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Subliminal Processing of Emotional Information in Anxiety and Depression

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The study investigated selective processing of emotional information in anxiety and depression using a modified Stroop color naming task. Anxious (n = 19), depressed (n = 18), and normal control (n = 18) subjects were required to name the background colors of anxiety-related, depression-related, positive, categorized, and uncategorized neutral words. Half of the words were presented supraliminally, half subliminally. Anxious subjects, compared with depressed and normal subjects, showed relatively slower color naming for both supraliminal and subliminal negative words. The results suggest a preattentive processing bias for negative information in anxiety.

According to Beck's schema model, anxiety and depression are each characterized by mood-congruent biases that operate throughout all aspects of processing, such as attention, reasoning, and memory (Beck, 1976; Beck, Emery, & Greenberg, 1986; Beck, Rush, Shaw, & Emery, 1979). Anxiety and depression are presumed to differ in terms of the content of the processing bias. According to this content-specificity hypothesis, anxious individuals selectively process anxiety-relevant information, whereas depressed individuals selectively process depression-relevant information.

The evidence for Beck's theory has been mixed. For example, several studies have suggested that anxiety is primarily associated with a bias in early aspects of processing such as attention (see Mathews, 1990, for a review), whereas depression is primarily associated with a bias in later stages of processing such as memory (for reviews, see Dalgleish & Watts, 1990; MacLeod, 1990; Williams, Watts, MacLeod, & Mathews, 1988). This apparent discrepancy in the cognitive characteristics of anxiety and depression led to the development of the model put forward by Williams et al. (1988). They proposed that biases operate at different stages of processing in anxiety and depression. In anxiety, the bias is presumed to operate at an automatic, preattentive stage. That is, in anxious individuals, processing resources are automatically drawn toward negative or threatening information even before that information has entered conscious awareness (e.g., Mathews & MacLeod, 1986). On the other hand, in depression, the bias favoring negative information is presumed to occur at later, controlled stages of processing, such as elaboration, that occur after the information has entered conscious awareness.

Earlier work has indicated that perceptual processes are influenced by emotional and motivational factors. Indeed, Bartlett (1932) concluded from a series of tachistoscopic studies conducted in 1916 that "temperament, interests and attitudes often direct the course and determine the content of perceiving" (p. 33). An extensive amount of research was carried out in the 1940s and 1950s (commonly known as the "New Look" in perception research) that investigated the effects of personality traits, motives, and emotionality on perceptual variables such as recognition thresholds (e.g., Bruner, 1957; Bruner & Krech, 1949; Postman, 1953; Postman, Bruner, & McGinnies, 1948). Although this research revealed an interaction between emotion and perception (see Erdelyi, 1974, for a review), the present study emerges from a somewhat different theoretical background. That is, perceptual and attentional biases may play a causal or maintaining role in emotional disorders (e.g., Beck, 1976; Williams et al., 1988). Moreover, recent theories differ from earlier work in suggesting that different emotional disorders, such as anxiety and depression, are associated with biases at different stages of processing. For example, recent theories suggest that a preattentive bias may be primarily associated with anxiety rather than depression (e.g., Williams et al., 1988).

The main aim of our experiment was to test the hypothesis that there is a preattentive bias in anxiety. Specifically, we predicted from Williams et al.'s (1988) model that anxiety, but not depression, is associated with a processing bias for negative information that operates outside conscious awareness.

Our second aim concerned the content-specificity of the processing biases in anxiety and depression. We examined whether the processing bias in anxiety would be more evident for anxiety-relevant information than for negative information in general.

The third aim was to address the question of whether anxious individuals also have a processing bias for positive information. This issue has been raised by Martin, Williams, and Clark (1991) who found that, on a modified Stroop color naming task, anxious patients were slower than normal controls in color naming both positive words and threat words, relative to neutral words. If this finding for positive material is confirmed, it

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would suggest that the anxiety-related bias operates for emotional information in general and not just for negative or anxiety-related material.

To test these hypotheses we carried out a study that had three groups: anxious subjects, depressed subjects, and normal controls. A modified Stroop color naming task was used to assess cognitive bias. Each stimulus word was presented on a computer screen on a background patch of color. Half of the words were presented briefly and masked so that subjects were unaware of their presence. The use of this subliminal condition allowed us to test for cognitive biases operating outside awareness. The other half of the words were presented supraliminally, that is, using longer exposure durations so that subjects become aware of the words. They were asked to ignore the words and to name the color of the background patch as quickly as possible. The time taken to name the background color is used as an index of the extent to which processing resources are being allocated to the word content.

