visibility of the words. As soon as subjects began to estimate consistently that detection performance was 50% correct, the prime-mask SOAs were noted and the session was terminated.

During the second session, the subjective threshold was carefully calibrated for each word-nonword pair. The prime-mask SOAs were adjusted until the objective detection accuracies for all words were relatively homogeneous (within 15%) and subjects consistently claimed that their performance was less than 55% correct. Individual prime-mask SOAs were adjusted by 16.7 msec after every block of trials until three consecutive blocks of trials requiring no adjustments were completed.

Colour-Naming Trials. Subjects were presented with the same instructions and information regarding congruent trial probability as in Experiment 1. In addition, subjects were told not to expect to see a prime on every trial.

On each trial, a colour-word or control prime was presented to the left eye for 16.7 msec and

TABLE 2
Mean Naming Latencies and Percentage Errors in Experiment 2

Prime Detectability	Prime-Target Relationship	Congruent Trial Probability .33 RT	.33 %E	.66 RT	.66 %E
Subjective Threshold	Congruent	446	2.1	439	1.7
	Control	464	2.1	470	3.4
	Incongruent	488	3.8	487	4.2
Suprathreshold	Congruent	424	0.8	412	0.4
	Control	465	1.1	469	2.1
	Incongruent	550	9.5	584	13.8

then masked via the right eye. The prime-mask SOA was equal to either the appropriate subjective threshold value or 250 msec for the suprathreshold condition. The prime-mask SOA for control trials presented under the subjective threshold condition was equal to an average of the four individual subjective threshold word-mask SOAs. Presentation of the prime was also followed by the presentation of a centrally located target at a prime-target SOA of 66.7 msec. The target remained in view until subjects named its hue.

Each congruent-trial probability condition was tested across 3 blocks of 96 experimental trials. Within each of these trial blocks, the subjective threshold and suprathreshold conditions were tested on an equal number of trials. The experimental trials were preceded by a block of 48 practice trials in which the prime-mask SOA was 250 msec. A 3-min rest was provided after completion of each block of trials.

Results

Detection Trials: For each subject, the percentage correct detection was calculated for each word-nonword pair at the prime-mask SOA established for the subjective threshold. Overall mean detection performance averaged across the four colour words was 64.8% correct (SD = 5.52), and the means for individual subjects ranged from 57.0% to 77.5% correct. The mean prime-mask SOA established for the subjective threshold was 34.8 msec, with a range of 16.7–83.3 msec.

Colour-Naming Trials: Table 2 presents the mean naming latency and the percentage errors for each condition. The naming latencies for the suprathreshold trials provide a precise replication of Experiment 1. As congruent trial probability increased from .33 to .66, naming latency increased substantially for incongruent trials, showed only a small increase for control trials, and decreased for congruent trials. Thus, the strategy effect was evident for the clearly visible primes in this experiment.

In contrast to the results for the suprathreshold condition, the subjective threshold data provide a rather different pattern of results. Although primes in the subjective threshold condition were clearly being perceived, as indicated by the substantial overall difference between incongruent and congruent trials, it appears that congruent-trial probability had virtually no influence on colour-naming performance. As indicated in Table 2, response latencies on incongruent, congruent, and control trials are very similar at both levels of congruent-trial probability. Thus, the variation in congruent trial probability appears to have no

