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Selective Processing of Threat Cues in Subjects with Panic Attacks

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Previous research has demonstrated that patients with generalised anxiety disorder, phobias, and obsessive-compulsive disorder show an attentional bias towards threat cues related to their respective disorders. Two studies are presented that used a modified Stroop colour naming task to assess attentional bias in subjects with panic attacks. In Study 1, 24 panic disorder patients and 24 normal controls were presented three cards containing threat words related to physical harm, separation, or social embarrassment. Colour naming times were compared between these cards and control cards containing matched non-threat words. Reaction time differences in the two groups were in opposite directions, patients tending to be slower in colour naming threat words, and controls, faster. In Study 2, 18 non-clinical panickers and 18 controls were presented cards containing physical threat words, neutral control words, or colour words, respectively. Panickers showed greater interference than controls in colour naming threat words but not in colour naming colour words. The results are consistent with an attentional bias for threat-related material in subjects with panic attacks. Implications for psychophysiological models of 'spontaneous' panic attacks are discussed.

INTRODUCTION

Panic attacks are discrete episodes of apprehension or fear accompanied by a variety of symptoms such as palpitations, dyspnea, sweating or dizziness. These attacks have been given a central role in the classification of anxiety

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disorders (APA, 1987). One of their most puzzling and fascinating features for clinicians and researchers is that they often occur in the absence of any perceived situational triggers.

Psychophysiological models of panic have recently received increasing attention and empirical support (for a review see Ehlers, Margraf, & Roth, 1988b). Panic attacks, including those that seem to occur "spontaneously", are seen as fear responses to *internal* stimuli, for example, bodily symptoms. Questionnaire studies have demonstrated that panic patients show a bias in the interpretation of bodily cues in that, compared to normal or clinical control groups, these patients report more fear of body sensations (McNally & Lorenz, 1987; Chambless, Caputo, Bright, & Gallagher, 1984) and tend to interpret bodily changes as indicators of an immediately impending danger (Clark et al., 1988; Foa, 1988; McNally & Foa, 1987; van den Hout, 1988a,b). Interview studies concur that catastrophic misinterpretations of body sensations occur during panic attacks (Beck, Laude, & Bohnert, 1974; Hibbert, 1984; Ottaviani & Beck, 1987; Rapee, 1985; Rachman, Levitt, & Lopatka, 1987; Zucker et al., submitted). Without further evidence from experimental or longitudinal studies, however, these results are inconclusive because they depend on the patients' recollections of their panic attacks. In addition, questionnaire and interview studies assess only conscious processes while the reported "spontaneity" demonstrates that patients have only limited insight into what triggers panic. Thus, at least some of the processes involved in panic might not be accessible by introspection.

Laboratory studies of experimental anxiety induction have demonstrated that the patients' anxiety responses depend on cognitive factors such as expectations, perceived control, or perception of bodily changes (Barlow, 1987; Clark et al., 1988; Ehlers, Margraf, & Roth, 1988a; Ehlers, Margraf, Roth, Taylor, & Birbaumer, 1988c; Foa, 1988; Margraf, Ehlers, & Roth, 1986b; in press; Rapee, Mattick, & Murrell, 1987; van den Hout, 1988a,b). In the present studies we used a different experimental approach other than anxiety induction to investigate cognitive processes in panic disorder. Researchers have recently started to apply methods developed in experimental cognitive psychology to the study of anxiety disorders (for a review see Mathews & Eysenck, 1987). They have found that anxiety patients show an attentional bias towards threat cues related to their respective disorders.

Most relevant to the study of panic disorder is a series of experiments of Mathews, MacLeod, and co-workers on information processing in generalised anxiety disorder. Like panic patients, these patients suffer from severe anxiety not triggered by phobic situations. In reaction time paradigms, for example, the Stroop colour naming task (Mathews & MacLeod, 1985), dichotic listening (Mathews & MacLeod, 1986), or a visual probe detection

task combined with word reading (MacLeod, Mathews, & Tata, 1986), generalised anxiety patients showed an attentional bias for material representing social threat (words like "stupid", "hated") or physical threat (for example, "paralysed" or "disease"). Whereas patients shifted their attention towards emotionally threatening material, controls tended to shift attention away from such material (MacLeod et al., 1986). The simultaneous presentation of threatening material interfered more with the patients' task performance than with that of controls (Mathews & MacLeod, 1985, 1986). Patients could not recall or recognise the threat words better than controls (Mathews & MacLeod, 1985, 1986), although they had responded to them differently. Mathews and MacLeod interpreted these results as meaning that the attentional shifts occurred outside of awareness.

The same pattern of results has been found for other anxiety disorders such as phobias (Burgess et al., 1981; Streblow, Hofmann, & Kasielke, 1985; Watts, MacKenna, Sharrock, & Trezise, 1986a) and obsessive compulsive disorder (Foa & McNally, 1986). Anxiety patients detected anxiety-relevant information in unattended material better or faster than neutral information (Burgess et al., 1981; Foa & McNally, 1986; Streblow et al., 1985), whereas control groups did not show this response pattern. When anxiety patients were presented with task-irrelevant but anxiety-relevant information, greater interference with task performance was found than in controls, even when subjects were told to ignore this information (Watts et al., 1986a). The patients' attentional bias disappeared after successful behaviour therapy indicating that the effects were not due to differences in familiarity with the stimulus material (Foa & McNally, 1986; Watts et al., 1986a). Memory processes are probably less strongly affected in anxious than in depressed patients (Mathews & MacLeod 1985, 1986; Mogg, Mathews, & Weinman, 1987; Watts, Trezise, & Sharrock, 1986b).

What kind of threat cues are relevant to the study of panic attacks? *Physical* threat seems to be especially important because patients report fear of bodily symptoms or disease and psychophysiological models emphasise the role of bodily cues as panic triggers. Material related to *separation* could be relevant since it has been hypothesised that panic disorder is a form of separation anxiety (Klein, 1980; cf. Margraf et al., 1986a). Social *embarrassment* is of interest because patients frequently report that they are afraid of doing something embarrassing when having a panic attack in public (e.g. Chambless et al., 1984; Goldstein & Chambless, 1978).

The goal of the present studies was to investigate whether patients with panic disorder and non-clinical panickers show attentional biases to threat cues. Such attentional processes might help explaining the occurrence of panic attacks in the apparent absence of situational triggers. It is possible

that information processing of threat cues without the patient's awareness is involved in triggering panic (cf. Mathews & MacLeod, 1986).

In a previous unpublished study of 30 panic disorder patients and 24 controls, we had investigated colour naming of threat and control words, but failed to find differences in interference effects between the groups. Patients took longer than controls to colour name both threat and non-threat words. However, there were methodological shortcomings in the stimulus material that may have accounted for the negative findings. Words were presented in a random order without the restriction of no colours being repeated in a row. It so happened that the number of these colour repetitions was unevenly distributed across cards. Colour naming times were influenced by this factor, as reaction times were shorter for cards with more sequential colour repetitions. In addition, the words were printed in larger and bolder letters than the ones used by Watts et al. (1986a) and Mathews and MacLeod (1985). Our impression was that the letters were so big that subjects could easily focus on a part of the word and miss the entire Gestalt. Furthermore, the cards differed from those used by Mathews and MacLeod in that the words were written in three instead of eight columns.

Although our findings were generally negative, there were a few differences between the groups. Patients, but not controls, had larger skin conductance levels (SCL) when colour naming threat words (Group × Condition interaction for log SCL: $F(1,50) = 6.01$, $P < 0.02$). In addition, although both groups discriminated threat words better than control words on a recognition questionnaire, the difference was larger in the patient group (Group × Condition interaction: $F(1,52) = 4.12$, $P < 0.05$). Therefore, we decided to repeat the study with revised stimulus material.

