Published in final edited form as:
Cogn Emot. 1999 July 1; 13(4): 435–456.

On the status of implicit memory bias in anxiety

Riccardo Russo, **Elaine Fox**, and **Robert J. Bowles**
Department of Psychology, University of Essex, Colchester, UK

Abstract

The present study evaluated the status of mood congruent memory bias in implicit memory tasks for threat related information. A literature review complemented by three experiments on high and low trait anxiety participants found no implicit memory bias for threat-related information in anxious individuals on either word fragment completion or tachistoscopic word identification tasks. The theoretical implications of these results are discussed.

Laboratory-based studies have provided evidence of a processing bias towards threat-related information in clinical anxiety and in people high in trait anxiety (for reviews see Logan & Goetsch, 1993; Wells & Matthews, 1994; Williams, Watts, MacLeod, & Mathews, 1997). For example, in the modified Stroop task clinically anxious patients and high trait anxious individuals show increased interference in naming the color in which threat-related words are presented, compared to non-anxious controls (Williams, Mathews, & MacLeod, 1996). Similarly, in the dot probe task it has been shown that anxious individuals are faster at detecting a visual probe when this is displayed in the same location as a threat-related item relative to a neutral item (e.g. Fox, 1993; Mogg, Bradley, & Hallowell, 1994). Comparable biases occur in tasks requiring the interpretation of ambiguous information. Anxious individuals interpret ambiguous information in a threatening way to a larger extent than do non-anxious individuals (e.g. Mathews, Richards, & Eysenck, 1989; Richards & French, 1992; MacLeod & Cohen, 1993; Calvo, Eysenck, & Castillo, 1997). [1]

Various information processing models on the relationships between cognition and emotion have been proposed to accommodate the above findings (e.g. Bower, 1981; Wells & Matthews, 1994; Williams, Watts, MacLeod, & Mathews, 1988; 1997). While several models make predictions on the status of memory bias in explicit tasks like free recall and recognition, Williams et al's information processing model is the only model which predicts that high trait anxious individuals should show a mood congruent memory bias in implicit memory tasks. More specifically, the implicit tasks relevant to Williams et al's model are generally called perceptual implicit memory tasks. This is because they are mainly sensitive to manipulations of perceptual features of target items. The aim of the present study is to assess the status of the memory bias in perceptual implicit tasks (the term perceptual will be omitted in the remaining part of the article) for threat-related information in anxious individuals. To this end some common implicit memory tasks are described. Then, a brief description of Williams et al.'s model is given which highlights the mechanism that they suggest should induce an implicit memory bias for threat-related information in anxious

Please send correspondence to: Riccardo Russo Department of Psychology University of Essex Wivenhoe Park Colchester CO4 3SQ UK tel: ++44 -1206 - 873782 e-mail: rrusso@essex.ac.uk.

[1]As a cautionary note, it is relevant to point out that while anxious individuals show a robust bias toward threat-related information it is not always clear if this bias applies exclusively to this type of information or if it also extends to emotional stimuli in general. Some empirical findings using the modified Stroop task (e.g. Mogg & Marden, 1990; Martin, Williams, & Clark, 1991, but see Mathews & Klug, 1993), the probe detection task (Gayle Beck, Stanley, Averill, Baldwin, & Deagle III, 1992; but see Mogg et al., 1994), and the homophone spelling task (Russo et al., 1996, but see Byrne & Eysenck, 1993) suggests that information processing bias in anxious individuals may occur for both positive and threat-related emotional information.

Europe PMC Funders Author Manuscripts

individuals. Finally, the relevant experimental literature on implicit memory in anxious people is reviewed and new empirical data are presented.

Implicit memory tasks assess the influence of a past experience on the performance of a cognitive task seemingly unrelated to the previous experience. For example, in a word stem completion task participants are asked to complete word stems (e.g. tra.....) with the first word that pops into their mind. In general, stems corresponding to target words experienced at learning are more likely to be completed with the correct target compared to stems corresponding to target words not experienced at learning. The positive influence of past experiences on performance in implicit memory tasks is usually called a priming effect. An important feature of these tasks is that the advantage shown for the primed targets occurs even when participants do not consciously recollect having experienced these targets during learning. Empirical studies have provided evidence of dissociations between explicit and implicit memory tasks (for a review see Roediger & McDermott, 1993). Theoretical interpretations of the empirical data has lead to the hypothesis that either different memory systems or different memory processes support implicit and explicit memory (for accounts about these different theoretical positions see Roediger & McDermott, 1993; Schacter, 1994).