Modified versions of the Stroop task have been previously used to demonstrate selective interference effects of negative word content on the color naming performance of generally anxious patients (e.g., Mathews & MacLeod, 1985; Mogg, Mathews, & Weinman, 1989) and depressed subjects (e.g., Gotlib & Cane, 1987; Gotlib & McCann, 1984; Williams & Nulty, 1986). However, none of these studies have included separate samples of anxious and depressed subjects within the same experiment, and all used supraliminal (rather than subliminal) presentations of the word stimuli.

A number of cognitive mechanisms have been implicated in such supraliminal color naming interference effects, including both automatic and strategic processes (see MacLeod, 1991, for a review). Thus, these previous findings do not provide a direct test of Williams et al.'s (1988) model, because supraliminal color naming interference effects in anxious or depressed subjects might reflect biases operating either at an automatic, preattentive stage or at later, controlled stages of processing. Consequently, a subliminal exposure condition was included in the present study, because selective interference effects due to subliminally presented words could not be accounted for in terms of strategic control processes involving awareness.[1]

Thus, to test Williams et al.'s (1988) model, the present study included separate samples of anxious and depressed subjects and examined the effects of subliminal versus supraliminal exposure conditions for the word stimuli. The main prediction from this model is that anxious subjects should be relatively slower in color naming the background colors of subliminal negative words in comparison with depressed and normal subjects.

Method

Design

There was one between-subjects variable—Group (3: anxious, depressed, control)—and two within-subjects variables—Exposure (2: subliminal, supraliminal) and Word Type (5: anxiety-relevant, depression-relevant, positive, categorized neutral, uncategorized neutral).

Subjects

There were three groups: anxious, depressed, and normal control subjects. All subjects were between 18 and 65 years old and their primary language was English. The anxious and depressed subjects were recruited from a variety of sources including hospital outpatient and inpatient services, a student counseling service, and an advertisement in the local newspaper. There were 19 subjects in the anxious group; the selection criteria were (a) a primary diagnosis of generalized anxiety disorder in the absence of major depression according to *Diagnostic and Statistic Manual of Mental Disorders* (rev. 3rd ed.; *DSM-III-R;* American Psychiatric Association, 1987) criteria (the diagnosis was determined in a clinical interview at the end of the experimental session) and (b) a score of 11 or more (the recommended cutoff for anxiety cases) on the Anxiety subscale of the Hospital Anxiety and Depression Scale (HAD; Zigmund & Snaith, 1982). There were 18 subjects in the depressed group[2]; the selection criteria were (a) a primary diagnosis of major depression according to *DSM-III-R* diagnostic criteria (without organic, psychotic, or manic features) and (b) a score of 13 or more on the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). The control group consisted of 18 subjects, mostly university employees with (a) no known history of emotional disorder and (b) anxiety and depression scores below the cutoffs for the other two groups (i.e., HAD-anxiety score less than 11 and BDI score less than 13). The control group was also matched to the other two groups for age, sex, and vocabulary level. Further subject characteristics are given in Table 1.

Stimulus Materials

The color naming task used five types of stimulus words with 40 words of each type. There were two types of negative words that were anxiety-relevant (e.g., *embarrassed, cancer*) and depression-relevant (e.g., *misery, discouraged*). These were drawn from a larger pool of words used in previous research into anxiety and depression (e.g., Bradley & Mathews, 1983; Mathews, Mogg, May, & Eysenck, 1989). The words were selected on the basis of three judges' ratings on 0–5 scales of their relevance to anxiety and depression. Words were selected as anxiety-relevant if all three judges rated them 3 or more for relevance to anxiety and less than 3 for relevance to depression. Similarly, words were selected as depression-relevant if all three judges rated them 3 or more for relevance to depression and less than 3 for relevance to anxiety.

The third word type served as the control condition and consisted of categorized neutral words that were household terms (e.g., *carpet, domestic*). The fourth word type was made up of positive words (e.g., *adorable, bliss*). The fifth consisted of uncategorized neutral words (e.g., *geometry, exchange*). The latter was included to address a subsidiary hypothesis about the effect of word categorization on Stroop performance.