STUDY 1

Method

Subjects

Twenty-four panic attack patients (16 women, 8 men) and 24 control subjects (16 women, 8 men) participated in this study. All were Caucasian. Patients had been recruited to participate in a treatment study at Stanford University. They had been asked to discontinue taking any psychotropic medication for at least 10 days before testing. Four patients and one control who had originally participated in the protocol had to be excluded because they had failed to comply with this requirement. They were replaced by subjects that were subsequently admitted to the study.

Patients met DSM-III criteria for panic disorder or agoraphobia with panic attacks as determined by the Structured Interview for DSM-III-

TABLE 1
Study 1: Subjects

	Patients *(n = 24)*	*Controls* *(n = 24)*
Age	35.5 (10.1)	36.2 (10.4)
Education (in years)	14.5 (1.9)	15.9 (1.8)
Trait Anxiety (STAI/T)	48.9 (10.4)	32.1 (6.8)
State Anxiety (STAI/S)	44.5 (10.1)	27.8 (6.2)
Depression (BDI, short form)	8.1 (6.5)	1.3 (2.1)
Avoidance (MI)		
accompanied	1.78 (0.58)	1.17 (0.22)
alone	2.55 (0.61)	1.31 (0.33)

Means (standard deviations) are given in brackets.

Upjohn version (SCID-UP, Spitzer & Williams, 1983). Patients were excluded if they had any history of major depressive episodes that preceded the onset of panic attacks. Control subjects described themselves as "non-anxious". They had to be free of any history of psychiatric problems as determined by the SCID-UP and a structured interview based on the SADS-L (Spitzer & Endicott, 1978). They were paid for their participation.

The groups were matched for age, ranging from 20 to 62 in the patient, and from 22 to 59 in the control group. All subjects were in good physical health as determined by medical history and physical examination. Table 1 shows the subjects' mean age, years of formal education, trait anxiety scores (State-Trait-Anxiety-Inventory, STAI/T, Spielberger, Gorsuch, & Luschene, 1970), state anxiety scores at baseline (STAI/S), Beck Depression Inventory scores (BDI, short version, Beck & Beck, 1972), and Mobility Inventory scores (a measure of agoraphobic avoidance behaviour; Chambless et al., 1985). Patients and controls differed significantly on all of the measures (all P's < 0.01) except age. Informed consent was obtained from all subjects after the nature of the procedures had been explained.

Procedure

General Procedure. Test sessions took place in the afternoon between 1 p.m. and 5 p.m. The experimenter allowed the subjects time to familiarise themselves with the laboratory environment. Subjects had spent more than one hour in the laboratory before baseline recordings began.

Colour Naming Task. A modified Stroop colour naming task similar to the one of Mathews and MacLeod (1985) was used to assess attentional bias. Subjects were asked to colour name cards (21 × 30cm) on which 96 words were handwritten in red, blue, green, or yellow. The size of the block capital letters was 0.5cm. Each card contained a set of 12 different words. This set of words was repeated 8 times in random order. Thus, a card contained 8 columns of 12 words to give a total of 96. The restriction was that the same colour did not occur twice in a row.

Three of the six cards contained threat words related to three categories (a list of the stimulus material is available from the authors):

Physical threat words (e.g. "disease" or "fatal"; the word list used by Mathews & MacLeod, 1985);
words related to *separation* (e.g. "separation", "lonely"); and
words related to *embarrassment* (e.g. "stupid", "humiliation").

The social threat stimulus set constructed by Mathews and MacLeod (1985) shows considerable overlap with our embarrassment scale. Our scale was slightly different in that we dropped words related to separation. In addition, British words that might be misunderstood by our subjects were replaced with American terms.

For each of the cards, a control card was constructed with neutral or positive (non-threat) words matched for word frequency and length (such as "leisure", "alert", "faithful", or "optimism"). The number of nouns, verbs, and adjectives was also matched. For the pair-wise frequency matching of threat and control words, we used the Standard Frequency Index (SFI) as recommended by Carroll, Davies, and Richman (1971). After a practice run with a card containing neutral words like "house" or "apple", the six cards were presented in balanced order. Subjects were instructed to name the word colours as fast as possible without making mistakes, and without attending to the word content. Between the single cards, subjects had a break of about one minute.

The colour naming test was presented after a 15min baseline. During the test, the experimenter sat next to the subject, took the colour naming time with a stopwatch, and monitored possible mistakes. After the colour naming test, subjects answered a recognition questionnaire containing the 72 words previously shown on the cards, randomly interspersed with 72 other (distractor) words. The distractor words were matched for threat content and word frequency. Thus, there were a total of 36 distractor words relating to physical threat, separation, or embarrassment, and 36 non-threat words. Subjects indicated whether they believed that they had seen the words during the colour naming task. Finally, the experimenter asked the subject what their primary worry was, i.e. whether they charac-

teristically worried more about their health (physical danger) or about interpersonal issues. If they worried more about the latter, they were asked whether their worries were more related to separation from significant other people or to embarrassment.

Assessment

The main dependent variable and indicator of information processing was the time it took subjects to colour name each of the cards. The time was measured by the experimenter with a stopwatch to the nearest second. To assess incidental memory, we calculated the number of hits and false alarms in the recognition questionnaire for each of the threat and control cards.

In addition, subjects' physiological and subjective responses to the colour naming tasks were recorded to look for possible differences between the groups. During the test, heart rate (HR) and skin conductance level (SCL) were continuously monitored. The EKG was recorded from electrodes over the 10th left rib on the midclavicular line and the right mastoid. Skin conductance was recorded from a pair of Ag–AgCl disc electrodes, 0.8cm^2 in area, both placed on the thenar eminence of the non-dominant hand. The electrolyte medium was a mixture of creamy ointment and physiological saline as recommended by Fowles, Christie, Edelberg, Grings, Lykken, and Venables (1981). The skin conductance transducer applied a constant 0.5V across the electrodes. Average HR and SCL levels during colour naming were calculated for each of the cards.

Before and after the test, subjects rated their anxiety and excitement on a scale from 0 (labelled "none") to 10 (labelled "extreme") (Anxiety Rating Scale, AR, Ehlers et al., 1986). In addition, they completed the state version of the Spielberger State-Trait Anxiety Inventory (STAI/S, Spielberger et al., 1970). On a symptom checklist, they indicated which of 15 panic and five control symptoms they experienced (Margraf et al., in press).

Results

The significance levels given in this paper are two-tailed.

Colour Naming Times. In an overall statistical analysis, we averaged the times to colour name each of the three threat cards and the three control cards, respectively. The results are shown in Table 2. A repeated measures ANOVA comparing the two groups (Group factor, patients vs. controls) and the two word valences (Valence factor, threat vs. control words) showed a significant Group × Valence interaction ($F(1,46) = 5.73$;

TABLE 2
Study 1: Average Colour Naming Times for Three Cards

	Patients (*n* = 24)	*Controls* (*n* = 24)
Threat words	74.7 (16.5)	69.7 (9.8)
Non-threat words	73.5 (15.6)	71.4 (9.9)

Means and standard deviations (in sec).

$P < 0.05$). Main effects were not significant. To clarify this interaction further, it was reduced to simple main effects as described by Winer (1970). Analyses of the Valence factor for panic and control subjects separately showed that the interaction resulted from non-significant reaction time differences being opposite in direction between the two groups: while patients tended to be slower when colour naming threat words ($F(1,46) = 1.99$; n.s.), controls tended to be faster ($F(1,46) = 3.90$; n.s.).

