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Responding to subliminal threat cues is related to trait anxiety and emotional vulnerability: a successful replication of Macleod and Hagan (1992)

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Summary—Macleod and Hagan (1992) [*Behaviour Research and Therapy, 30,* 151–161] reported that threat-relevant interference on a masked Stroop task, where neutral and negative words cannot be consciously perceived, is positively correlated with trait anxiety and emotional vulnerability to stressful life events. Their findings were obtained from subjects who were currently stressed. The aim of the present study was to determine whether the Macleod and Hagan findings could be replicated in a sample that was not currently stressed. Using a sample of 32 volunteers, we found a significant correlation between trait anxiety and threat-relevant interference on a masked Stroop. Furthermore, it was found that the single best predictor of vulnerability to life stress was the interference on the masked Stroop. The findings of the present study correspond quite closely to those reported by Macleod and Hagan (1992).

INTRODUCTION

Studies using the modified Stroop task consistently show that anxious patients are slower in colournaming threat words than neutral words. Normal subjects do not show this threat-relevant interference and in some studies they were reported to show the opposite bias (Macleod, 1990). The performance of anxious patients is typically seen as a manifestation of attentional bias; attentional resources are said to be selectively allocated to threat cues. In the modified Stroop, as typically used, subjects are aware of the words to be colournamed. Recently, Mogg, Bradley, Williams and Mathews (1993) presented the Stroop words subliminally. That is, after very brief presentation, the words were replaced by a coloured mask, preventing conscious identification of the masked word. Anxious *S*s were slower to colourname the mask if it was preceded by negative words than by neutral words. Normal *S*s did not show this threat-interference. These observations confirm Williams, Watts, Macleod and Mathews' (1988) hypothesis that attention bias operates automatically and does not require consciousness.

Macleod and Hagan (1992) suggest that assessment of automatic attention bias with the masked Stroop is useful in applied settings. In a group of 31 women awaiting colposcopy, they found no correlation between threat interference on the unmasked Stroop and trait and state anxiety. Threat interference on the *masked* Stroop however did correlate with trait anxiety (0.38) and state anxiety (0.36). The authors assessed 15 women who later received a diagnosis of cervical pathology. They found the single best predictor of seriousness of emotional distress was Threat Interference on the Masked Stroop (in the following abbreviated as 'TIMS'). The predictive power of TIMS was not due to its association with trait anxiety. The authors concluded that TIMS provides a measure of emotional vulnerability that may have important implications for clinical practice. That is, the results should predict who will become more distressed when faced with important life stressors. But there is a problem. In an earlier study, Macleod and Rutherford (1992) found that high trait anxious subjects displayed an attention bias on a masked stroop task only if they experienced current situational stress. Note that in the Macleod and Hagan (1992) colposcopy study too, the women had reason for profound anticipatory anxiety. Indeed, their state anxiety scores were high for a non-psychiatric group. But in the applied settings where TIMS is held to be useful, subjects are likely not to be as stressed as the subjects from the studies reviewed above. If the masked Stroop is to be used in predicting distress, the observations from the Macleod and Hagan study should be replicable in subjects not currently suffering from acute situational distress.

Acknowledging the potential applied utility of the masked Stroop, we investigated whether selective attention to subliminal threat cues, measured by TIMS, is related to self-report measures of anxiety and emotional vulnerability in subjects who are not currently exposed to environmental stress.

METHOD

Subjects

34 healthy students participated in exchange for a small remunerative reward. There were 11 men and 23 women. Mean age was 23 years.

Assessments

State/trait anxiety. Subjects completed the state and trait versions of State Trait Anxiety Inventory (Spielberger, 1983).