The Williams et al. (1988, 1997) model predicts that high trait anxious individuals should show an implicit memory bias for threat-related information. Williams et al argue that an affective decision mechanism operates at a pre-attentive level and determines the threat value of incoming stimuli. This affective decision mechanism can be influenced by elevated state anxiety which favours an increment of the affective salience of threat stimuli. Stimuli are then directed to a resource allocation mechanism where threat-related stimuli receive preferential allocation of resources in individuals with high trait anxiety. This increased allocation of pre-attentive resources towards an item is considered by Williams et al. to be functionally equivalent to multiple exposures to the same item. Following Mandler's (1980) dual process theoretical framework, a framework which partly inspired Williams et al.'s model, increased allocation of pre-attentive resources towards threat-related stimuli during study should facilitate their integration. Integrative processes are said to operate on the perceptual/structural characteristics of an event by reactivating the relationships among the perceptual features of the event. One of the consequences of integration is that if an event has to be matched to some stored internal representation, its previous integration should favour this matching.

Consider now the study phase of an implicit memory task. People are usually presented with a series of items to be incidentally learned for a later test. According to the above mechanism, only threat-related information should receive preferential allocation of resources at a pre-attentive level in high trait anxious people. This mechanism, which operates only in high anxious individuals, induces better perceptual integration of threat-related compared to neutral studied information. The consequence of this extra integration of threat-related studied (or more generally primed) information is that this information “will be more likely to be produced (or heard, or seen) when only some of its components are presented” (Williams et al. 1997, p.281). Given that implicit memory tasks are based on the production or identification of incomplete or difficult to perceive versions of primed and unprimed targets, it follows, according to Williams et al., that only high anxious people should show an advantage in the production or identification of primed threat-related information over primed neutral information (i.e. they should show an implicit memory bias for threat-related information).

Consistent with the above prediction, Williams et al's (1997) review of implicit memory bias in anxiety suggests that the majority of the published studies have found evidence for a bias

toward negative material. However, it is important to note that no clear criteria for memory bias were specified by the authors. Therefore, in order to have an unequivocal assessment of implicit memory bias in anxiety it is important to re-evaluate the available empirical data using clearly specified criteria.

We argue that evidence indicative of implicit memory bias for threat-related information in anxiety should comply with the following criteria (see also Eysenck & Byrne, 1995 for similar criteria):

- **a)** There should be a significant interaction between anxiety status and word type on the magnitude of the priming effect;
- **b)** The pattern of the interaction should be such that high anxious individuals show larger priming effects for threat-related words compared to low anxious individuals. This should be coupled with low anxious people showing better or equal priming effects than high anxious individuals for neutral words; or alternatively, high anxious people may show a larger priming effect for neutral words compared to low anxious people, provided that this difference is smaller than the one detected for threat-related information.
- **c)** High anxious individuals should show significantly larger priming effects for threat-related information compared to neutral information.

This last criterion follows from the assumption that threat-related information presented at learning is more perceptually integrated than learned neutral information in high anxious individuals (Williams et al., 1997). However, we acknowledge that criterion c may be valid only in theory but not in practice. For instance, this criterion could be questioned on the grounds that there may be differences in the intrinsic primability between neutral and threat-related target words despite the fact that target items are usually matched for lexical variables like word length or word frequency which may affect implicit memory tasks (for a review see Roediger & McDermott, 1993).

Memory bias for threat-related information in high trait anxiety has been investigated in five previous studies using implicit memory tasks (i.e. Richards & French, 1991; Bradley, Mogg & Williams, 1994; Eysenck & Byrne, 1994; Nugent & Mineka, 1994; Lang & Craske, 1997). Four studies assessed the presence of bias for threat-related information in implicit memory tasks among generalised anxiety disorder (GAD) patients (Mathews, Mogg, May, & Eysenck, 1989; Otto, McNally, Pollack, Chen, & Rosenbaum, 1994; Mathews, Mogg, Kentish, & Eysenck, 1995; MacLeod & McLaughlin, 1995).