Further statistical analyses were performed to test whether the interaction occurred for each type of threat word. Means and standard deviations are shown in Table 3. An ANOVA comparing the reaction times of patients and controls (Group factor) for threat and control words (Valence factor) of the three types of threat material (Type factor, which was called the Material factor in the study of Mathews & MacLeod, 1985) showed a main effect of Type ($F(2,92) = 9.24$; $P < 0.001$) and both a Type × Valence interaction ($F(2,92) = 5.73$; $P < 0.005$) and a Group × Valence interaction ($F(1,46) = 5.73$; $P < 0.05$). Separate ANOVAs for each threat type showed a significant Group × Valence interaction only for *physical* threat ($F(1,46) = 4.17$; $P < 0.05$) and not for the two types of

TABLE 3
Study 1: Colour Naming Times for Single Cards

	Patients (*n* = 24)	*Controls* (*n* = 24)
Physical threat	76.3 (15.6)	70.8 (13.0)
Non-threat words	72.7 (15.3)	71.0 (9.6)
Separation	74.9 (17.1)	69.9 (10.0)
Non-threat words	76.2 (17.1)	74.0 (12.0)
Embarrassment	72.8 (18.0)	68.3 (8.5)
Non-threat words	71.5 (16.3)	69.2 (10.3)

Means and standard deviations (in sec).

TABLE 4
Study 1: Mean Colour Naming Times (in sec) of Subjects with Physical or Social Worries

	Patients		*Controls*	
	Physical Worries (n = 16)	*Social Worries (n = 7)*	*Physical Worries (n = 12)*	*Social Worries (n = 11)*
Physical threat	72.7	84.9	70.1	72.5
Non-threat	69.3	80.3	69.5	73.9
Social threat	69.6	83.9	68.8	70.2
Non-threat	69.8	83.0	69.9	74.5

Social threat is the average of the separation and embarrassment conditions.

social threat words. However, the Group × Valence × Type interaction was not significant.

The distribution of subjects' major concerns did not differ between the groups. Sixteen patients and 12 controls worried mostly about their health, 6 patients and 8 controls about issues of separation, and 1 patient and 3 controls about social embarrassment. One subject in each group could not come to a decision. Following Mathews and MacLeod (1985), we further analysed colour naming times by dividing the patient and control groups according to the threat domain reported as most worrisome. As too few subjects chose embarrassment, we averaged the colour naming times for the two social threat cards and for their control cards, respectively, and compared physical and social worriers (Worry factor). The results are shown in Table 4. In the ANOVA, there was a marginally significant main effect of the Worry factor ($F(1,42) = 4.02$, $P < 0.06$), but no interactions with other factors. As in the analysis described above, significant Group × Valence ($F(1,42) = 7.99$, $P < 0.01$) and Valence × Type interactions ($F(1,42) = 5.30$; $P < 0.05$) were found. Differences in colour naming times tended to be opposite in direction between patients and controls.

Relationship to Anxiety and Depression. As shown in Table 1, patients and controls differed not only in anxiety, but also in depression and education. We analysed which of the variables was most closely related to the disruption of colour naming threat vs. non-threat words by calculating product–moment correlations between a threat interference score (difference of the average colour naming times for threat and control words) and

TABLE 5
Study 2: Subjects

	Panickers (*n* = 18)	*Controls* (*n* = 18)
Age	25.2 (5.2)	24.7 (4.6)
Trait Anxiety (STAI/T)	44.9 (8.2)	37.8 (8.0)
State Anxiety (STAI/S)	43.3 (9.7)	36.6 (9.6)
Depression (BDI, long form)	13.6 (8.3)	5.4 (3.0)
Avoidance (MI)		
accompanied	1.38 (0.38)	1.15 (0.18)
alone	1.70 (0.55)	1.47 (0.36)

Means (standard deviations) are given in brackets.

Mobility Inventory scores (German translation, Ehlers & Margraf, unpublished). Except for age and avoidance behaviour when alone (Mobility Inventory score), panickers and controls differed significantly on all measures (all P's < 0.05).

Procedure

The experimenter was unaware of the diagnostic status of the subjects.

Colour Naming Task. Subjects were asked to colour name cards similar to those used in Study 1, but different in a number of details: The cards contained 72 words (6 columns of 12 words) written in red, blue, green, or black. The physical threat items consisted of 12 words such as "disease" or "death". A control card was constructed of neutral words ("box", "air") matched to threat words for length and frequency (Meier, 1967). Both stimulus sets consisted of 11 nouns and 1 verb. In this study, we omitted the social threat conditions and added a control condition in which subjects were asked to colour name colour words (standard Stroop test).

After a practice run with a card containing neutral words like "house" or "bird", the standard Stroop card (colour words) was given. The physical threat and control cards were then presented in balanced order. After the colour naming test, subjects answered a recognition questionnaire containing the 24 words previously shown on the cards and 24 distractor words.

Assessment

Assessments were similar to Study 1 with the exception that heart rate, skin conductance level, and self-rated excitement were not measured.

TABLE 6
Study 2: Colour Naming Times

	Panickers (*n* = 18)	*Controls* (*n* = 18)
Physical threat words	56.4 (11.5)	49.8 (5.9)
Non-threat words	49.1 (7.7)	46.6 (5.5)
Colour words	71.1 (17.3)	68.8 (10.1)

Means and standard deviations (in sec).

Results

Colour Naming Times. Colour naming times of panickers and controls are shown in Table 6. Repeated measures ANOVA of colour naming times for threat and control words showed a significant Group × Valence interaction ($F(1,34) = 5.21$, $P < 0.05$) and a highly significant Valence effect ($F(1,34) = 36.30$, $P < 0.001$). The Group effect did not reach significance ($F(1,34) = 3.24$, $P < 0.09$). The results were the same when colour naming times were logarithmically transformed. Analyses of simple main effects of the Valence factor showed that both panickers and controls took significantly longer to colour name threat words ($F(1,34) = 34.53$, $P < 0.001$ for panickers; $F(1,34) = 7.01$, $P < 0.05$ for controls), the interference being greater in the panic group ($t = 2.28$, $P < 0.05$).

To test whether the greater interference of panickers was specific to the threat condition, colour naming times for colour words were compared to those for neutral words. (Because the colour word condition was always given first, we decided not to do an overall ANOVA comparing neutral, threat, and colour words.) Both groups were much slower in colour naming colour words than neutral words (Condition effect: $F(1,34) = 178.18$, $P < 0.0001$) and here there was no Group × Condition interaction ($F(1,34) = 0.01$, $P > 0.90$). Both groups were about 12sec slower in colour naming colour words than neutral words.

Relationship to Anxiety and Depression. Correlations of state and trait anxiety, anxiety increases (STAI), and depression (BDI) with the difference between colour naming times for threat and non-threat words (threat interference scores) were non-significant.

Other Variables. On the recognition questionnaire, both groups identified more threat words correctly than control words (Condition factor: $F(1,34 = 29.14$, $P < 0.0001$) and there were no interactions with the Group factor. Subjects' responses to the colour naming task were analysed

by a multivariate analysis of variance comparing self-reports of anxiety (STAI/S, AR), panic and control symptoms of panickers and controls (Group factor) before and after colour naming (Time factor). Panickers tended to rate themselves as more anxious and to report more symptoms than controls (overall Group effect: $F(4,31) = 2.25$, $P < 0.09$; significant univariate Group effects for STAI/S, AR-anxiety and panic symptoms, all P's < 0.05, marginally significant effect for control symptoms, $P < 0.07$). There were no significant main effects of Time or interactions.

DISCUSSION

Our two studies provide evidence for selective information processing of threat cues in people with panic attacks. Panic disorder patients as well as non-clinical panickers showed greater interference in colour naming threat words than non-threat words. This effect was specific to threat-related words as panickers did not show greater interference with colour words (Study 2). Thus, the results could not be due to a general deficit in performing relatively difficult tasks in the panic group. A similar pattern of results was observed in spider phobics by Watts et al. (1986a). Overall, the results are consistent with an attentional bias towards material related to threat in people with panic attacks.