Vulnerability questionnaire. An indication of perceived emotional vulnerability was obtained by an *ad hoc* constructed questionnaire that was independently piloted. On 0–100 scale, *S*s indicated how upset they would be if they would find

themselves in 15 different stressful situations. The same items were scored in a second version, but now *S*s indicated how upset they thought other people would be in response to these events. Item scores were subtracted and the 15 differences were added up; a positive end score indicating that a *S* saw him/herself as more vulnerable than others; a negative score indicating that (s)he viewed him/herself as relatively invulnerable. The difference-scores on this Vulnerability Questionnaire were internally consistent (alpha = 0.86).

Modified Stroop

Stimulus words were administered on slides, projected into a white wall, approx. 2.5 m in front of the *S*. Depending on the number of letters constituting the word, its length was 26–54 cm; height was 9 cm. Each presentation was preceded by a 1 sec warning tone administered by earphones. The interval between slide onset was 3 sec. A compar shutter, directed by a Compaq Deskpro 386/25 e personal computer, assured exact time of slide onset. A Sony Cardoid Dynamic microphone F560, which *S*s held in their hands, was connected to a voice level detector that stopped the computer's clock at the initiation of the *S*s vocal response. Slide presentation was stopped at the moment of vocalization. Target words that were presented supraliminally were projected in red, yellow, blue and green on a grey background. The same colours were used with the sub-liminal presentations. Here the target word was, after exactly 30 Msec, replaced by a mask consisting of a randomly selected letterstring containing as many letters as the masked word. The mask had the same colour as the masked word and was projected by a different Kodak Carousel, directed by the same PC.

There were four types of stimuli: (1) unmasked threat words, (2) unmasked neutral words; (3) masked threat words; and (4) masked neutral words. The threat words used were "war", "hate", "treachery", "torture", "violence", "deceit", "abuse" and "murder". Neutral words were "Square", "coatpocket", "fork", "potato", "percent", "month", "blanket" and "key." Threat and neutral words were matched for number of syllables and total length in the Dutch language and were the same as those used in an earlier study (Lavy, van Oppen & van den Hout, 1994). Each word was presented in each of the four colours under both masked and unmasked conditions. Thus, each of the 16 words was presented 8 times. Presentation of the various words was determined randomly, with the restriction that neither a particular colour, nor a particular word type (threat vs neutral), nor a condition (masked vs unmasked) was presented more than three consecutive times. For each *S* the threat interference was computed by subtracting colournaming latencies for neutral words from the latency for threat words. This was done separately for Masked and Unmasked conditions.

Awareness check

Pilot studies demonstrated that, with a 30 Msec masked presentation, the pertinent word is not consciously recognized. To ascertain that in the present sample too *S*s were unaware of the to be presented cues, the experiment started with an awareness-check. Five words and 5 non-words (the same type of random letter string as described above) were presented for 30 Msec and then replaced by a mask. *S*s were told that the chance of a mask being preceded by a word was exactly 50% and they were urged to verbally indicate whether a pertinent mask was preceded by a word or a non-word.

PROCEDURE

Subjects were instructed to ignore the meaning of the targets to be presented and to name its colour as quick as possible. To become familiar with the procedure, the experiment started with 4 practice trials consisting of 2 masked and 2 unmasked word presentations. Afterwards, the awareness check was done and then the actual colournaming task was performed. Questionnaires were scored immediately after the experiment.

RESULTS

The awareness checks indicated that *S*s were unaware of the masked cues: when asked to tell whether a masked cue was a word or a non-word, 52% of the responses were correct; chance probability being 50%.

Following the findings of Macleod and Hagan, we predicted significant correlations between TIMS and (a) state-trait anxiety and (b) emotional vulnerability. To avoid possibly unwarranted metric assumptions about TIMS, rank order correlations were used. Table 1 shows that the earlier findings were replicated: there were significant correlations between TIMS and state/trait anxiety and between TIMS and emotional vulnerability.