The five word types were matched for word length and frequency using Carroll, Davies, and Richman's (1971) norms. The anxiety-rele-

[1] An unpublished study by Mathews, MacLeod, and Tata (cited in Mathews, 1990) suggested that brief masked presentations of negative words produced relatively more color naming interference in both anxious and depressed patients compared with normal control subjects. However, these preliminary findings were inconclusive because of methodological difficulties. For example, the anxious and depressed groups were not matched for age or intellectual ability, and there was some evidence that control subjects were aware of some of the words in the masked condition.

[2] There were originally 19 subjects who satisfied the selection criteria for the depressed group, but one was excluded from the study due to outlying response times on the color naming task (i.e., condition means were more than three standard deviations above the mean response time for that group).

Table 1
Subject Characteristics

Characteristic	Group: Control	Group: Anxious	Group: Depressed	$F(2, 52)$	p
n	18	19	18		
Sex ratio (F/M)	10/8	14/5	14/4		*ns*
Age	39.1	38.2	34.8	0.5	*ns*
Mill Hill Vocabulary	22.9	21.5	22.3	0.4	*ns*
Anxiety measures					
STAI–State Anxiety	33.8[a]	44.8[b]	50.4[b]	12.1	<.001
STAI–Trait Anxiety	40.1[a]	58.9[b]	61.3[b]	32.4	<.001
HAD–Anxiety	4.9[a]	14.8[b]	13.8[b]	60.2	<.001
Depression measures					
HAD–Depression	2.8[a]	7.5[b]	10.6[c]	32.8	<.001
BDI	4.1[a]	17.3[b]	27.1[c]	74.6	<.001

Note. Within a row, values with different superscripted letters are significantly different from each other. STAI = Spielberger State-Trait Anxiety Inventory; HAD = Hospital Anxiety and Depression Scale; BDI = Beck Depression Inventory.

vant, depression-relevant, and positive words were also matched on ratings of emotionality by the three judges. Each of the five word lists was divided in half to provide two equivalent sets of words matched for length, frequency, and emotionality. Thus, there were two word sets (A and B) with 100 words in each set (20 of each word type in each set). The allocation of the word sets to the subliminal and supraliminal conditions was balanced across subjects; half the subjects received set A subliminally and set B supraliminally, and vice versa for the other half.

Apparatus

The color naming task was presented using a Toshiba T3100SX portable computer, IBM 8513 12″ color monitor, MEL (Micro Experimental Laboratory; Schneider, 1988) response box with voice key and microphone. The response box was modified to increase the sensitivity of the voice key. MEL software (version 1.0) was used to control the presentation of the stimuli and the recording of response latency and accuracy.

Procedure

Before the main color naming task, there were 24 practice trials, which were the same as the experimental trials described below except that the stimulus words were all uncategorized neutral words (e.g., *glisten, counted*). In the main task, each of the 200 stimulus words was presented once in either the subliminal or supraliminal condition. The 200 trials were presented in a new, fully random order for each subject, determined by MEL. Each trial started with a fixation box (13 mm high × 30 mm wide) for 500 ms in the center of the screen. This was immediately followed by the stimulus word presented in white, uppercase letters (approx. 4 mm high; average length 18 mm [7 letters]) on a background patch of color (5 mm × 38 mm) that was either red, green, blue, or magenta (pink). In order to restrict the display of the background color (which filled one line across the screen) to the fixation area, each side of the screen was masked with a black card (35 mm × 100 mm).

In the subliminal condition, the stimulus word and color background patch were presented for approximately 1 ms. A mask was presented 14 ms after the onset of the stimulus word (i.e., 14 ms stimulus onset asynchrony [SOA]).[3] The mask was a random string of white, uppercase letters (e.g., WNJOKL) presented on a black background so that the preceding word, but not the color background, was masked. (The color background was not masked in order to allow awareness of the color so that subjects could perform the color naming task). The letter mask was matched for length with the preceding stimulus word and was displayed until the subject made a vocal response.

In the supraliminal condition, the sequence of events was the same except that there was no mask and the word remained displayed until response. Each trial commenced with a fixation box for 500 ms. The stimulus word and background patch of color was then presented for approximately 1 ms. After 14 ms SOA, the same stimulus word was presented again on a black background. This was displayed on the screen until the subject named the preceding colored background patch. Thus, the duration of the color background display was the same in the supraliminal and subliminal conditions, whereas the presentation of the stimulus word varied. The spatial arrangement of stimulus events in the supraliminal and subliminal conditions was modeled on that used by Marcel (1983; Experiment 3).