However, our results should be interpreted with caution. First, the effects found in our studies are small. Whereas the average colour naming times followed the pattern predicted by the hypothesis, standard deviations were large, especially in the panic groups. Future studies might attain clearer results by monitoring colour naming times of single words instead of averaging across a large number of trials. Secondly, the results seem to depend on how the stimulus material is presented. In a previous study that did not control the number of sequential colour repetitions and that differed in word legibility, we did not find evidence for greater interference with threat words in panic disorder patients. Thirdly, we cannot rule out that the effects were due to differences in response bias although the threat material was irrelevant for the colour naming task.

Despite these problems, the pattern of results from Studies 1 and 2 is consistent with the interpretation that persons with panic attacks differ from normal controls in their attentional bias to threat-related material. Threat cues put demands on limited processing resources also needed for task performance to a larger extent in panickers than in controls. This was especially the case for physical threat words: In both studies panickers colour named physical threat words more slowly than neutral words. This pattern of results is in line with psychophysiological models of panic disorder that postulate an association between bodily symptoms and danger as a primary feature of panic attacks (Ehlers et al., 1988b).

Emotional salience of words has been shown to cause interference in colour naming in several studies. The mechanisms of interference, however, are yet unclear and might differ from those of the standard Stroop test (Watts et al., 1986a). Emotional interference could stem from various attentional disturbances. There might be difficulty in forming and maintaining over time an attentional set to ignore word content. Colour naming times for single words would be relevant here as they might demonstrate increased interference over trials compatible with flagging attention. MacLeod & Mathews (submitted) have suggested that a critical feature of paradigms demonstrating attentional bias in anxiety patients is competition for cognitive resources, i.e. that subjects are required to select among processing options. In the Stroop studies, anxious and non-anxious subjects may differ in their ability to create or maintain processing priority for the task-relevant aspects (colour) of the stimulus input.

Another possibly important factor is arousal or activation level. At high levels performance may be impaired through attentional (e.g. distraction) or other mechanisms. Threat words could increase arousal and impair colour naming performance. The physiological measures recorded during colour naming in Study 1 (SCL, HR) do not support this explanation. Furthermore, correlations of interference effects and increases in self-rated anxiety were not significant. However, as we did not monitor changes in self-reported, subjective anxiety continuously, we cannot completely rule out this hypothesis.

In contrast to the Mathews and MacLeod (1985) colour naming study, we did not find a significant relationship between state anxiety and the magnitude of interference caused by threat material. Later studies of the Mathews group using different paradigms also failed to find correlations of state or trait anxiety with interference (Mathews & MacLeod, 1986; MacLeod et al., 1986). It is possible that attentional bias in panickers does not require an anxious mood state. This is especially plausible as panic patients often insist that their panic attacks have occurred in relaxed or positive mood states.

Another aspect of our results that differs from those of Mathews and MacLeod (1985) is the relationship between reactions to specific types of threat words and reported domain of worries. Mathews and MacLeod (1985) found that among patients with generalised anxiety disorder only those who reported physical worries showed increased interference by physical threat material on the Stroop test, although they were unable to verify this with other experimental paradigms (Mathews & MacLoed, 1986; MacLeod et al., 1986). In our studies, all panic disorder patients, including those who reported social worries as their primary concern, showed increased interference in colour naming physical threat words (Study 1). One might speculate that the different patterns of results reflect

differences in the danger schemata or fear structures of panic and generalised anxiety patients (see Foa & Kozak, 1986). A direct comparison of these patient groups would be desirable with the refinement that words be matched for intensity of threat. Such matching was not attempted by Mathews and MacLeod (1985) or ourselves.

A number of authors have suggested that anxiety patients maintain danger schemata in relatively permanent states of activation or that these fear structures are more easily activated by relevant input (Foa & Kozak, 1986; Ingram & Kendall, 1987; Mathews & MacLeod, 1985). Our results are compatible with the notion of active danger schemata for physical threat—and possibly social threat—in persons prone to panic attacks. The activation of such schemata would make it more likely for panickers than for controls to direct attentional resources to the processing of physical threat. Panickers may be unable to avoid attending to material associated with physical threat such as information related to disease or changes in body function.

If these attentional shifts occur without the subjects' awareness (for a discussion of this issue see Mathews & MacLeod, 1986; MacLeod et al., 1986; Trandel & McNally, 1987) or if subjects do not remember what instigated them, they would be unable to identify panic triggers. Our studies did not find evidence for differential recognition memory of threat words between patients and controls. These results are in line with previous research supporting attentional, but not memory bias in anxiety disorders (Mathews & MacLeod, 1985, 1986; Mogg et al., 1987). Thus, although panickers seem to direct their attention to threat cues, this increased attention is not reflected in better memory for this stimulus material. On the other hand, panickers as well as controls recognised threat words better than neutral words. Further clarification is necessary at which levels of attentional or memory processes information processing is biased in subjects with panic attacks.

Several questions remain to be addressed by future research. Longitudinal studies are needed to test the hypothesis that attentional bias may contribute to the maintenance of panic attacks. Furthermore, the specificity of biases to panic patients compared to other anxiety disorders or depression needs to be investigated. Finally, studies of attentional bias towards bodily stimulation would be desirable as psychophysiological models emphasise the role of physical symptoms as anxiety triggers in panic patients.

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Selective Processing of Threat Cues in Subjects with Panic Attacks

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Previous research has demonstrated that patients with generalised anxiety disorder, phobias, and obsessive-compulsive disorder show an attentional bias towards threat cues related to their respective disorders. Two studies are presented that used a modified Stroop colour naming task to assess attentional bias in subjects with panic attacks. In Study 1, 24 panic disorder patients and 24 normal controls were presented three cards containing threat words related to physical harm, separation, or social embarrassment. Colour naming times were compared between these cards and control cards containing matched non-threat words. Reaction time differences in the two groups were in opposite directions, patients tending to be slower in colour naming threat words, and controls, faster. In Study 2, 18 non-clinical panickers and 18 controls were presented cards containing physical threat words, neutral control words, or colour words, respectively. Panickers showed greater interference than controls in colour naming threat words but not in colour naming colour words. The results are consistent with an attentional bias for threat-related material in subjects with panic attacks. Implications for psychophysiological models of 'spontaneous' panic attacks are discussed.

INTRODUCTION

Panic attacks are discrete episodes of apprehension or fear accompanied by a variety of symptoms such as palpitations, dyspnea, sweating or dizziness. These attacks have been given a central role in the classification of anxiety

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disorders (APA, 1987). One of their most puzzling and fascinating features for clinicians and researchers is that they often occur in the absence of any perceived situational triggers.

Psychophysiological models of panic have recently received increasing attention and empirical support (for a review see Ehlers, Margraf, & Roth, 1988b). Panic attacks, including those that seem to occur "spontaneously", are seen as fear responses to *internal* stimuli, for example, bodily symptoms. Questionnaire studies have demonstrated that panic patients show a bias in the interpretation of bodily cues in that, compared to normal or clinical control groups, these patients report more fear of body sensations (McNally & Lorenz, 1987; Chambless, Caputo, Bright, & Gallagher, 1984) and tend to interpret bodily changes as indicators of an immediately impending danger (Clark et al., 1988; Foa, 1988; McNally & Foa, 1987; van den Hout, 1988a,b). Interview studies concur that catastrophic misinterpretations of body sensations occur during panic attacks (Beck, Laude, & Bohnert, 1974; Hibbert, 1984; Ottaviani & Beck, 1987; Rapee, 1985; Rachman, Levitt, & Lopatka, 1987; Zucker et al., submitted). Without further evidence from experimental or longitudinal studies, however, these results are inconclusive because they depend on the patients' recollections of their panic attacks. In addition, questionnaire and interview studies assess only conscious processes while the reported "spontaneity" demonstrates that patients have only limited insight into what triggers panic. Thus, at least some of the processes involved in panic might not be accessible by introspection.