Table 1 presents a summary of the relevant clinical and nonclinical studies. As shown, criterion a was only passed by three studies (Mathews et al., 1989; Eysenck & Byrne, 1994; MacLeod & McLaughlin, 1995). In these studies there was a significant anxiety by word type interaction on priming in implicit tasks. The same studies also passed criterion b in the form of the significant interaction. However, only the Eysenck and Byrne (1995) study passed criterion c. In their study, anxious individuals showed a significantly larger priming effect for threat-related words compared to neutral stimuli in a word stem completion task. Finally, the outcome of some experiments was difficult to evaluate due to some problems in the experimental design employed. For example, Nugent and Mineka's (1994) Experiment 2 it is difficult to interpret since they did not use a within-subjects measure of baseline. A similar problem applies to Lang and Craske's (1997) study where baseline measures are not reported. In summary, on the basis of this literature review it seems that there is actually very little evidence to support the presence of an implicit memory bias among either high trait anxiety individuals or clinically anxious individuals. To further test for the presence of implicit memory bias for threat-related information in anxiety we tested high and low trait

anxiety individuals in two types of implicit memory task: word fragment completion and word identification.

Experiment 1 employed a word fragment completion task in which participants read target words during study and then completed word fragments at test. Experiments 2a and 2b employed the identification of tachistoscopically presented words as implicit memory tasks. In all experiments, an attempt was made to increase the participants level of state anxiety. According to the Williams et al. model, elevated state anxiety favours better integration of threat-related information by orienting processing resources toward threat, it should therefore be easier to detect the presence of an implicit memory bias for threat-related words among high trait anxious people when state-anxiety is elevated. However, to anticipate the obtained results, we did not find any evidence that trait anxiety increases the magnitude of implicit memory biases for threatening information in any experiment.

Experiment 1

A study reported by Richards and French (1991) using a word fragment completion task has frequently been cited as evidence for the presence of an implicit memory bias for threat-related information in high trait anxiety (e.g. Williams et al, 1997). However, a close look at their data shows that the priming advantage for threat-related material in anxious individuals occurred only after a self-referenced imagery condition, and was not significantly larger than the advantage shown by low trait anxious individuals (see Table 1). Given the relevance that was given to the far from clear cut results obtained in the Richards and French (1991) study we considered that a replication was important . Therefore, we used a very similar procedure except that we used only the read-only condition at study.

Method

Participants—A total of fifty-two graduate and undergraduate students aged between 18 and 50 took part in the experiment. Twenty-eight people who obtained a score of 42 or above on the Trait form of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) were allocated to a high trait anxiety group (M = 52.6, SD = 7.3, range 42-71), while twenty-four people scoring below 38 were allocated to the low trait anxiety group (M = 33.5, SD = 3.3, range 25-37). Participant ratings on the state and trait forms of the anxiety inventory were collected at least four weeks before they took part in the study.

Design and material—We employed a mixed design. Word type (threatening vs. neutral) and priming (primed words vs. unprimed words) were within-subjects factors. Trait anxiety (high vs. low) was a between-subjects factor.

Two different lists of words (A and B) were used in this experiment. Each list comprised 24 threat-related and 24 neutral words. These words, and their corresponding word fragments, were the same as those originally used by Richards and French (1991). Half of the participants in each group studied list A, while word fragments from list B were employed at test to measure baseline word fragment completion performance. The remaining participants studied list B, while word fragments from list A served at test to measure baseline performance. Threat-related and neutral words were randomly arranged within each study list. Only two different random orders were employed, one for each study list. The word fragment completion test list comprised the word fragments from both sets presented in the same random order for all participants. A preliminary analysis including word list as a factor, indicated that there was neither a significant main effect of word list on word completion, nor that the list factor interacted significantly with any other experimental variable.

Procedure—Participants were told they would be asked to perform a series of tasks intended to collect normative data. Before study, participants were asked to rate the emotional impact of a series of pictures of unpleasant newspaper photographs. This was done in an attempt to increase the participants' level of state anxiety. Each participant was then presented with words from list A or list B. Words were presented one at the time for 2.5 s each with a 0.5 s blank interval between each word. During this time, participants were required to read aloud each word. No mention was made to the participants that they were taking part in a memory test. In fact, they were told that the task was intended to collect normative data on how people pronounce words. During the five minute delay between the study and the test phase participants were asked to perform a filler task (i.e. a digit cancellation task). During the test phase, participants were presented with all of the 96 word fragments and were asked to complete each word fragment, if possible, with the first English word they could think of. Fragments were shown one by one and participants were given 13.5 s to try to complete each fragment. The allowed completion time per fragment is comparable to that employed in similar experiments (e.g. in Challis & Brodbeck, 1992, 10 s per fragment were allowed; in Craik, Moscovitch & McDowd, 1994, 15 s per fragment were allowed). Finally each participant was given the state form of the State-Trait Anxiety Inventory questionnaire to complete.