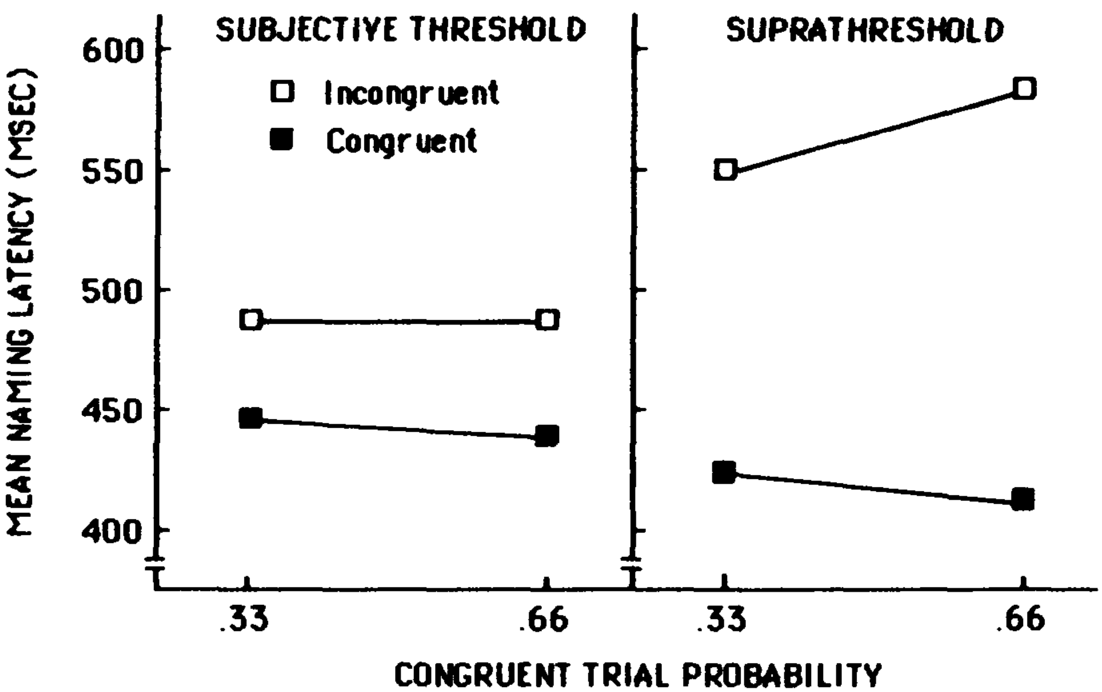

Figure 1. Mean naming latencies for congruent and incongruent trials as a function of congruent-trial probability under subjective and suprathreshold conditions in Experiment 2.

effect when observers claim no awareness for the primes.

The different patterns of results observed in each threshold condition were confirmed by an overall analysis of variance which revealed a three-way interaction involving prime-target relationship, congruent-trial probability, and threshold condition, $F(2, 30) = 8.01$, $p < .005$. In order to clarify this interaction, the data from each threshold condition were analyzed separately after the control trials had been excluded. This approach was adopted for three reasons. First, since the critical comparison for demonstrating an effect of congruent-trial probability involves only congruent and incongruent trials, the most sensitive analysis requires exclusion of the control trials. Second, separate analyses for each threshold condition were warranted since the variability in the data under the suprathreshold condition was considerably greater than under the subjective threshold condition. Finally, in the subjective threshold condition, the control trials may not have been completely comparable to the other two types of trials. Although separate prime-mask SOAs were determined for each word used on the congruent and incongruent trials, each observer's prime-mask SOA for the control stimulus was based on the average prime-mask SOA for the colour words. Thus, the neutral stimulus may have been more discriminable than the colour words.

The mean congruent and incongruent trial naming latencies for each threshold condition are presented in Figure 1. As found in Experiment 1, the analysis of variance on the data for the suprathreshold condition revealed a significant main effect for prime-target relationship, $F(1, 15) = 165.73, p < .001$, a nonsignificant main effect of congruent-trial probability, $F(1, 15) = 3.14$, $p < .10$, and a significant interaction between these variables, $F(1, 15) = 16.61, p < .001$. The interaction indicates that the difference between congruent and incongruent trials increased as congruent-trial probability increased from .33 to .66. In contrast to the results found for the suprathreshold condition, the analysis of the data for the subjective threshold condition revealed a significant main effect only for prime-target relationship, $F(1, 15) = 95.65, p < .001$, and neither the main effect for congruent trial probability, $F(1, 15) < 1$, nor the interaction between these variables, $F(1, 15) = 1.32$, were significant sources of variance. Thus, although Stroop priming occurred under both threshold conditions, the increase in congruent-trial probability influenced performance only when the primes were clearly visible in the suprathreshold condition.

A series of planned comparisons evaluating performance on congruent and incongruent trials as a function of congruent trial probability confirmed that different patterns of results occurred under the two threshold conditions. These comparisons indicated that, under the suprathreshold condition, the increase in congruent-trial probability decreased naming latencies on congruent trials, $t(15) = 2.51, p < .05$,[3] and increased naming latencies on incongruent trials, $t(15) = 3.08, p < .05$. However, under the subjective threshold condition, no change in naming latency occurred on either congruent trials, $t(15) = 1.20$, or incongruent trials, $t(15) < 1$, when congruent-trial probability was increased.