Laboratory studies of experimental anxiety induction have demonstrated that the patients' anxiety responses depend on cognitive factors such as expectations, perceived control, or perception of bodily changes (Barlow, 1987; Clark et al., 1988; Ehlers, Margraf, & Roth, 1988a; Ehlers, Margraf, Roth, Taylor, & Birbaumer, 1988c; Foa, 1988; Margraf, Ehlers, & Roth, 1986b; in press; Rapee, Mattick, & Murrell, 1987; van den Hout, 1988a,b). In the present studies we used a different experimental approach other than anxiety induction to investigate cognitive processes in panic disorder. Researchers have recently started to apply methods developed in experimental cognitive psychology to the study of anxiety disorders (for a review see Mathews & Eysenck, 1987). They have found that anxiety patients show an attentional bias towards threat cues related to their respective disorders.

Most relevant to the study of panic disorder is a series of experiments of Mathews, MacLeod, and co-workers on information processing in generalised anxiety disorder. Like panic patients, these patients suffer from severe anxiety not triggered by phobic situations. In reaction time paradigms, for example, the Stroop colour naming task (Mathews & MacLeod, 1985), dichotic listening (Mathews & MacLeod, 1986), or a visual probe detection

task combined with word reading (MacLeod, Mathews, & Tata, 1986), generalised anxiety patients showed an attentional bias for material representing social threat (words like "stupid", "hated") or physical threat (for example, "paralysed" or "disease"). Whereas patients shifted their attention towards emotionally threatening material, controls tended to shift attention away from such material (MacLeod et al., 1986). The simultaneous presentation of threatening material interfered more with the patients' task performance than with that of controls (Mathews & MacLeod, 1985, 1986). Patients could not recall or recognise the threat words better than controls (Mathews & MacLeod, 1985, 1986), although they had responded to them differently. Mathews and MacLeod interpreted these results as meaning that the attentional shifts occurred outside of awareness.

The same pattern of results has been found for other anxiety disorders such as phobias (Burgess et al., 1981; Streblow, Hofmann, & Kasielke, 1985; Watts, MacKenna, Sharrock, & Trezise, 1986a) and obsessive compulsive disorder (Foa & McNally, 1986). Anxiety patients detected anxiety-relevant information in unattended material better or faster than neutral information (Burgess et al., 1981; Foa & McNally, 1986; Streblow et al., 1985), whereas control groups did not show this response pattern. When anxiety patients were presented with task-irrelevant but anxiety-relevant information, greater interference with task performance was found than in controls, even when subjects were told to ignore this information (Watts et al., 1986a). The patients' attentional bias disappeared after successful behaviour therapy indicating that the effects were not due to differences in familiarity with the stimulus material (Foa & McNally, 1986; Watts et al., 1986a). Memory processes are probably less strongly affected in anxious than in depressed patients (Mathews & MacLeod 1985, 1986; Mogg, Mathews, & Weinman, 1987; Watts, Trezise, & Sharrock, 1986b).

What kind of threat cues are relevant to the study of panic attacks? *Physical* threat seems to be especially important because patients report fear of bodily symptoms or disease and psychophysiological models emphasise the role of bodily cues as panic triggers. Material related to *separation* could be relevant since it has been hypothesised that panic disorder is a form of separation anxiety (Klein, 1980; cf. Margraf et al., 1986a). Social *embarrassment* is of interest because patients frequently report that they are afraid of doing something embarrassing when having a panic attack in public (e.g. Chambless et al., 1984; Goldstein & Chambless, 1978).

The goal of the present studies was to investigate whether patients with panic disorder and non-clinical panickers show attentional biases to threat cues. Such attentional processes might help explaining the occurrence of panic attacks in the apparent absence of situational triggers. It is possible

that information processing of threat cues without the patient's awareness is involved in triggering panic (cf. Mathews & MacLeod, 1986).

In a previous unpublished study of 30 panic disorder patients and 24 controls, we had investigated colour naming of threat and control words, but failed to find differences in interference effects between the groups. Patients took longer than controls to colour name both threat and non-threat words. However, there were methodological shortcomings in the stimulus material that may have accounted for the negative findings. Words were presented in a random order without the restriction of no colours being repeated in a row. It so happened that the number of these colour repetitions was unevenly distributed across cards. Colour naming times were influenced by this factor, as reaction times were shorter for cards with more sequential colour repetitions. In addition, the words were printed in larger and bolder letters than the ones used by Watts et al. (1986a) and Mathews and MacLeod (1985). Our impression was that the letters were so big that subjects could easily focus on a part of the word and miss the entire Gestalt. Furthermore, the cards differed from those used by Mathews and MacLeod in that the words were written in three instead of eight columns.

Although our findings were generally negative, there were a few differences between the groups. Patients, but not controls, had larger skin conductance levels (SCL) when colour naming threat words (Group × Condition interaction for log SCL: $F(1,50) = 6.01$, $P < 0.02$). In addition, although both groups discriminated threat words better than control words on a recognition questionnaire, the difference was larger in the patient group (Group × Condition interaction: $F(1,52) = 4.12$, $P < 0.05$). Therefore, we decided to repeat the study with revised stimulus material.

STUDY 1

Method

Subjects

Twenty-four panic attack patients (16 women, 8 men) and 24 control subjects (16 women, 8 men) participated in this study. All were Caucasian. Patients had been recruited to participate in a treatment study at Stanford University. They had been asked to discontinue taking any psychotropic medication for at least 10 days before testing. Four patients and one control who had originally participated in the protocol had to be excluded because they had failed to comply with this requirement. They were replaced by subjects that were subsequently admitted to the study.

Patients met DSM-III criteria for panic disorder or agoraphobia with panic attacks as determined by the Structured Interview for DSM-III-

TABLE 1
Study 1: Subjects

	Patients (*n* = 24)	*Controls* (*n* = 24)
Age	35.5 (10.1)	36.2 (10.4)
Education (in years)	14.5 (1.9)	15.9 (1.8)
Trait Anxiety (STAI/T)	48.9 (10.4)	32.1 (6.8)
State Anxiety (STAI/S)	44.5 (10.1)	27.8 (6.2)
Depression (BDI, short form)	8.1 (6.5)	1.3 (2.1)
Avoidance (MI)		
accompanied	1.78 (0.58)	1.17 (0.22)
alone	2.55 (0.61)	1.31 (0.33)

Means (standard deviations) are given in brackets.

Upjohn version (SCID-UP, Spitzer & Williams, 1983). Patients were excluded if they had any history of major depressive episodes that preceded the onset of panic attacks. Control subjects described themselves as "non-anxious". They had to be free of any history of psychiatric problems as determined by the SCID-UP and a structured interview based on the SADS-L (Spitzer & Endicott, 1978). They were paid for their participation.

The groups were matched for age, ranging from 20 to 62 in the patient, and from 22 to 59 in the control group. All subjects were in good physical health as determined by medical history and physical examination. Table 1 shows the subjects' mean age, years of formal education, trait anxiety scores (State-Trait-Anxiety-Inventory, STAI/T, Spielberger, Gorsuch, & Luschene, 1970), state anxiety scores at baseline (STAI/S), Beck Depression Inventory scores (BDI, short version, Beck & Beck, 1972), and Mobility Inventory scores (a measure of agoraphobic avoidance behaviour; Chambless et al., 1985). Patients and controls differed significantly on all of the measures (all P's < 0.01) except age. Informed consent was obtained from all subjects after the nature of the procedures had been explained.