Results and Discussion

The presentation of the unpleasant newspaper photographs was not successful in increasing the level of state anxiety from the baseline level measured at least four weeks before the memory task was administered. State anxiety scores increased from an average of 32.1 to 32.4 in low trait anxiety individuals, and from 43 to 45.5 in high trait anxiety individuals. A 2 (high vs. low trait anxiety) by 2 (before and after picture presentation) mixed ANOVA on these data showed only a main effect of groups, $F(1,52) = 27.54$, $MSE = 129.5$, $p < .01$, indicating that high trait anxiety individuals displayed higher level of state anxiety compared to low trait anxiety participants. However, state anxiety was not significantly elevated following presentation of the threatening photographs, and the interaction was also not significant, $Fs < 1.29$.

Table 2 presents the mean number of fragments completed, as well as the priming scores (i.e. the difference between primed and non-primed words) for each experimental condition. A 2 (word type; threatening vs. neutral) by 2 (trait anxiety; high vs. low) mixed ANOVA on the number of unprimed completed word fragments did not show any significant main effect or interaction, $Fs < 1$, indicating that baseline performance was comparable across word types and anxiety groups.

A 2 (word type; threatening vs. neutral) by 2 (priming; primed words vs. unprimed words) by 2 (trait anxiety; high vs. low) mixed ANOVA on the number of completed words showed only a significant main effect of priming, $F(1, 50) = 210.72$, $MSE = 6.64$, $p < .01$, indicating that primed targets were identified more often than non-primed baseline words. No other main effects or interactions were significant, $Fs < 2.25$. For high anxious people the difference between priming scores for threat-related items minus the priming score for neutral words was 0.18 items (95% CI ranged from −1.46 to 1.81 items), while this difference was 0.54 items for low trait anxiety participants (95% CI ranged from −1.53 to 2.62 items). Assuming a medium effect size in the population (i.e. $d = 0.5$; see Cohen, 1988), the statistical power that Experiment 1 had to detect a significant difference between priming scores for threat-related items compared to neutral items in high trait anxiety participants was .84 (one-tail). It therefore appears that the priming effect for threat-related vs. neutral words was not affected by trait anxiety in this experiment .

Europe PMC Funders Author Manuscripts

The results obtained in Experiment 1 failed to replicate Richards and French's (1991) finding. No mood congruent memory bias was found in high trait anxious participants. High anxious participants did not show a larger priming effect for threat-related stimuli compared to neutral stimuli. Moreover, the interaction between word type and trait anxiety on priming was nonsignificant. Therefore, none of the three criteria indicative of an implicit memory bias for threat-related information in anxiety were passed.

This conclusion may be premature, however, because word fragment completion may not be a pure measure of implicit memory (e.g. Perruchet & Baveaux, 1989; Russo & Andrade, 1995). In other words, despite the precautions that were taken to disguise the mnemonic nature of the test by including it within a series of seemingly unrelated tasks, it is possible that explicit memory strategies may have been used to complete the target fragments. Therefore, we thought it important to assess implicit memory for threat words by using a word identification task. MacLeod and McLaughlin (1995) have argued that tachistoscopic word identification is an implicit task that is less likely to be contaminated by conscious retrieval of target information (see Perruchet & Baveaux, 1989). Thus, this task may be more appropriate to detect an implicit mood congruent memory bias in anxious individuals. It is also possible that the failure to increase the level of state anxiety in the current study might have resulted in the null result. Therefore, to further test the hypothesis about the presence of an implicit memory bias for threat words in anxious individuals, we conducted two more experiments using the identification of tachistoscopically presented under conditions in which state anxiety was elevated.

Experiment 2a

Experiment 2a used tachistoscopic word identification to study implicit memory. In this task, primed and unprimed words are presented for a very brief duration at test. Given the difficulty of detecting the briefly presented words, primed words are more likely to be read than unprimed words. MacLeod and McLaughlin (1995) found that there was a significant anxiety by word type interaction with a sample of Generalised Anxiety Disorder patients (GAD). However, it is unclear from their study if GAD patients showed a reliably larger priming effect for threat-related compared to neutral words (criterion C). The present experiment was designed to assess the presence or absence of an implicit memory bias for threat-related information in non-clinical high trait anxious individuals using a word identification task.