Subjects were asked to ignore the words or random letters and to name the color of the background patch by speaking into the microphone as quickly as possible. Subjects were seated approximately 60 cm from the monitor. The experimenter recorded the subject's response by pressing one of four keys on the response box, corresponding to the four target colors, so that errors were recorded. A prompt was then displayed, "Press to continue," and subjects could initiate the next trial by pressing the space bar on the keyboard.

Following the color naming task, there were two awareness checks for the subliminal condition: detection and lexical decision tasks (cf., Merikle & Reingold, 1990). The presentation order of these tasks was balanced across subjects. In each of the detection and lexical decision tasks, there were 16 practice trials and 60 experimental trials.

For the detection task, on half of the trials (i.e., 30 experimental trials), the stimulus presentation was the same as in the subliminal condition of the color naming task (i.e., 500 ms fixation box, a stimulus word and background color for 1 ms, followed at 14 ms SOA by a letter mask that was displayed until response). The 30 stimulus words used in

[3] To achieve an SOA of 14 ms, the duration of the stimulus display on MEL (version 1.0) was set to 1 ms. The exposure duration and SOA was checked using a light-sensitive diode, filters (to restrict wavelengths to the visible spectrum), and oscilloscope.

these trials were a subset of those words presented subliminally in the color naming task, with 6 words of each type. On the other half of the trials in the detection task (i.e., 30 trials), no stimulus word was presented so that only the background color was displayed before the mask. Subjects were asked to indicate their decision about the presence or absence of a word by pressing one of two response keys.

For the lexical decision task, on half of the trials, stimulus words were presented in the same manner as described above. The 30 stimulus words used in these trials were different to those used in the detection task, although they were also drawn from the subliminal condition of the color naming task, with 6 words of each type. On the other half of the trials (i.e., 30 trials), a nonword was presented with the background color. Subjects indicated whether a word or nonword had been presented by pressing one of two response keys.

The color naming task (with its accompanying awareness checks) was presented in the session together with a probe detection task; the order of the tasks was counterbalanced across the subjects in the three groups such that half the subjects received the color naming task before the probe detection task and the other half received them in the reverse order (further details of the probe detection task are given in Mogg, Bradley, & Williams, 1993).[4] Finally, subjects completed the following questionnaires: State–Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), BDI, HAD, and the synonyms section of the Mill Hill Vocabulary Scale (Raven, 1965).

Table 2
Mean Color Naming Latencies in Milliseconds

	Group					
	Control (n = 18)		Anxious (n = 19)		Depressed (n = 18)	
Word type	*M*	*SD*	*M*	*SD*	*M*	*SD*
Supraliminal condition						
Anxiety	581	90	614	84	611	70
Depression	577	93	623	93	601	79
Positive	582	100	617	97	607	72
Uncategorized neutral	577	98	634	95	605	68
Categorized neutral	596	98	611	99	619	91
Subliminal condition						
Anxiety	563	97	605	79	598	81
Depression	571	87	617	86	594	76
Positive	581	97	602	79	588	82
Uncategorized neutral	566	95	589	85	589	74
Categorized neutral	565	85	590	74	594	85

Results

Subject Characteristics

The three groups did not differ significantly in sex ratio, age, or Mill Hill Vocabulary scores (see Table 1). On the anxiety measures (STAI–state, STAI–trait, HAD–anxiety), the anxious and depressed groups did not differ significantly, although both groups were more anxious than the control group. On the depression measures (BDI, HAD–depression), the depressed group was significantly more depressed than the anxious group, who in turn was more depressed than the controls. Thus, on self-report measures, the depressed and anxious groups differed only in their level of depression and not in their level of anxiety.

Color Naming Task

Mean number of color naming errors was 3.5% across all subjects (means for the control, anxious, and depressed groups were 3.7%, 3.5%, and 3.2%, respectively). Color naming latency data were excluded from the analyses on those trials when subjects made color naming errors or when response times were less than 100 ms or more than 4 s. To further reduce the influence of outliers, response latencies that were more than three standard deviations above each subjects' mean were removed.