The error data were also analyzed separately for each threshold condition after excluding the control trials. Each analysis revealed a significant main effect for prime-target relationship, both Fs$(1, 15) > 7.83, p < .025$, and the main effect for congruent trial probability was significant under the suprathreshold condition, $F(1, 15) = 6.72, p < .025$, but nonsignificant under the subjective threshold condition, $F(1, 15) < 1$. In addition, the interaction between prime-target relationship and congruent-trial probability was significant for the suprathreshold condition, $F(1, 15) = 8.37, p < .025$, but failed to reach significance for the subjective threshold trials, $F(1, 15) < 1$. Thus, in general, the error data and the naming latency data are completely consistent.

Discussion

The different patterns of results obtained under the subjective threshold and suprathreshold conditions are consistent with the hypothesis that strategy effects occur only when observers are consciously aware of the primes. Despite the fact that the primes were perceived under both threshold conditions, as indicated by the presence of significant priming effects, the probability effect was observed only in the suprathreshold condition. Given that the observers could capitalize on the predictive relationship between primes and targets only when the primes were clearly visible, the data provide strong support for the assumption that the subjective threshold defines the transition between conscious and unconscious perceptual processing.

The qualitatively different effects found under the suprathreshold and

[3]Individual error terms were calculated for each comparison and Type I error rates were corrected using the Bonferroni t procedure.

subjective threshold conditions indicate that priming effects, per se, are mediated by a different set of perceptual processes than the probability effect induced by variations in congruent-trial probability. The presence of significant priming under both threshold conditions indicates that both conscious and unconscious processes contribute to the overall magnitude of Stroop priming. However, the absence of a probability effect under the subjective condition suggests that voluntary strategies are adopted only as a consequence of conscious perceptual processing. One possible reason for such processing differences has been proposed by Marcel (1983b) who argues that conscious and unconscious processes are based on qualitatively different representational codes. From this view, it follows that conscious processes should provide a unique contribution to the processing of stimuli, which unconscious processes, by themselves, do not provide. The absence of a probability effect when observers were unaware of the primes is totally consistent with this idea.

EXPERIMENT 3

The primary purpose of this experiment was to replicate the results obtained in the previous experiment under slightly different experimental conditions. Even though the previous results are entirely consistent with the view that the subjective threshold provides an appropriate definition of the boundary between conscious and unconscious perceptual processes, a replication of the basic findings under somewhat different conditions would provide additional empirical support for the proposed theoretical position.

Relative to Experiment 2, two major procedural changes were introduced in the present experiment. First, the detection trials used to establish subjective thresholds were based on a four-alternative, forced-choice recognition task involving the four colour words used in the subsequent priming task. The forced-choice recognition task provided a direct measure of each observer's ability to assign responses to colour words confidently. For this reason, it provided a better measure of each observer's subjective threshold than the lexical-decision task used in Experiment 2. The lexical-decision task did not necessarily ensure that the observers could not confidently discriminate among the four colour words, since it only required observers to discriminate the four colour words from the four colour-word variants.

The second major procedural change involved the introduction of a more extreme variation in congruent-trial probability. This change was implemented by eliminating the control trials and setting the probability of a congruent trial within a session at either .25 or .75. These two modifications ensured that each prime was followed by each target equally often when congruent-trial probability was set at .25. Thus, there was absolutely no predictive relationship between primes and targets in the .25 probability condition in the present experiment. In Experiment 2, on the other hand, the lower congruent-probability condition (i.e., .33) actually involved a small predictive relationship between primes and targets, as primes were presented only on two-thirds of the trials, and each prime was followed by a congruent colour target on one-half of these trials. The more extreme variation in congruent-trial probability studied in the present experiment allowed an assessment of the probability effect under conditions in which there was either no predictability or high predictability between primes and targets.

Method

Subjects: Sixteen volunteers, ranging in age from 18 to 31, received $30 for participating in four sessions.

Apparatus and Materials: The apparatus was the same as used in Experiments 1 and 2. However, the arrangement of the stimulus materials was changed in order to allow the primes to be presented and masked within the fixation area.

Each stimulus display consisted of five separate components: a white fixation rectangle, a forward pattern mask (QYGRUEWN), a colour-word prime (BLUE, GREEN, RED, or YELLOW), a backward pattern mask (RYBULOG), and a rectangular colour frame (blue, green, red, or yellow). The fixation rectangle measured 4.8 cm (4.2°) horizontal by 2.1 cm (1.9°) vertical, and the colour words were centred within this area. As in the previous experiments, the pattern masks and the primes were presented in white uppercase letters using the standard 5 × 7 character font provided by the microcomputer. The length of the forward and backward masks measured 3.8 cm (3.4°) and 3.4 cm (3.0°), respectively, and the length of the colour words ranged from 1.5 cm (1.3°) to 3.2 cm (2.8°). The colour frames completely enclosed the fixation rectangle. Each side of a colour frame was 0.3 cm (0.3°) wide, and the outer dimensions of the frames were 6.6 cm (5.8°) horizontal by 3.9 cm (3.4°) vertical.