Method

Participants—Sixty-one undergraduate students aged between 19 and 24 took part in the experiment. From this sample, those participants who obtained a score of 45 and above, i.e. n = 27, were allocated to the high trait anxiety group (M = 49.01, SD = 2.76, range 45-54), while those participants who obtained a score of 36 and below, i.e. n = 24, were allocated to the low trait anxiety group (M = 29.4, SD = 5.7, range 20-36). The data from the remaining participants were not included in the statistical analyses. In Experiment 2a we used a stricter criterion for the inclusion of participants in the high trait anxiety group. This was done in order to increase the power to detect an implicit memory bias among anxious individuals.[2]

Design and material—We employed a mixed design. Word type (threatening vs. neutral) and priming (primed words vs. unprimed words) were within-subjects factors. High versus

[2]In Experiments 2a and 2b participants were included in the high anxiety groups if they scored 45 and above in the trait anxiety questionnaire. We therefore reanalyzed the data of Experiment 1 including in the high anxious groups only those participants who scored 45 and above in the anxiety questionnaire (i.e. n = 22). The results of this analysis did not differ from those obtained with the full sample.

low trait anxiety was the between-subjects factor. The target words were the same as those used in Experiment 1. When participants studied word list A, words from list B were employed at test to measure baseline word identification performance, and vice versa. Among high trait anxiety participants, 16 people studied list A and 11 list B. Among low trait anxiety participants, 13 people studied list A and 11 studies list B. Preliminary analyses including the effect of list type indicated that there was no significant main effect of word list on word identification, and that word list did not interact significantly with any of the other experimental variables. Therefore, the imperfect counterbalancing cannot be held responsible for the obtained results in the word identification test. The word identification test list comprised the words from both sets in random order.

Procedure—Initially each participant completed the trait and state forms of the State-Trait Anxiety Inventory. Then all participants undertook the task used in the previous experiment to increase state anxiety. Following this task participants were given the state form of the State-Trait Anxiety Inventory for the second time.

After the mood induction procedure, the study phase of the word identification task began. In this phase each word was presented for 5 s with an interstimulus interval of 0.5 s. In order to induce incidental learning of target material, participants were required to imagine themselves in relation to the presented word. No mention was made to the participants that they were taking part in a memory test.

During the interval between the study and the test phase of the word identification test, participants were given a calibration task in order to find an exposure speed at which word identification was impaired. This task started by presenting single words on a computer screen for 153 ms. If the individual could read the word at a given speed the exposure duration was decreased by 17 ms steps. The exposure duration at which a participant made two consecutive errors was the critical exposure duration for that person employed in the test phase of the word identification test. This task lasted between 5 and 10 min. None of the target experimental words was used in this task.

Finally, during the test phase of the word identification task, participants were shown all the 96 words one by one at the critical exposure duration previously determined. These words were presented in a different random order for each participant. Everybody who participated in the experiment had to try to read out each word as it was presented.

Results and Discussion

The presentation of unpleasant newspaper photographs was successful in increasing the level of state anxiety. State anxiety scores increased from an average of 27.7 to 28.7 in low trait anxiety participants, and from 45 to 49.7 in high anxiety participants. A 2 (high vs. low trait anxiety) by 2 (before and after picture presentation) mixed ANOVA on these data showed that state anxiety was significantly elevated, $F(1, 48) = 14.76$, $MSE = 18.04$, $p < .01$. The significant interaction between the two factors, $F(1, 48) = 4.63$, $MSE = 18.04$, $p < .05$, suggests that the increment in state anxiety was larger in the high trait anxiety group. The state anxiety test scores of one participant were not included in the above analysis because they are missing.

Table 3 reports the mean number of words identified, as well as the priming scores (i.e. the difference between primed and non-primed words) for each experimental condition. A 2 (word type; threatening vs. neutral) by 2 (trait anxiety; high vs. low) mixed ANOVA on the number of unprimed identified words did not show any significant main effect or interaction, $Fs < 1.13$, indicating that baseline performance was comparable across word types and anxiety groups.