The mean color naming latencies in each condition are given in Table 2. A repeated measures analysis of variance (ANOVA) was carried out for the whole data with Group (3: control, anxious, depressed) as a between-subjects variable and Exposure (2: subliminal, supraliminal) and Word Type (5: anxiety, depression, positive, categorized and uncategorized neutral) as within-subjects variables. The results showed a significant main effect of Exposure, $F(1, 52) = 29.18$, $p < .001$; latencies were faster in the subliminal (M = 588 ms) than the supraliminal (M = 604 ms) condition. There was a significant Group × Word Type interaction, $F(8, 208) = 2.02$, $p < .05$, but no other significant effects involving Group (e.g., main effect of Group, $F[2, 52] = 0.83$, *ns*). Further analyses of the latency data were hypothesis-driven; each hypothesis will be dealt with in turn.

To address the first hypothesis, interference scores were calculated for each negative word type. Thus, the anxiety word interference score was calculated for each subject and exposure condition by subtracting the mean latencies for categorized neutral words from those for anxiety words. Similarly, the depression word interference score was calculated by subtracting the latencies for categorized neutral words from those for depression words. Larger interference scores, for example, for anxiety words, indicate that subjects were relatively slower in color naming anxiety-relevant words than neutral words.

Initially, we carried out a repeated measures ANOVA of interference scores for negative words with Group (3: anxious, depressed, control) as a between-subjects variable and Exposure (supraliminal vs. subliminal) and Word Type (anxiety- vs. depression-relevant) as within-subjects variables (see Figure 1 for means). This showed a significant difference between the three groups in the interference effect of negative words (i.e., the combination of anxiety- and depression-relevant words)—main effect of Group, $F(2, 52) = 4.76$, $p < .05$. Anxious subjects showed relatively more color naming interference for negative words in comparison with both depressed, $F(1, 35) = 5.81$, $p < .05$, and control subjects, $F(1, 35) = 8.53$, $p < .01$. This effect did not depend on the exposure duration of the words—Group × Exposure $F(2, 52) = 0.07$, *ns*.

To test the specific hypothesis of a preattentive bias for negative information in anxious individuals compared with normal

[4] All the ANOVAs described in the Results section were repeated after including Task Order (whether the color naming task preceded or followed the probe detection task in the session) as a between-subjects factor. There were no significant interactions involving task order for the color naming latency data or interference scores or for accuracy scores from the awareness checks.

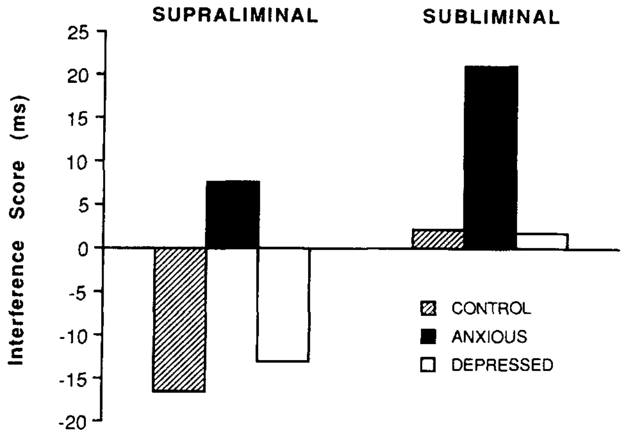

Figure 1. Mean interference scores for negative words in each group and exposure condition.

controls and depressed subjects, separate analyses were carried out of negative interference scores for subliminal words only. The results confirmed the predicted group differences within the subliminal condition (i.e., anxious vs. control group: $F[1, 35] = 4.64$, $p < .05$; anxious vs. depressed: $F[1, 35] = 4.96$, $p < .05$).[5]

As can be seen in Figure 1, the anxious group showed relatively more color naming interference for negative words in comparison with the other two groups across both exposure conditions. The results from the subliminal condition support our first hypothesis that there is a preattentive processing bias for negative information in anxiety.

The second question concerned the content specificity of the bias. That is, is the processing bias in anxious individuals more evident for anxiety-relevant words than for depression-relevant words? The ANOVA of interference scores for negative words showed no evidence of an interaction between Group and type of negative word, $F(2, 52) = 1.99$, *ns*, or between Group, Word Type, and Exposure, $F(2, 52) = 0.12$, *ns.* Thus, there was no evidence to support the notion of content specificity.