Design: The experimental design was a 2 (prime-target relationship) by 2 (congruent-trial probability) by 2 (threshold condition) factorial. The two prime-target relationships were congruent and incongruent, the two threshold conditions were suprathreshold and subjective threshold, and the two levels of congruent-trial probability were either .25 or .75. As in the previous experiment, colour naming performance for each congruent trial probability condition was evaluated over separate sessions and counterbalanced across subjects. Within each session, displays corresponding to each prime-target relationship and threshold condition were randomly intermixed and administered in blocks of 32 trials.

For each trial block, the displays were equally divided between suprathreshold and subjective threshold presentation conditions, and each target appeared equally often within each threshold condition. When congruent-trial probability was .25, each threshold condition contained 4 congruent trials and 12 incongruent trials, so each unique congruent and incongruent prime-target combination was presented once. When congruent trial probability was .75, each threshold condition contained 12 congruent and 4 incongruent items. In this case, the 4 unique congruent trials were presented three times each, while 4 of the possible 12 unique incongruent prime-target combinations were selected. Thus, three blocks of trials were required before the entire set of incongruent combinations was exhaustively sampled for each threshold condition. Within each trial block, the 32 trials were presented randomly with the same constraints used in Experiments 1 and 2.

The stimuli used on the detection trials were the four colour words. They were presented in blocks of 24 trials consisting of six repetitions of each word. The 24 stimulus displays in each block were randomly presented with the constraint that the same word never appeared three times in succession.

Procedure: The subjects were tested individually over four 1-hour sessions. The prime-mask SOAs corresponding to the subjective threshold for each word were established during the first 2 sessions, and colour naming performance was evaluated across the final 2 sessions.

Detection Trials. The subjects were informed that one of four colour words would be presented within the fixation rectangle and that responses should be indicated by pressing the button corresponding to the colour word. The subjects were also told that each colour word would appear equally often and therefore their guesses should be distributed across the four possible responses. In addition, the subjects were informed that after every block of 24 trials they would be required to indicate the total number of detection responses they were confident were correct. Since subjects could keep a running total of their confident detection decisions in every block, they found this procedure much easier than estimating overall performance, as subjects were required to do in Experiment 2. Finally, the subjects were asked to report after every trial block which colour words were clearly visible.

On each trial, the fixation rectangle was presented to both eyes and remained in view throughout the trial. After the start button had been depressed, there was a 250-msec delay before the forward mask was presented to the right eye for 50 msec. Following a delay of 50 msec after the offset of the forward mask, a word was presented to the left eye for 16.7 msec. The backward mask was subsequently presented to the right eye for 50 msec at the predetermined prime-mask SOA. Once a detection response was made, the screen went blank for approximately 500 msec before the fixation rectangles for the next trial reappeared.

Subjective thresholds were established by basically the same procedures followed in Experiment 2. During the first session, the prime-mask SOA for each word was systematically decreased until subjects consistently indicated over 3 consecutive blocks of 24 trials that less than 3 of the 24 detection decisions were made with confidence. During the second session, the objective detection levels for each word were matched as closely as possible by adjusting the prime-mask SOAs until the criterion of five consecutive trial blocks (i.e., 120 trials) requiring no further adjustments was met.

Colour-Naming Trials. With the exception that subjects were instructed to name the colour of the frame surrounding the fixation rectangle, the instructions and information given to subjects at the beginning of each colour-naming session were the same as in Experiment 2. The sequence of events on each trial was similar to that which occurred on the detection trials, except that following a 100-msec prime-target SOA, a colour frame was presented and remained in view until subjects responded.

Twelve blocks of 32 trials were administered to each subject during each colour-naming session. The first 3 blocks were treated as practice and the remaining 288 trials provided the experimental observations. During the first 2 blocks of practice trials, the primes were always masked at the 300-msec suprathreshold SOA. For the third trial block, the suprathreshold and subjective threshold trials were randomly intermixed as they were during the experimental trials. The subjects were given a short rest after every block of trials.