Procedure

General Procedure. Test sessions took place in the afternoon between 1 p.m. and 5 p.m. The experimenter allowed the subjects time to familiarise themselves with the laboratory environment. Subjects had spent more than one hour in the laboratory before baseline recordings began.

Colour Naming Task. A modified Stroop colour naming task similar to the one of Mathews and MacLeod (1985) was used to assess attentional bias. Subjects were asked to colour name cards (21 × 30cm) on which 96 words were handwritten in red, blue, green, or yellow. The size of the block capital letters was 0.5cm. Each card contained a set of 12 different words. This set of words was repeated 8 times in random order. Thus, a card contained 8 columns of 12 words to give a total of 96. The restriction was that the same colour did not occur twice in a row.

Three of the six cards contained threat words related to three categories (a list of the stimulus material is available from the authors):

Physical threat words (e.g. "disease" or "fatal"; the word list used by Mathews & MacLeod, 1985);
words related to *separation* (e.g. "separation", "lonely"); and
words related to *embarrassment* (e.g. "stupid", "humiliation").

The social threat stimulus set constructed by Mathews and MacLeod (1985) shows considerable overlap with our embarrassment scale. Our scale was slightly different in that we dropped words related to separation. In addition, British words that might be misunderstood by our subjects were replaced with American terms.

For each of the cards, a control card was constructed with neutral or positive (non-threat) words matched for word frequency and length (such as "leisure", "alert", "faithful", or "optimism"). The number of nouns, verbs, and adjectives was also matched. For the pair-wise frequency matching of threat and control words, we used the Standard Frequency Index (SFI) as recommended by Carroll, Davies, and Richman (1971). After a practice run with a card containing neutral words like "house" or "apple", the six cards were presented in balanced order. Subjects were instructed to name the word colours as fast as possible without making mistakes, and without attending to the word content. Between the single cards, subjects had a break of about one minute.

The colour naming test was presented after a 15min baseline. During the test, the experimenter sat next to the subject, took the colour naming time with a stopwatch, and monitored possible mistakes. After the colour naming test, subjects answered a recognition questionnaire containing the 72 words previously shown on the cards, randomly interspersed with 72 other (distractor) words. The distractor words were matched for threat content and word frequency. Thus, there were a total of 36 distractor words relating to physical threat, separation, or embarrassment, and 36 non-threat words. Subjects indicated whether they believed that they had seen the words during the colour naming task. Finally, the experimenter asked the subject what their primary worry was, i.e. whether they charac-

teristically worried more about their health (physical danger) or about interpersonal issues. If they worried more about the latter, they were asked whether their worries were more related to separation from significant other people or to embarrassment.

Assessment

The main dependent variable and indicator of information processing was the time it took subjects to colour name each of the cards. The time was measured by the experimenter with a stopwatch to the nearest second. To assess incidental memory, we calculated the number of hits and false alarms in the recognition questionnaire for each of the threat and control cards.

In addition, subjects' physiological and subjective responses to the colour naming tasks were recorded to look for possible differences between the groups. During the test, heart rate (HR) and skin conductance level (SCL) were continuously monitored. The EKG was recorded from electrodes over the 10th left rib on the midclavicular line and the right mastoid. Skin conductance was recorded from a pair of Ag–AgCl disc electrodes, 0.8cm^2 in area, both placed on the thenar eminence of the non-dominant hand. The electrolyte medium was a mixture of creamy ointment and physiological saline as recommended by Fowles, Christie, Edelberg, Grings, Lykken, and Venables (1981). The skin conductance transducer applied a constant 0.5V across the electrodes. Average HR and SCL levels during colour naming were calculated for each of the cards.

Before and after the test, subjects rated their anxiety and excitement on a scale from 0 (labelled "none") to 10 (labelled "extreme") (Anxiety Rating Scale, AR, Ehlers et al., 1986). In addition, they completed the state version of the Spielberger State-Trait Anxiety Inventory (STAI/S, Spielberger et al., 1970). On a symptom checklist, they indicated which of 15 panic and five control symptoms they experienced (Margraf et al., in press).

Results

The significance levels given in this paper are two-tailed.

Colour Naming Times. In an overall statistical analysis, we averaged the times to colour name each of the three threat cards and the three control cards, respectively. The results are shown in Table 2. A repeated measures ANOVA comparing the two groups (Group factor, patients vs. controls) and the two word valences (Valence factor, threat vs. control words) showed a significant Group × Valence interaction ($F(1,46) = 5.73$;

TABLE 2
Study 1: Average Colour Naming Times for Three Cards

	Patients (*n* = 24)	*Controls* (*n* = 24)
Threat words	74.7 (16.5)	69.7 (9.8)
Non-threat words	73.5 (15.6)	71.4 (9.9)

Means and standard deviations (in sec).

$P < 0.05$). Main effects were not significant. To clarify this interaction further, it was reduced to simple main effects as described by Winer (1970). Analyses of the Valence factor for panic and control subjects separately showed that the interaction resulted from non-significant reaction time differences being opposite in direction between the two groups: while patients tended to be slower when colour naming threat words ($F(1,46) = 1.99$; n.s.), controls tended to be faster ($F(1,46) = 3.90$; n.s.).

Further statistical analyses were performed to test whether the interaction occurred for each type of threat word. Means and standard deviations are shown in Table 3. An ANOVA comparing the reaction times of patients and controls (Group factor) for threat and control words (Valence factor) of the three types of threat material (Type factor, which was called the Material factor in the study of Mathews & MacLeod, 1985) showed a main effect of Type ($F(2,92) = 9.24$; $P < 0.001$) and both a Type × Valence interaction ($F(2,92) = 5.73$; $P < 0.005$) and a Group × Valence interaction ($F(1,46) = 5.73$; $P < 0.05$). Separate ANOVAs for each threat type showed a significant Group × Valence interaction only for *physical* threat ($F(1,46) = 4.17$; $P < 0.05$) and not for the two types of

TABLE 3
Study 1: Colour Naming Times for Single Cards

	Patients (*n* = 24)	*Controls* (*n* = 24)
Physical threat	76.3 (15.6)	70.8 (13.0)
Non-threat words	72.7 (15.3)	71.0 (9.6)
Separation	74.9 (17.1)	69.9 (10.0)
Non-threat words	76.2 (17.1)	74.0 (12.0)
Embarrassment	72.8 (18.0)	68.3 (8.5)
Non-threat words	71.5 (16.3)	69.2 (10.3)

Means and standard deviations (in sec).

TABLE 4
Study 1: Mean Colour Naming Times (in sec)[1] of Subjects with Physical or Social Worries

	Patients		*Controls*	
	Physical Worries (n = 16)	*Social Worries (n = 7)*	*Physical Worries (n = 12)*	*Social Worries (n = 11)*
Physical threat	72.7	84.9	70.1	72.5
Non-threat	69.3	80.3	69.5	73.9
Social threat	69.6	83.9	68.8	70.2
Non-threat	69.8	83.0	69.9	74.5

Social threat is the average of the separation and embarrassment conditions.

social threat words. However, the Group × Valence × Type interaction was not significant.

The distribution of subjects' major concerns did not differ between the groups. Sixteen patients and 12 controls worried mostly about their health, 6 patients and 8 controls about issues of separation, and 1 patient and 3 controls about social embarrassment. One subject in each group could not come to a decision. Following Mathews and MacLeod (1985), we further analysed colour naming times by dividing the patient and control groups according to the threat domain reported as most worrisome. As too few subjects chose embarrassment, we averaged the colour naming times for the two social threat cards and for their control cards, respectively, and compared physical and social worriers (Worry factor). The results are shown in Table 4. In the ANOVA, there was a marginally significant main effect of the Worry factor ($F(1,42) = 4.02$, $P < 0.06$), but no interactions with other factors. As in the analysis described above, significant Group × Valence ($F(1,42) = 7.99$, $P < 0.01$) and Valence × Type interactions ($F(1,42) = 5.30$; $P < 0.05$) were found. Differences in colour naming times tended to be opposite in direction between patients and controls.