In the Macleod and Hagan study, TIMS was the *only* predictor of vulnerability; correlations of vulnerability with other measures were not significant. Inspection of the bottom row of Table 1 shows that this observation too was replicated. Finally, we tried to determine if the correlation between masked threat interference and vulnerability remains significant when trait anxiety is partialled out. Acknowledging that Spearman's non-parametric 'r' is essentially a parametric correlation on parameter-values recoded as ranks, a partial correlation was carried out on ranked parameter values. When trait anxiety was partialled out, there still was a significant correlation between masked threat interference and vulnerability ($r = 0.31$; $P < 0.05$).

The main deviation of this correlation matrix from the Macleod and Hagan data is that we, but not Macleod and Hagan, observed an association between trait/state anxiety and unmasked threat interference.

Table 1. Spearman correlation between threat-relevant processing bias (masked and unmasked), anxiety and emotional vulnerability

	Unmasked interference	Masked interference (TIMS)	Trait anxiety	State anxiety
Masked interference (TIMS)	−0.02			
Trait anxiety	0.31*	0.43*		
State anxiety	0.09	0.49*	0.75*	
Emotional vulnerability	−0.13	0.34*	0.15	0.21

*$P < 0.05$.

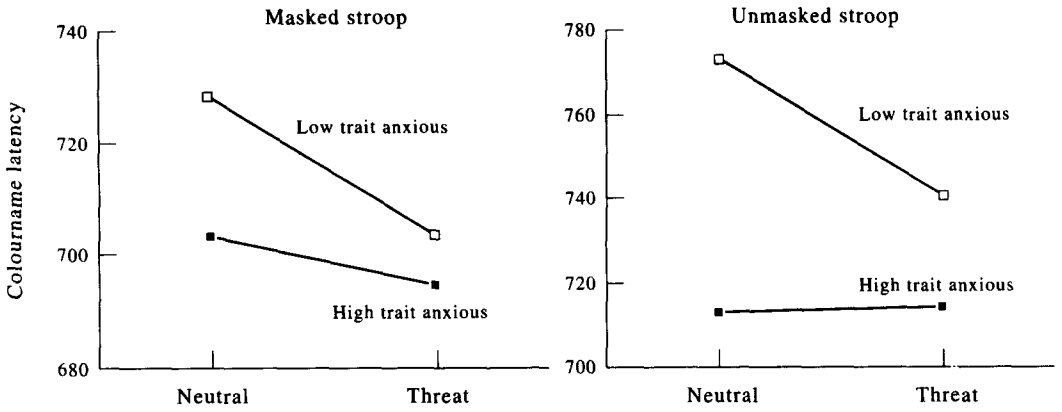

Fig. 1

Overall, *S*s were significantly faster in colour-naming threat words as compared to neutral words. The significant correlations between stroop interference and trait/state anxiety were thus mainly due to high anxious *S*s being less likely to speed up in case of threat words. This is shown in Fig. 1, where colour-name latencies for neutral and threat words are plotted against anxiety status of the *S*s.

For the unmasked stroop, we conducted a two-way ANOVA with high vs low trait anxiety as between-group factor, and threat vs neutral words as within-group factor, There was a significant main effect of word type ($F = 4.4$; $df = 1,30$; $P < 0.05$) and a significant interaction between group and word-type ($F = 4.6$; $df = 1,30$; $P < 0.05$). Comparable results were obtained with the masked Stroop: a main effect of word type ($F = 15.8$; $df = 1,30$; $P < 0.001$) and a trend in the interaction ($F = 3.4$; $df = 1,30$; $P = 0.075$). In contrast to what Fig. 1 suggests, group effects were not significant. The (near) significant interactions reflect the fact that low anxious *S*s, more than high anxious *S*s, speeded up in colournaming threat words.