Results

Detection Trials: For each subject, percentage correct detection was calculated for each colour word at the prime-mask SOA established for the subjective threshold. The mean detection performance averaged across the four colour words was 55.3% (*SD* = 5.51), and the means for individual subjects ranged from 46.7% to 63.3%. The mean word-mask SOA used for subjective threshold presentations was 44.8 msec, and individual word-mask SOAs ranged from 16.7 to 66.7 msec. Despite the relatively high level of detection accuracy obtained using these word-mask SOAs, the overall mean performance estimate was only 32.3% (*SD* = 3.7) correct.

Colour-Naming Trials: The mean naming latencies and percentage errors for each condition are presented in Table 3. When congruent trial probability was .25, each mean was based on a maximum of 36 observations/subject for congruent trials and 108 observations/subject for incongruent trials. Conversely, when congruent trial probability was .75, congruent and incongruent means were based on a maximum of 108 and 36 observations/subject, respectively.

TABLE 3
Mean Naming Latencies and Percentage Errors in Experiment 3

Prime Detectability	Prime-Target Relationship	Congruent Trial Probability .25 RT	.25 %E	.75 RT	.75 %E
Subjective Threshold	Congruent	473	1.5	454	2.1
	Incongruent	500	2.7	500	4.2
Suprathreshold	Congruent	445	0.2	409	0.6
	Incongruent	540	5.9	586	12.5

As indicated by Figure 2, the pattern of results for the suprathreshold condition is consistent with the results obtained in Experiments 1 and 2. As congruent trial probability increased from .25 to .75, naming latency for incongruent trials increased (45 msec) while congruent trial naming latency decreased (36 msec). Thus, changes in the predictability of the primes substantially influenced performance for both congruent and incongruent trials.

On the other hand, the data for the subjective threshold condition indicate that the manipulation of congruent-trial probability had considerably different effects on the processing of congruent and incongruent primes. Although the increase in congruent-trial probability produced absolutely no effect on incongruent trial naming latencies, there was a small decrease in congruent trial naming latencies (20 msec) when congruent trial probability increased from .25 to .75. This observation indicates that some component of the processing of congruent primes is influenced by changes in congruent trial probability despite claimed unawareness.

The data were analyzed using a 2 (prime-target relationship) by 2 (congruent-trial probability) by 2 (threshold condition) analysis of variance. The presence of a significant three-factor interaction, $F(1, 15) = 41.20, p < .001$, indicates that a different pattern of results occurred in each threshold condition. For this reason, separate analyses of variance were performed on the data for each threshold condition. Both analyses yielded highly significant main effects for prime-target relationship, both $Fs(1, 15) > 27.08, p < .001$, but neither analysis revealed a significant main effect for congruent-trial probability, both $Fs(1, 15) < 2.14$. Furthermore, the interaction between prime-target relationship and congruent-trial probability was a significant source of variance in the data for both the suprathreshold, $F(1, 15) = 19.22, p < .001$, and the subjective threshold condition, $F(1, 15) = 14.47, p < .005$. Planned comparisons revealed that performance in the suprathreshold condition changed significantly on both congruent, $t(15) = 5.87, p < .01$, and incongruent trials, $t(15) = 3.87, p < .01$, as congruent-trial probability increased from .25 to .75. In contrast, similar planned comparisons on the data for the subjective threshold condition revealed a significant decrease in performance on the congruent trials, $t(15) = 3.02, p < .05$, but no change in performance on the incongruent trials, $t(15) < 1$, as a function of congruent trial probability. Thus, the analyses indicate that the manipulation of congruent-trial probability affected both congruent and