The third aim of the study was to address the question of whether anxious or depressed subjects show a processing bias for positive information. Interference scores for positive words were calculated by subtracting the latencies for categorized neutral words from those for positive words. Mean positive interference scores for control, anxious, and depressed subjects respectively were −14, 6, and −12 in the supraliminal condition and 16, 12, and −6 in the subliminal condition. An ANOVA of positive interference scores, with Group and Exposure duration as variables, showed no significant effect or interaction involving Group, $Fs(2, 52) < 1.9$, *ns.*

Additional analyses further examined whether the preattentive bias in anxious subjects was specific to negative stimuli. An ANOVA was carried out of negative versus positive subliminal interference scores in anxious versus control subjects. This showed a significant (negative vs. positive) Word Type × Group interaction, $F(1, 35) = 4.21$, $p < .05$. The anxious and control groups differed significantly in terms of their negative subliminal interference scores, $Ms = 21$ and 2, respectively; $F(1, 35) = 4.64$, $p < .05$, but not positive subliminal interference scores, $Ms = 12$ and 16, respectively; $F(1, 35) = 0.18$, *ns.* These results further support the view that the preattentive bias in anxiety operates specifically for negative information rather than for emotional information in general.

A subsidiary question concerned the extent to which color naming interference effects are influenced by word categorization. An ANOVA was carried out of color naming latencies for uncategorized and categorized neutral words, with Group (3: anxious, depressed, control) as a between-subjects variable and Exposure (2: subliminal, supraliminal) and Categorization (2: categorized, uncategorized) as within-subjects variables (see Table 2 for means). The main effect of word categorization on color naming latencies was not significant, $F(1, 52) = 0.31$, *ns.* However, there was an unexpected Group × Exposure × Categorization interaction, $F(2, 52) = 4.50$, $p < .05$. Separate analyses for each exposure condition showed a significant Group × Categorization interaction in the supraliminal condition, $F(2, 52) = 4.79$, $p < .05$, but not in the subliminal condition, $F(2, 52) = 0.13$, *ns.* Further post hoc comparisons revealed that, within the supraliminal condition only, anxious subjects were relatively slower in color naming uncategorized than categorized neutral words ($Ms = 634$ vs. 611 ms, respectively) compared with depressed subjects (605 vs. 619 ms) and normal controls (577 vs. 596 ms). This finding was not predicted and is difficult to interpret.

Pearson correlation coefficients were calculated between each of the anxiety and depression measures and the interference scores for negative words in each of the subliminal and supraliminal conditions. There were no significant results either within each group or across the whole sample.

Awareness Checks

In the lexical decision task, the mean percentages of trials with correct responses were 50.5%, 50.7%, and 50.0% for control, anxious, and depressed groups, respectively. There was no difference between the groups in their performance as indicated by percentage correct scores, $F(2, 52) = 0.10$, *ns.* A paired samples *t*-test was carried out to assess the extent to which subjects' percentage correct scores deviated from chance (50%). This showed that the overall performance of the sample ($M = 50.4\%$, $SD = 5.0$) was not significantly different from that expected by chance ($t < 1$).

The detection task produced the same pattern of results. Mean percentages of trials with correct responses were 51.5%, 51.7%, and 50.1% for control, anxious, and depressed groups, respectively. There were no group differences in response accuracy, $F(2, 52) = 0.33$, *ns*, and overall performance ($M = 51.1\%$, $SD = 6.3$) was not significantly different from chance. These results suggest that subjects were unaware of the presence of the stimulus words in the subliminal condition.

[5] Within the supraliminal condition alone, negative words produced relatively more interference in anxious subjects compared with normal controls, $F(1, 35) = 4.35$, $p < .05$, which successfully replicates previous findings (e.g., Mathews & MacLeod, 1985).

Discussion

The main hypothesis that there is a preattentive processing bias in anxiety is supported. The results showed that anxious subjects were relatively slower in color naming negative words that were subliminally presented. This finding may be taken as providing some support for Williams et al.'s (1988) model that proposes that, in anxiety, processing resources are automatically drawn toward threatening information and that this bias does not depend on conscious awareness of the stimuli.