Relationship to Anxiety and Depression. As shown in Table 1, patients and controls differed not only in anxiety, but also in depression and education. We analysed which of the variables was most closely related to the disruption of colour naming threat vs. non-threat words by calculating product–moment correlations between a threat interference score (difference of the average colour naming times for threat and control words) and

state anxiety, trait anxiety, anxiety increases with the test (STAI), depression (BDI), and years of education. Noen of the correlations were significant within either the patient or control group, but for the total sample, depression correlated significantly with interference ($r = 0.36$, $P < 0.05$). However, neither depression nor anxiety or education, when used as covariates in ANCOVAS of colour naming times, abolished the significance of the Group × Valence interactions.

Other Measures. Most subjects did not make any mistakes in colour naming, so a statistical comparison of patients and controls was impossible. In the recognition questionnaire, patients (controls) identified 45.0% (48.3%) of the threat words and 32.5% (41.2%) of the control words correctly (hits). In addition, patients (controls) marked 24.3% (22.8%) of the threatening and 27.1% (34.7%) of the non-threat distractor words (false alarms). The data were subjected to a signal-detection analysis. For each subject, measures of sensitivity (d') and response bias (log β) were determined for each of the six sets of words (McNicol, 1972). An ANOVA of the average sensitivity scores for danger and control words showed a significant Valence effect ($F(1,46) = 61.33$; $P < 0.0001$), patients and controls discriminating threat words better than control words. There were no Group effects or Group × Valence interactions. The results were the same when separate analyses were performed for each of the three threat types. Similarly, a Valence effect ($F(1,46) = 9.67$, $P < 0.005$), but no Group effect or interaction were found for response bias (log β). Both groups tended to endorse more threat than control words.

Mean heart rates and skin conductance levels during colour naming were calculated for each of the cards. There were no differences between the groups or between danger and control cards.

The subjects' responses to the colour naming test were analysed by a multivariate analysis of variance comparing self-reports of anxiety (STAI/S, AR), excitement (AR), panic, and control symptoms of patients and controls (Group factor) at the end of the 15min baseline and after colour naming (Time factor). Patients rated themselves as more anxious and reported more symptoms than controls (overall Group effect: $F(5,42) = 13.91$, $P < 0.0001$; significant univariate Group effects for STAI/S, AR-anxiety, panic, and control symptoms, all P's < 0.01). Significant main effects of the Time factor were only found for self-rated excitement (overall Time effect: $F(5,42) = 2.84$, $P < 0.05$; univariate Time effect: $F(1,46) = 7.35$, $P < 0.01$). Both groups rated themselves as more excited after the colour naming test. Because the overall Group × Time interaction was not significant, trends towards larger increases in anxiety (STAI/S, AR) in the patient group cannot be interpreted.

STUDY 2

Study 1 provided preliminary evidence for selective processing of threat cues in patients with panic disorder. In Study 2, we attempted to replicate these results in a sample of non-clinical subjects with panic attacks. We were interested in this subject group to rule out possible sampling biases associated with clinical samples. Differences between clinical patients and controls might be due to factors other than having panic attacks, for instance, factors related to help-seeking behaviour.

Method

Subjects

Study 2 compared 18 non-clinical panickers (12 women, 6 men) and 18 control subjects (12 women, 6 men). Subjects were selected from a larger group of undergraduates participating in psychology courses (n = 136) who had completed a German translation of the Panic Attack Questionnaire by Norton, Dorward, and Cox (1986) (for details about the selection procedure see Margraf & Ehlers, 1988).

In the PAQ, 59% of the subjects reported at least 1 panic attack in the past year. Twenty-nine subjects who fulfilled criteria for panic attacks according to the PAQ were invited for a Structured Clinical Interview for DSM-III-R diagnoses (SCID-P, Spitzer & Williams, 1986; German translation of Margraf & Ehlers, unpublished). Of these 29 questionnaire-determined panickers, 19 met DSM-III-R criteria for at least 1 panic attack (SCID) and were thus eligible for Study 2. One panicker, however, had to be excluded because she started to cry when colour naming threat words and refused to continue the test. Eight of the non-clinical panickers included in Study 2 reported a history of panic attacks frequent enough for a DSM-III-R diagnosis of panic disorder. The 10 subjects who had reported panic attacks on the PAQ, but did not meet DSM-III-R criteria were excluded. For a more detailed description of the comparison of interview and questionnaire data see Margraf and Ehlers (1988).

Control subjects did not endorse panic attacks on PAQ and were free of any history of psychiatric problems as determined by the SCID. The groups were of comparable age, ranging from 20 to 40 in the panic, and from 19 to 33 in the control group. All subjects were in good physical health by self-report and did not take any medication. Table 5 shows the subjects' mean age, trait anxiety scores (STAI/T, German version of the State-Trait Anxiety Inventory, Laux, Glanzmann, Schaffner, & Spielberger, 1981), state anxiety scores at baseline (STAI/S), Beck Depression Inventory scores (BDI, German 21-item version, Kammer, 1983), and

TABLE 5
Study 2: Subjects

	Panickers (*n* = 18)	*Controls* (*n* = 18)
Age	25.2 (5.2)	24.7 (4.6)
Trait Anxiety (STAI/T)	44.9 (8.2)	37.8 (8.0)
State Anxiety (STAI/S)	43.3 (9.7)	36.6 (9.6)
Depression (BDI, long form)	13.6 (8.3)	5.4 (3.0)
Avoidance (MI)		
accompanied	1.38 (0.38)	1.15 (0.18)
alone	1.70 (0.55)	1.47 (0.36)

Means (standard deviations) are given in brackets.

Mobility Inventory scores (German translation, Ehlers & Margraf, unpublished). Except for age and avoidance behaviour when alone (Mobility Inventory score), panickers and controls differed significantly on all measures (all P's < 0.05).

Procedure

The experimenter was unaware of the diagnostic status of the subjects.

Colour Naming Task. Subjects were asked to colour name cards similar to those used in Study 1, but different in a number of details: The cards contained 72 words (6 columns of 12 words) written in red, blue, green, or black. The physical threat items consisted of 12 words such as "disease" or "death". A control card was constructed of neutral words ("box", "air") matched to threat words for length and frequency (Meier, 1967). Both stimulus sets consisted of 11 nouns and 1 verb. In this study, we omitted the social threat conditions and added a control condition in which subjects were asked to colour name colour words (standard Stroop test).

After a practice run with a card containing neutral words like "house" or "bird", the standard Stroop card (colour words) was given. The physical threat and control cards were then presented in balanced order. After the colour naming test, subjects answered a recognition questionnaire containing the 24 words previously shown on the cards and 24 distractor words.

Assessment

Assessments were similar to Study 1 with the exception that heart rate, skin conductance level, and self-rated excitement were not measured.

TABLE 6
Study 2: Colour Naming Times

	Panickers (*n* = 18)	*Controls* (*n* = 18)
Physical threat words	56.4 (11.5)	49.8 (5.9)
Non-threat words	49.1 (7.7)	46.6 (5.5)
Colour words	71.1 (17.3)	68.8 (10.1)

Means and standard deviations (in sec).