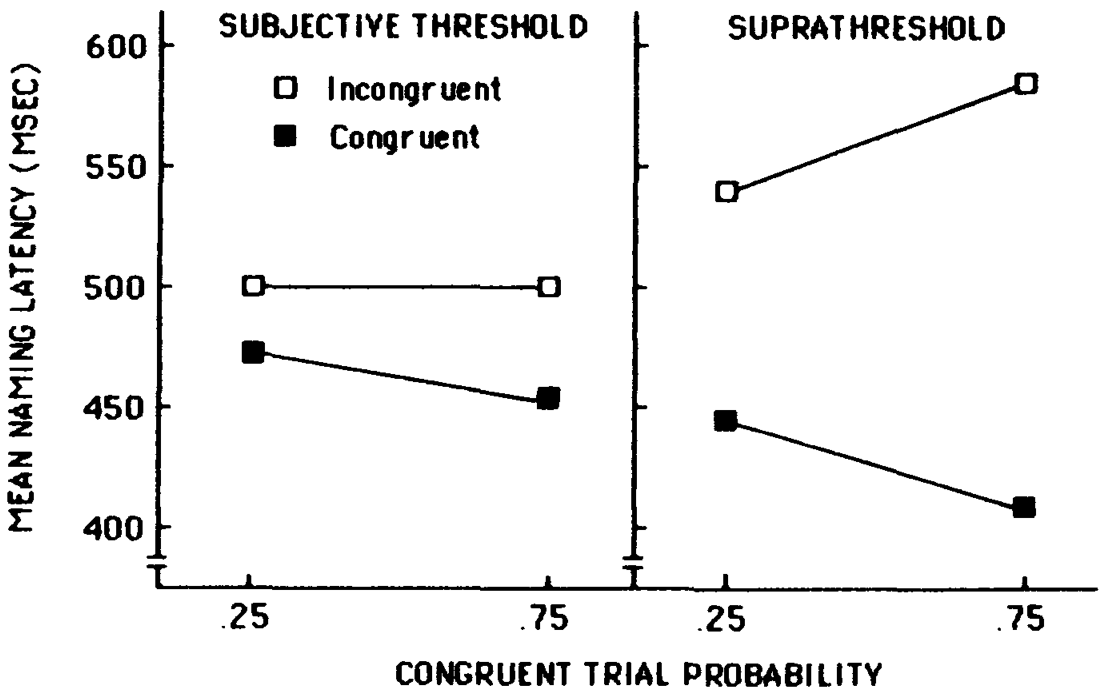

Figure 2. Mean naming latencies for congruent and incongruent trials as a function of congruent-trial probability under subjective and suprathreshold conditions in Experiment 3.

incongruent trial performance when the primes were clearly visible, but only performance on congruent trials is affected when the primes were masked so that observers claimed to have no awareness of the stimuli.

The error data were also submitted to a separate 2×2 analysis of variance for each threshold condition. The analysis for the subjective threshold condition revealed no significant differences, all $Fs(1, 15) < 2.90, p > .10$. In comparison, the analysis of the errors from the suprathreshold condition revealed significant main effects for prime-target relationship and congruent trial probability, as well as a significant interaction between these factors, all $Fs(1, 15) > 16.99, p < .001$. Planned comparisons indicated that the source of the interaction was an increase in incongruent trial error rates as congruent-trial probability increased, $t(15) = 5.08, p < .001$, without a corresponding increase in congruent trial error rates, $t(15) = 2.20, p > .05$.

Discussion

In general, the results of this experiment replicate, under somewhat different experimental conditions, the findings observed in Experiment 2. In both experiments, the increase in congruent-trial probability under the suprathreshold condition produced a large increase in naming latency on the incongruent trials and a relatively smaller decrease in naming latency on the congruent trials. More importantly, under the subjective threshold condition in both experiments, the increase in congruent-trial probability had absolutely no effect on naming latency on the incongruent trials, even though the presence of significant priming effects indicates that the colour words were perceived. These different effects of congruent-trial probability on incongruent trials under the subjective threshold and suprathreshold conditions indicate that the primes were processed in a considerably different manner, depending on whether or not they were presented under conditions leading to claimed awareness. Thus, the results of both experiments provide strong support for the view that the subjective threshold defines the transition between conscious and unconscious perceptual processes.

The one finding in the present experiment that differs from the results of Experiment 2 concerns the effect of congruent-trial probability on congruent trials under the subjective threshold condition. In both experiments, the increase in congruent-trial probability produced a small decrease in naming latency under the subjective threshold condition. However, in the present experiment, this small decrease, which was approximately one-half the decrease observed in the suprathreshold condition, was significant, whereas in Experiment 2, the comparable decrease was statistically nonsignificant. The slightly larger effect observed in the present experiment is probably due to the more extreme variation in congruent-trial probability. This finding suggests that some component of perceptual processing on congruent trials is selectively influenced by variations in congruent-trial probability even when observers claim not to be aware of the primes.