A 2 (word type; threatening vs. neutral) by 2 (priming; primed words vs. unprimed words) by 2 (trait anxiety; high vs. low) mixed ANOVA on the number of identified words showed a significant main effect of priming, $F(1, 49) = 34.91$, $MSE = 6.51$, $p < .01$, indicating that primed targets were identified more often than non-primed baseline words. No other main effects or interactions approached significance, $Fs < 1.58$. None of the differences between priming scores for threat-related and neutral items were significant. For high anxious participants the difference between the priming scores for threat-related items and the priming scores for neutral words was −1.04 items (95% CI ranged from −2.42 to 0.35 items), while this difference was 0.13 items for low trait anxiety participants (95% CI ranged from −1.17 to 1.42 items).

Experiment 2a did not show any indication of mood congruent memory bias for threat-related information in high trait anxiety participants in a word identification task despite elevated levels of state anxiety. If anything, the priming effect for threat-related stimuli compared to neutral words was numerically lower in high trait anxiety people compared to low anxious controls. In order to assess the robustness of the absence of a mood congruent memory bias for threat-related information in high trait anxiety we conducted a further experiment. Experiment 2b was intended to replicate Experiment 2a using a different set of words (i.e. those originally used by MacLeod & McLaughlin, 1995). To induce incidental learning of target words, participants were asked to perform a read-only encoding task and a self-referenced task. These conditions were used in order to increase the possibility of detecting an implicit memory bias among anxious participants. For example, MacLeod and McLaughlin (1995) using a reading encoding task, found a significant anxiety by word type interaction using a word identification task, while Richards and French (1991) detected a reliable implicit memory bias in a non-clinical sample of anxious individuals using a self-reference encoding condition. In Experiment 2b state anxiety was elevated by naturally occurring stressors (i.e. impending examination). Given that naturalistic stressors have been shown to induce attentional bias more readily than laboratory-based stressors (e.g. Mogg et al., 1994), it should, therefore, be easier to detect an implicit memory bias for threat-related information in anxious individuals (if it exists) under a naturalistic stressful condition.

Experiment 2b

Method

Participants—Thirty-two undergraduate students took part in the experiment. These were selected from a large sample of students who completed both state and trait forms of the State-Trait Anxiety Inventory at the beginning of the academic year. Participants scoring 45 and above in the trait anxiety inventory were allocated to the high anxious group (16 people). This group had a mean trait anxiety score of 54.6 ($SD = 5.9$, range 45-64. Participants scoring 35 and below in the trait anxiety inventory were allocated to the low anxious group (16 people). This group had a mean trait anxiety score of 28.3 ($SD = 4.7$, range 22-35). Testing took place approximately two to three weeks prior to the end of year exams. This time was chosen because we expected that students would have increased levels of state anxiety close to the examination period relative to their baseline measured early in the academic year.

Design and material—We employed a mixed design. Word type (threatening vs. neutral), priming (primed words vs. unprimed words), and encoding conditions (self-referenced vs. read-only) were within-subjects factors. High versus low trait anxiety was the between-subjects factor. The target words were the same as those used by MacLeod and McLaughlin (1995). There were 192 words in total (96 threat-related and 96 neutral). Twenty-four threat-related and twenty-four neutral words were randomly selected to create four different sets of words (A1, A2, B1 and B2). Sets A1 and A2 were used in the self-

referenced encoding condition, while sets B1 and B2 were used in the read-only condition. It is therefore relevant to point out that the lack of counterbalancing between word sets and study conditions (i.e. reading vs. self-reference) makes it difficult to evaluate any effect of the encoding conditions on priming. When participants studied word sets 1, words from sets 2 were employed at test to measure baseline word identification performance, and vice versa. Each study list therefore consisted of 48 threat-related and 48 neutral words. The counterbalancing of word sets and order of encoding conditions insured that four participants in each anxiety group were presented with one of these study lists (i.e. A1B1, B1A1, A2B2, B2A2). The word identification test list comprised all the 192 words which were presented in a different random order for each participant.

Procedure—Initially all participants were given the state form of the State-Trait Anxiety Inventory. During the study phase of the word identification task each word was presented for 1 s. The appearance of the next word in the list was under the control of the participants. In order to induce incidental learning of target items, participants were required either to imagine themselves in relation to the presented word (i.e. self-referenced encoding), or to read the target words (i.e. read-only encoding). The self-referenced and read-only encoding conditions were employed for different blocks of words. Specific encoding instructions were provided to the participants immediately before the relevant block of items. Both read-only and self-referenced encoding tasks were performed silently by the participants. Word sets, as well as the order of the encoding conditions at study, were fully counterbalanced across participants. No mention was made to the participants that they were taking part in a memory test.