DISCUSSION

In 1992, Macleod and Hagan reported that TIMS is: (a) correlated with trait anxiety; and (b) a significant predictor of emotional vulnerability, not deriving its predictive power from a mutual association of TIMS with trait anxiety and vulnerability. These findings were obtained in a currently stressed sample, but Macleod and Hagan tacitly assumed that the data-pattern would be refound in a non-stressed sample. The present paper reports a replication study in such a non-stressed group and the data were clear: pre-conscious allocation of attention to threat, measured by TIMS, correlated significantly with trait anxiety and indeed TIMS had the unique power to predict self-rated vulnerability to life stress. The findings provide a fairly precise replication of the Macleod and Hagan report. The only divergence between the two data sets is that in the present study there is a correlation between the *un*masked threat interference index and trait anxiety. The fact that Macleod and Hagan's *S*s were considerably stressed while our *S*s were not may be responsible for this difference. Mathews and Sebastian (1993) found that fear-arousal suppressed the emotional stroop effect in phobic *S*s. Likewise, the presence of a real life stressor in the Macleod and Hagan sample may have abolished any interference effect in the unmasked condition precluding the occurrence of a correlation between interference and trait anxiety. But while the presence of a real life threat may alter processing priorities on a *strategic* level, habitual ways of *automatically* prioritising information may remain unaffected.

Crucial to the interpretation of the findings is the assumption that *S*s really were unaware of masked words. In earlier studies and in ours, this unawareness was checked by calculating if *S*s, *as a group*, were able to identify a masked cue above chance level. This procedure may be inappropriate. Perhaps the samples contained subgroups who *were* able to identify target words and possibly these subgroups were responsible for the observed associations. Data were re-analyzed. Five out of the 32 *S*s had 70% or more right identifications (chance level = 50%). When excluding these 5 *S*s from the analysis, all the predicted associations remained intact; in fact they became slightly higher. This indicates that, at least in our study, the correlational pattern was not due to unforeseen cue-awareness in a subgroup and it supports Williams' *et al.* (1988) suggestion that the tendency of anxious *S*s to favour processing threat cues does not require consciousness.

As mentioned in the results section and as depicted in Fig. 1, the high vs low trait anxiety difference in TIMS was not due to high anxious *S*s showing attention selectivity: they responded equally fast to neutral and threat cues. Rather, it was the low anxious Ss who speeded up when having to colourname threat cues. This pattern has been reported earlier in normal samples with the unmasked Stroop. In the Mogg *et al.* (1993) study, for instance, the difference between patients and controls in threat-interference was also largely due to normal controls being faster on threat words than on neutral words. From the Macleod and Hagan study it cannot be inferred if the reported TIMS resulted from high anxious *S*s slowing down on threat words, or from low anxious *S*s being quick in colournaming threat words. However, for the present purposes, the crucial issue is that in both studies high anxious *S*s had larger interference scores than low anxious *S*s. Sampling differences may explain why in some studies a larger interference in high anxious *S*s is due to anxious *S*s slowing down on threat while in other studies low anxious *S*s speed up with colournaming threat words. Given the significant association between TIMS and vulnerability, questions about causality ensue: does TIMS cause vulnerability, does vulnerability cause TIMS or are they reciprocally related? Of course, another possibility is that some third factor, like a history of negative (traumatic?) life events underlies both future vulnerability and vigilance for threat, reflected in TIMS. Alternatively, a repressive coping style may be involved: in low anxious *S*s, repressive coping goes hand in hand with high threat interference in an unmasked stroop (Dawkins & Furnham, 1989) while instructing normal *S*s to suppress certain thoughts results in slowing down of colournaming the to be repressed thoughts (Lavy & van den Hout, 1994). Thus, repressive coping or "cognitive avoidance" in general (de Ruiter and Brosschot, 1994) may link TIMS and vulnerability. Further psychometric

and experimental dissection of pre-conscious distractibility by threat is not only of theoretical interest. Macleod and Hagan argued that TIMS holds a promise for applied psychology. This idea was the starting point for the present replication study. The fact that their data proved replicable in a non-distressed sample strongly suggests a practical utility. Research on the reliability and validity of TIMS as well as its potential to classify individuals and predict individual behaviour, would serve both theoretical and applied psychology.

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