The present results are entirely consistent with the hypothesis that observers can initiate a strategy based on the predictive relationship between primes and targets only when they are consciously aware of the primes. As indicated by the results obtained in the suprathreshold condition, adoption of this strategy has both costs and benefits. Although the strategy leads to improved performance on congruent trials, it also leads to a considerable decrement in performance on incongruent trials. The results obtained in the subjective threshold condition, on the other hand, indicate that a predictive strategy was not adopted in this condition, as the probability manipulation had absolutely no effect on performance on the incongruent trials. Rather, the results for the subjective threshold condition indicate than an increase in congruent-trial probability produces a small benefit on congruent trials, without an associated cost on incongruent trials when observers are not consciously aware of the primes. This benefit without cost in the subjective threshold condition indicates that there are several components to the effect of the probability manipulation, as has been suggested by other investigators (Glaser & Glaser, 1982; Taylor, 1977).

Taken together, the results of both this experiment and Experiment 2 support the view that the subjective threshold defines the boundary between conscious and unconscious perceptual processes. The different effects of congruent-trial probability observed in the suprathreshold and subjective threshold conditions indicate that the primes were processed in a qualitatively different manner in each condition. Given these differential effects of congruent-trial probability in the two threshold conditions, the present results establish the validity of the subjective threshold as a measure of the boundary between conscious and unconscious processes.

GENERAL DISCUSSION

The present studies provide strong support for using the subjective threshold, or the threshold of claimed awareness, to define the boundary between conscious and unconscious perceptual processes. The subjective threshold is an appealing measure of awareness as, intuitively, it seems to capture the phenomenological distinction between conscious and unconscious perceptual experiences. However, by itself, the subjective threshold is a useless measure of awareness. As noted previously (Merikle, 1983, 1984), when awareness is defined simply in terms of subjective confidence, it is equivalent to asking observers whether or not they are conscious of a stimulus. Thus, in effect, each observer is asked to provide his or her own definition of awareness. For this reason, before the subjective threshold can be used effectively to define awareness, at least one additional criterion or converging operation is required. In the present studies, this additional criterion was satisfied by the demonstration that variations in congruent-trial probability differentially affected performance under the suprathreshold and subjective threshold conditions. This demonstration of qualitative differences in perceptual processing as a function of claimed awareness supports the conclusion that the subjective threshold defines the transition between conscious and unconscious perceptual processes.

Adoption of this proposed twofold approach based on subjective thresholds and subsequent demonstrations of qualitative differences in perceptual processing has two major advantages. First, demonstrations of qualitative differences in perceptual processing as a function of claimed awareness indicate how conscious and unconscious processes differ, and it is only by establishing qualitative differences that it will ever be possible to specify the critical differences that distinguish conscious from unconscious perceptual processes. In fact, if qualitative differences in perceptual processing cannot be demonstrated, even the need for a distinction between conscious and unconscious perceptual processes becomes questionable. A second advantage of the proposed approach is that it provides a basis for resolving the controversies surrounding recent studies presumed to demonstrate perception without awareness (Balota, 1983; Fowler et al., 1981; Marcel, 1983a; McCauley et al., 1980). If it is assumed that subjective rather than objective thresholds were inadvertently established in these studies, then the results of these studies are entirely consistent with the present approach. Of course, as previously mentioned, these studies have a major shortcoming in that the data, at best, can only suggest that perceptual information is processed without awareness, since no attempt was made to demonstrate qualitatively different effects for consciously and unconsciously perceived information.

If many of the previous studies which appear to provide evidence for unconscious perceptual processing did involve an evaluation of performance at the subjective threshold, then the results from some of these studies can be interpreted as providing support for unconscious perceptual processing, since the reported data suggest that consciously and unconsciously perceived stimuli are processed in qualitatively different ways. In one important study, Marcel (1980) observed that the interpretation of polysemous or ambiguous words is biased by prior context when the words are clearly visible, but remains relatively unaffected by prior context when the words are masked so that observers claim not to be aware of their presence. Marcel's experiment involved lexical decisions to clearly visible target stimuli that were presented immediately following the presentation of either masked or unmasked polysemous words used as primes. Furthermore, a clearly visible context word which was either neutral with respect to all possible meanings of the polysemous word or closely related to one meaning of the polysemous word was presented prior to the presentation of each prime. The interesting result found in this study was that lexical decisions to words semantically-related to the biased meaning of a prime were facilitated and lexical decisions to words unrelated to the biased meaning were inhibited when the primes were clearly visible. However, when the primes were masked so that they were presented below the awareness threshold, the prior context had no selective effect, as lexical decisions to words related to either meaning of a polysemous word were facilitated. Thus, Marcel's experiment demonstrates that the same priming stimulus can produce either inhibition or facilitation depending on whether or not it is consciously or unconsciously perceived.