During the delay interval, participants were given a calibration test in order to find an exposure speed at which word identification was impaired. This task was carried out as in Experiment 2a and lasted between 5 and 10 min. None of the target experimental words was used in this task. Finally during the test phase of the word identification task, all 192 words were shown one by one at the critical exposure duration previously determined, with a different random order for each participant. The task was to read out each word as it was presented.

Results and Discussion

The temporal proximity of the end of year did indeed induce higher levels of state anxiety. State anxiety scores increased from an average of 23.3 to 27.4 in low trait anxiety participants, and from 43.4 to 45 in high anxiety participants. A 2 (high vs. low trait anxiety) by 2 (first and second state anxiety measurement) mixed ANOVA on these data showed that state anxiety was significantly elevated, $F(1, 30) = 5.90$, $MSE = 21.44$, $p < .03$. The lack of a significant interaction between the two factors, $F(1, 30) < 1.17$, suggests that the increment in state anxiety was comparable in both high and low trait anxiety groups.

Table 4 reports the mean number of words identified, as well as the priming scores (i.e. the difference between primed and non-primed words) for each experimental condition. Preliminary analyses indicated that there was no significant main effect of either word set or order of encoding conditions on the number of words identified, and that these variables did not interact significantly with priming. Word set, however, did interact significantly with word type (i.e. threat-related vs. neutral), $F(1,24) = 5.09$, $p < .05$, suggesting that more threat-related words were identified compared to neutral words for set 2, while there were no differences between the number of identified threat-related and neutral words for set 1. The important point is that word set neither interacted with priming nor with the anxiety factor.

A 2 (word type; threatening vs. neutral) by 2 (encoding conditions; self-referenced vs. read only) by 2 (trait anxiety; high vs. low) mixed ANOVA on the number of baseline identified

words showed significant main effects of word type, F(1, 30) = 6.92, MSE = 1.09, p < .02, suggesting that more threat-related unprimed words were identified. There was a significant main effect of encoding conditions, F(1, 30) = 5.23, MSE = 3.59, p < .03, suggesting that more unprimed words were identified in the self-referenced condition. It is, however, relevant to point out that the effect of encoding conditions might reflect differences in the target material since there was no counterbalancing of study material with learning conditions. Neither the main effect of anxiety nor any of the interactions were significant, Fs(1, 30) < 2.15.

A 2 (word type; threatening vs. neutral) by 2 (priming; primed words vs. unprimed words) by 2 (encoding conditions; self-referenced vs. read only) by 2 (trait anxiety; high vs. low) mixed ANOVA on the number of identified words showed a significant main effect of priming, F(1, 30) = 54.62, MSE = 6.01, p < .01, indicating that primed targets were identified more often than non-primed baseline words. There was also a significant main effect of word type, F(1, 30) = 7.72, MSE = 2.07, p < .01, suggesting that more threat-related words (i.e. both primed and unprimed) were identified, and of encoding condition, F(1, 30) = 13.12, MSE = 5.03, p < .01, suggesting that more words (i.e. both primed and unprimed) were identified in the self-referenced condition, but see the above caveat. Neither the main effect of anxiety nor any of the interactions were significant, Fs(1, 30) < 3.34. The magnitudes of the F ratios for the critical three-way interaction involving trait anxiety, priming, and word type, and the critical four-way interaction involving trait anxiety, priming, word type, and encoding conditions were less than 1.43. It therefore appears that implicit memory effects for threat-related versus neutral words was neither affected by trait anxiety, nor by an interaction between trait anxiety and encoding conditions. The difference between threat-related and neutral words priming scores was on average 0.68 items for high anxious participants (95% CI ranged from −1.28 to 2.65 items), while this difference was −0.56 items for low trait anxiety participants (95% CI ranged from −1.63 to 0.50 items). It therefore appears that the priming effect for threat-related versus neutral words was not affected by trait anxiety even when state anxiety was increased by a naturalistic stressor.

It is important to note that the display time at study in Experiment 2a was 5 s, while in Experiment 2b this was 1 s only. However, the difference in study time between the two experiments should not have affected the possibility of detecting an implicit memory bias. In fact, empirical evidence seems to suggest that study time generally does not affect the overall magnitude of priming (e.g. Neill, Beck, Bottalico, & Molloy, 1990). Moreover, the size of the priming effect was not smaller in Experiment 2b compared to Experiment 2a where a longer exposure of target words at study was employed.