Results

Colour Naming Times. Colour naming times of panickers and controls are shown in Table 6. Repeated measures ANOVA of colour naming times for threat and control words showed a significant Group × Valence interaction ($F(1,34) = 5.21$, $P < 0.05$) and a highly significant Valence effect ($F(1,34) = 36.30$, $P < 0.001$). The Group effect did not reach significance ($F(1,34) = 3.24$, $P < 0.09$). The results were the same when colour naming times were logarithmically transformed. Analyses of simple main effects of the Valence factor showed that both panickers and controls took significantly longer to colour name threat words ($F(1,34) = 34.53$, $P < 0.001$ for panickers; $F(1,34) = 7.01$, $P < 0.05$ for controls), the interference being greater in the panic group ($t = 2.28$, $P < 0.05$).

To test whether the greater interference of panickers was specific to the threat condition, colour naming times for colour words were compared to those for neutral words. (Because the colour word condition was always given first, we decided not to do an overall ANOVA comparing neutral, threat, and colour words.) Both groups were much slower in colour naming colour words than neutral words (Condition effect: $F(1,34) = 178.18$, $P < 0.0001$) and here there was no Group × Condition interaction ($F(1,34) = 0.01$, $P > 0.90$). Both groups were about 12sec slower in colour naming colour words than neutral words.

Relationship to Anxiety and Depression. Correlations of state and trait anxiety, anxiety increases (STAI), and depression (BDI) with the difference between colour naming times for threat and non-threat words (threat interference scores) were non-significant.

Other Variables. On the recognition questionnaire, both groups identified more threat words correctly than control words (Condition factor: $F(1,34 = 29.14$, $P < 0.0001$) and there were no interactions with the Group factor. Subjects' responses to the colour naming task were analysed

by a multivariate analysis of variance comparing self-reports of anxiety (STAI/S, AR), panic and control symptoms of panickers and controls (Group factor) before and after colour naming (Time factor). Panickers tended to rate themselves as more anxious and to report more symptoms than controls (overall Group effect: $F(4,31) = 2.25$, $P < 0.09$; significant univariate Group effects for STAI/S, AR-anxiety and panic symptoms, all P's < 0.05, marginally significant effect for control symptoms, $P < 0.07$). There were no significant main effects of Time or interactions.

DISCUSSION

Our two studies provide evidence for selective information processing of threat cues in people with panic attacks. Panic disorder patients as well as non-clinical panickers showed greater interference in colour naming threat words than non-threat words. This effect was specific to threat-related words as panickers did not show greater interference with colour words (Study 2). Thus, the results could not be due to a general deficit in performing relatively difficult tasks in the panic group. A similar pattern of results was observed in spider phobics by Watts et al. (1986a). Overall, the results are consistent with an attentional bias towards material related to threat in people with panic attacks.

However, our results should be interpreted with caution. First, the effects found in our studies are small. Whereas the average colour naming times followed the pattern predicted by the hypothesis, standard deviations were large, especially in the panic groups. Future studies might attain clearer results by monitoring colour naming times of single words instead of averaging across a large number of trials. Secondly, the results seem to depend on how the stimulus material is presented. In a previous study that did not control the number of sequential colour repetitions and that differed in word legibility, we did not find evidence for greater interference with threat words in panic disorder patients. Thirdly, we cannot rule out that the effects were due to differences in response bias although the threat material was irrelevant for the colour naming task.

Despite these problems, the pattern of results from Studies 1 and 2 is consistent with the interpretation that persons with panic attacks differ from normal controls in their attentional bias to threat-related material. Threat cues put demands on limited processing resources also needed for task performance to a larger extent in panickers than in controls. This was especially the case for physical threat words: In both studies panickers colour named physical threat words more slowly than neutral words. This pattern of results is in line with psychophysiological models of panic disorder that postulate an association between bodily symptoms and danger as a primary feature of panic attacks (Ehlers et al., 1988b).

Emotional salience of words has been shown to cause interference in colour naming in several studies. The mechanisms of interference, however, are yet unclear and might differ from those of the standard Stroop test (Watts et al., 1986a). Emotional interference could stem from various attentional disturbances. There might be difficulty in forming and maintaining over time an attentional set to ignore word content. Colour naming times for single words would be relevant here as they might demonstrate increased interference over trials compatible with flagging attention. MacLeod & Mathews (submitted) have suggested that a critical feature of paradigms demonstrating attentional bias in anxiety patients is competition for cognitive resources, i.e. that subjects are required to select among processing options. In the Stroop studies, anxious and non-anxious subjects may differ in their ability to create or maintain processing priority for the task-relevant aspects (colour) of the stimulus input.

Another possibly important factor is arousal or activation level. At high levels performance may be impaired through attentional (e.g. distraction) or other mechanisms. Threat words could increase arousal and impair colour naming performance. The physiological measures recorded during colour naming in Study 1 (SCL, HR) do not support this explanation. Furthermore, correlations of interference effects and increases in self-rated anxiety were not significant. However, as we did not monitor changes in self-reported, subjective anxiety continuously, we cannot completely rule out this hypothesis.

In contrast to the Mathews and MacLeod (1985) colour naming study, we did not find a significant relationship between state anxiety and the magnitude of interference caused by threat material. Later studies of the Mathews group using different paradigms also failed to find correlations of state or trait anxiety with interference (Mathews & MacLeod, 1986; MacLeod et al., 1986). It is possible that attentional bias in panickers does not require an anxious mood state. This is especially plausible as panic patients often insist that their panic attacks have occurred in relaxed or positive mood states.

Another aspect of our results that differs from those of Mathews and MacLeod (1985) is the relationship between reactions to specific types of threat words and reported domain of worries. Mathews and MacLeod (1985) found that among patients with generalised anxiety disorder only those who reported physical worries showed increased interference by physical threat material on the Stroop test, although they were unable to verify this with other experimental paradigms (Mathews & MacLoed, 1986; MacLeod et al., 1986). In our studies, all panic disorder patients, including those who reported social worries as their primary concern, showed increased interference in colour naming physical threat words (Study 1). One might speculate that the different patterns of results reflect

differences in the danger schemata or fear structures of panic and generalised anxiety patients (see Foa & Kozak, 1986). A direct comparison of these patient groups would be desirable with the refinement that words be matched for intensity of threat. Such matching was not attempted by Mathews and MacLeod (1985) or ourselves.

A number of authors have suggested that anxiety patients maintain danger schemata in relatively permanent states of activation or that these fear structures are more easily activated by relevant input (Foa & Kozak, 1986; Ingram & Kendall, 1987; Mathews & MacLeod, 1985). Our results are compatible with the notion of active danger schemata for physical threat—and possibly social threat—in persons prone to panic attacks. The activation of such schemata would make it more likely for panickers than for controls to direct attentional resources to the processing of physical threat. Panickers may be unable to avoid attending to material associated with physical threat such as information related to disease or changes in body function.

If these attentional shifts occur without the subjects' awareness (for a discussion of this issue see Mathews & MacLeod, 1986; MacLeod et al., 1986; Trandel & McNally, 1987) or if subjects do not remember what instigated them, they would be unable to identify panic triggers. Our studies did not find evidence for differential recognition memory of threat words between patients and controls. These results are in line with previous research supporting attentional, but not memory bias in anxiety disorders (Mathews & MacLeod, 1985, 1986; Mogg et al., 1987). Thus, although panickers seem to direct their attention to threat cues, this increased attention is not reflected in better memory for this stimulus material. On the other hand, panickers as well as controls recognised threat words better than neutral words. Further clarification is necessary at which levels of attentional or memory processes information processing is biased in subjects with panic attacks.

Several questions remain to be addressed by future research. Longitudinal studies are needed to test the hypothesis that attentional bias may contribute to the maintenance of panic attacks. Furthermore, the specificity of biases to panic patients compared to other anxiety disorders or depression needs to be investigated. Finally, studies of attentional bias towards bodily stimulation would be desirable as psychophysiological models emphasise the role of physical symptoms as anxiety triggers in panic patients.

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