Another important study suggesting that consciously and unconsciously perceived words lead to qualitatively different effects has recently been reported by Forster and Davis (1984). Using a lexical-decision task in conjunction with repetition priming, Forster and Davis found that high and low frequency primes which were unavailable for conscious report produced equivalent priming effects. This finding contrasts with the results observed when the primes were clearly visible since, in this situation, there was a more pronounced repetition priming effect for low frequency than high frequency words. On the basis of these results, Forster and Davis argued that lexical access, per se, occurs unconsciously but that conscious perceptual processing is necessary before the differential effects of word frequency become evident.

Finally, Groeger (1984), using a somewhat different approach, has shown that conscious and unconscious perceptual processes lead to qualitatively different error patterns when observers make subsequent forced-choice decisions. In his study, a word was briefly presented, and observers were then required to select a response from a subsequently-presented matrix of words. These matrices never contained the actual word that had been presented, and they consisted solely of words either semantically or structurally related to a previously-presented target word. When the target words were presented so that the observers claimed not to have seen a stimulus, the words selected from the matrices were semantically related to the target words. However, when the target words were presented at longer exposure durations, the subsequently selected words were visually similar to the target words. Thus, it appears that decisions concerning target words are primarily influenced by meaning when the words are unconsciously perceived and guided by structural characteristics when the words are consciously perceived.

Taken together, the results of these studies are consistent with the proposed approach, as long as it is assumed that unconscious perceptual processing in these studies was evaluated at a level of discriminative responding more similar to a subjective than an objective threshold. In fact, Marcel (personal communication, October 29, 1984) has indicated that the awareness threshold established in his study for each observer probably did reflect a subjective rather than an objective threshold. Likewise, the pilot data presented by Forster and Davis (1984) indicate that their subjects were probably able to respond discriminatively to the primes at a somewhat better than chance level of accuracy. Given that subjective thresholds were probably established in these studies, then the reported results indicating qualitatively different effects for consciously and unconsciously perceived stimuli are entirely consistent with the proposed approach. Furthermore, the nature of these differences provides an indication of how conscious and unconscious perceptual processes may differ.

The present emphasis on the need to establish qualitative differences between conscious and unconscious processes is consistent with Marcel's (1983b) theoretical discussions of the role of conscious experience in perceptual processing. Marcel states that the single most important distinction between conscious and unconscious processes is that they reflect qualitatively different representational codes. According to Marcel, conscious perceptual processing is not merely a stronger version of unconscious processing. Rather, conscious perceptual processing allows structures and interpretations to be imposed on perceptual information which are unavailable when information is processed unconsciously. Although Marcel, in his model, equated conscious perceptual processing or phenomenological experience with the presence of any form of discriminative responding, it is possible, with relatively minor changes, to revise his model so that conscious perceptual processing is aligned with the subjective threshold rather than an objective threshold (cf. Cheesman & Merikle, 1985). With these revisions, Marcel's model becomes consistent with both the recent evidence indicating that discriminative responding provides a completely adequate measure of all perceptual processing (Cheesman & Merikle, 1984; Nolan & Caramazza, 1982) and the present proposal that the transition from unconscious to conscious perceptual processing is reflected by the subjective threshold, or in other words, the threshold for claimed awareness.

Clearly, the final success of the subjective threshold or other possible related measures of awareness depends upon the success of future research in elucidating additional differences that distinguish conscious from unconscious perceptual processes. The real advantage of the present approach over other approaches that have been used to study unconscious processes is that the subjective threshold emphasizes the importance of distinguishing perceptual processes on the basis of correlated phenomenological experiences, as opposed to distinguishing perceptual processes simply on the basis of discriminative responding. Thus, the present approach provides a basis of resolving the controversies surrounding the use of discriminative responding as an index of awareness (e.g., Merikle, 1982). Furthermore, even though the proposed approach implies that discriminative responding, per se, does not provide an adequate measure of awareness, it is entirely consistent with the view that discriminative responding does provide a completely accurate indicator of perceptual processing (e.g., Eriksen, 1960). Finally, adoption of the present approach, with its emphasis on establishing qualitative differences between conscious and unconscious processes, changes the important research questions from those that ask whether unconscious perceptual processing occurs to those that ask how conscious and unconscious perceptual processes may differ.

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