This processing bias in anxious subjects does not appear to operate specifically for anxiety-related information, because the selective interference effect in color naming performance was found for negative information in general. This finding may suggest that such interference effects arise when the word stimuli have only undergone a relatively superficial level of semantic analysis regarding their global negative emotional characteristics. Such an interpretation might be regarded as being inconsistent with previous findings indicating that interference effects are highly specific to the primary concerns of anxious patients (e.g., Mathews & MacLeod, 1985; Mogg et al., 1989). However, these earlier findings were obtained with a modified version of the color naming task in which stimulus words were presented together with other words from the same category on a card in blocked format. This blocked presentation might be more likely to elicit content-specific interference effects because of increased opportunity for more elaborate processing of the semantic content of the word stimuli. In contrast, in the present experiment, the words were presented individually in a random sequence. Therefore, there would be less opportunity for elaborate processing to occur and, consequently, for content-specific effects to emerge. Thus, it is suggested that, in the absence of an opportunity to engage in elaborate analysis of the word meanings, selective processing effects operate in a relatively nonspecific fashion for negatively valenced information in anxious individuals.

The present study also found no evidence of a processing bias for positive information in anxious subjects. This null result contrasts with previous research showing that, using the card version of the modified Stroop task, anxious subjects were slower in color naming both threat-related and positive words compared with controls (Martin et al., 1991; Mogg & Marden, 1990). On the other hand, the absence of an anxiety-related bias for positive words is entirely consistent with Richards and Millwood's (1989) results from a computer-presented, random-sequence version of the Stroop task, similar to that used in the present study. Taken together, these results suggest that anxiety-related processing biases for positive stimuli are evident only on tasks that allow elaborate processing, such as the card Stroop, rather than the random-sequence Stroop task that provides less opportunity for such processing (as discussed above). Thus, the presence of an anxiety-related bias for positive information may primarily depend on controlled, elaborative processes, in contrast to the bias for negative information that involves automatic, preattentive processes (as indicated by the subliminal condition).

The presence of a preattentive bias for negative information in anxious subjects and the absence of such a bias in depressed individuals was predicted by Williams et al.'s (1988) model. Thus, our results from the subliminal condition appear to support the view that anxiety and depression have different cognitive characteristics. The absence of the bias in the depressed group is of particular interest, given that these subjects had a similar level of anxiety to that found in the anxious group (Table 1).[6] This finding suggests that the presence of a high level of anxiety is not sufficient to elicit a preattentive bias for negative information, because the bias is absent in subjects who have high levels of both anxiety and depression. Thus, Williams et al.'s (1988) model may require some modification to explain why depressed subjects do not show a preattentive bias for negative information despite their typically high level of anxiety. One might speculate that the anxiety-related bias is inhibited by elevated levels of depression. This suggestion would seem to be consistent with the view that anxiety is a motivational state directed toward the detection of potentially aversive stimuli in order to take appropriate action (Oatley & Johnson-Laird, 1987). In contrast, depression may be regarded as an amotivational state that reflects helplessness and hopelessness. Thus, the preattentive bias toward negative information might primarily be a function of an individual's motivational state (i.e., his or her readiness to detect and deal with a potential threat) rather than the presence of anxiety per se.

One slightly puzzling feature of the present results is the failure to confirm previous evidence of interference effects of supraliminally presented negative information in depressed subjects (cf. Gotlib & Cane, 1987; Gotlib & McCann, 1984, Experiment 1). There were a number of methodological differences between these earlier studies and the present one (e.g., different stimulus words, use of uncategorized vs. categorized neutral words as the control condition, and differing levels of depression and anxiety in the subject samples), but it is not clear if any of these differences can satisfactorily account for the discrepant results. However, the inconsistent findings might instead indicate that supraliminal interference effects of negative words are not a reliable feature of depression. Only careful further research can address these issues. Williams et al.'s (1988) model does not appear to provide a strong prediction of such effects in depression, partly because of uncertainty about the precise cognitive mechanisms underlying supraliminal color naming interference effects (MacLeod, 1991). Fortunately, the results from the subliminal condition do not give rise to such interpretative difficulties, because the influence of strategic, controlled processes is excluded.

A subsidiary concern of the present study was to examine the effect of word categorization on color naming interference. We found an unexpected interaction effect of group and word cate-

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[6] It may be noted that the results from the questionnaire measures of anxiety and depression are consistent with those from earlier clinical studies. For example, our anxious and depressed subjects, respectively, had similar anxiety and depression levels to those found in other samples of clinically anxious (e.g., Mathews & MacLeod, 1985; Mathews et al., 1989; Mogg, Mathews, & Weinman, 1987) and clinically depressed patients (e.g., Bradley & Mathews, 1983; Derry & Kuiper, 1981). Furthermore, the high level of anxiety found in our depressed group is consistent with previous evidence indicating that a high frequency of anxiety symptoms is typically associated with major depression (e.g., Clark, 1989).

gorization that was in the supraliminal condition only. This suggests that the effect of word categorization on color naming performance is mediated specifically by controlled, strategic processes, possibly as a result of categorical priming effects. This finding indicates the importance for researchers using supraliminal versions of the Stroop task to control for word categorization when selecting and matching the neutral control words. In contrast, there was no evidence that word categorization affected color naming interference in the subliminal condition. This suggests that, although supraliminal Stroop effects should be interpreted with caution (unless word categorization is controlled), interference effects in the subliminal condition are not confounded by word categorization.

Our main finding of a color naming interference effect of subliminal negative words in anxious subjects may have wider implications for the study of the role of consciousness in the perceptual processing of words. Cheesman and Merikle (1985) made an important distinction between subjective and objective thresholds. For example, subjects may report that they are simply guessing when making discriminations on a detection task even when their actual performance is significantly above chance levels. In such a case, subjects would be performing below the subjective threshold but above the objective threshold. In contrast, below the objective threshold, actual performance is no better than chance.

Cheesman and Merikle (1985) argued that "when discriminated, forced choice responses . . . are at a chance level [i.e., at or below the objective threshold], no other evidence of perceptual processing is found" (p. 312), such as interference effects in the color-conflict condition of the traditional Stroop task. They argued that such interference effects, which indicate perceptual processing of the word meaning, only arise when stimuli are presented above the objective threshold of awareness. They proposed that Stroop effects can occur when masked stimuli are presented below the subjective threshold (i.e., when subjects claim that they are unable to discriminate perceptual information at a better-than-chance level).

Cheesman and Merikle (1985) argued that previous findings of subliminal Stroop effects may be interpreted as being consistent with their formulation (e.g., Marcel, 1983). However, the present results provide evidence of color naming interference effects due to the negative emotional meaning of words in anxious individuals, even when subjects' abilities to detect the presence of the stimuli are at chance level (i.e., below the objective threshold). The present results appear to be consistent with other recent evidence suggesting that perceptual processing of word meaning can occur without awareness, as indicated by an objective threshold measure (e.g., Kemp-Wheeler & Hill, 1988; Merikle & Reingold, 1990).

However, it is also important to acknowledge that proof of subliminality is a difficult and controversial issue. There are well-documented methodological difficulties in ensuring complete absence of awareness in the subliminal condition (see Holender, 1986, for detailed discussion of this issue). For example, as a result of light adaptation, perceptual thresholds may lower during the course of the task—for this reason, the awareness checks were administered immediately after the experimental trials of the color naming task. Furthermore, in order to minimize fluctuation in the level of light adaptation between the color naming and awareness check trials, similar stimulus conditions were used in each task, testing was carried out in a lit room, and subjects were light-adapted. It is clearly difficult to establish that subjects are completely unaware of the word stimuli on every trial in the subliminal condition. Thus, although we adopted a stringent criterion for awareness, namely an objective measure of detectability (Merikle & Reingold, 1990), it is important to include this cautionary note.

The main aim of our study was fulfilled; the results provided supportive evidence of a preattentive processing bias for negative information in anxiety. The finding of such a bias may have important implications for clinical assessment and treatment. For example, there may be important cognitions associated with anxiety that are inaccessible to the patient and that cannot be assessed by self-report methods. This is clearly problematic because self-report methods currently provide the primary tool in the clinical assessment of anxiety disorders. In addition, the presence of a preattentive bias in anxious individuals may suggest a limitation of cognitive therapy that deals only with conscious thoughts or images. If the processing bias operates outside awareness, then the modification of conscious cognitions or thoughts may not remove the underlying bias. This raises the question of whether cognitive therapy is effective by training people in how to cope with their anxiety symptoms rather than by removing the underlying cognitive bias.

In conclusion, the present results indicate that there are important cognitive features of anxiety that operate outside conscious awareness, namely a preattentive bias for negative information.

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