A further analysis was carried out to bolster the conclusion that there was no mood congruent memory bias for threat-related information in high trait anxiety participants. We examined the statistical power that Experiments 2a and 2b combined had to detect an expected medium effect size of d = 0.5 in the difference between priming scores for threat-related items compared to neutral items in high trait anxiety participants. The total number of high trait anxiety participants in Experiments 2a and 2b was 43. On average, the difference in the priming scores between threat-related and neutral words in this sample was −1.6% (95% CI ranged from −6.3% to 3%; percentages are used because the total number of target items differed in Experiments 2a and 2b). Assuming that the manipulation of threat-related versus neutral words on the magnitude of priming scores had an expected medium effect size (i.e. d = 0.5), with 43 participants we had a power of .94 (one-tail) to reject the false null hypothesis of no difference between priming scores for threat-related versus neutral words among high trait anxiety individuals. Therefore, the empirical evidence appear to support the view that trait anxiety does not induce a mood congruent memory bias for threat-related information in implicit memory tasks. Finally, we would like to point out that

the administration of the State Anxiety Inventory at the beginning of the experimental session in Experiments 2a and 2b is unlikely to have induced a response bias in anxious individuals given that there was no significant difference in the baseline performance between high and low anxious participants.

General Discussion

Using word fragment completion and word identification, it is clear that none of our experiments passed any of the criteria indicative of an implicit memory bias for threat-related information in high trait anxiety participants. This lack of implicit memory bias occurred in two experiments under conditions of elevated state anxiety (Experiments 2a and 2b), which, according to Williams et al. should facilitate the detection of such bias in anxious individuals. Power analysis showed that the power to detect a significant difference in priming effects between threat-related and neutral stimuli among anxious individuals was 84% and 94% for the word completion and the word identification tasks, respectively. Therefore, the results obtained in Experiments 1, 2a and 2b complements those previously described in the literature review on implicit memory bias in anxiety and suggest that there is, in fact, no mood congruent bias in implicit memory tasks for high trait anxious nonclinical individuals. A similar conclusion is also reached if we expand the literature review to include published studies employing panic disorder patients or social phobic individuals (Amir et al, 1996; Cloitre, Shear, Cancienne & Zeitlin, 1994; Otto et al., 1994; Lundh & Ost, 1997; Lundh, Czyzykow & Ost, 1997; Rapee, McCallum, Melville, Ravenscroft & Rodney, 1997). Only the Amir et al. study would pass the three previously defined criteria, but only in one of three exposure conditions used in an implicit memory task based on the assessment of the loudness of the noise in which target items were embedded. While the Cloitre et al (1994) study would pass criteria a and b, the remaining studies did not pass any of the three criteria for implicit memory bias in anxiety. Therefore, the large majority of published experimental evidence indicates that anxious individuals do not show a mood congruent bias in implicit memory tasks.

As is evident from the above reasoning and evidence, our conclusions on the status of mood congruent implicit memory bias for threat-related information in anxiety are based on the acceptance of the null hypothesis. It is important to point out that we accepted the null hypothesis only after an extensive effort to try to disprove it. As suggested by Frick (1995), this good effort criterion, even if subjective, is a plausible approach on which to base the acceptance of the null hypothesis. Our conclusion was reached only after extensive testing. In our three experiments, we used two different implicit memory tasks to assess the generalizability of the obtained findings (in this case of the absence of a mood congruent implicit memory bias). It is important to note that each experiment showed a strong overall implicit memory effect, suggesting that the absence of a mood congruent effect cannot simply be ascribed to the use of tasks insensitive to experimental manipulations. We also showed that similar results are present in the published literature examining the effect of anxiety on implicit memory tasks. In sum, it appears that there is a viable ground on which to accept the null hypothesis concerning the absence of a mood congruent implicit memory bias in anxiety.

Williams et al. (1997) have suggested a reason why anxious individuals may not show a threat-related bias in implicit tasks. They argue that while threat-related target words may be more fluent and thus more likely to be perceived by anxious individuals, these people may then have an aversion to output threat words. As a consequence, high anxious people, may fail to show an underlying mood congruent bias because it is masked by a response bias. We think, however, that this hypothesis can be discounted on empirical grounds. To illustrate, if anxious individuals tend to avoid the production of threat-related information, they would be

expected to produce significantly less threat-related items than low anxious people in the baseline condition (i.e. those items or fragments presented only at test). However, inspecting the results obtained in Experiments 1, 2a and 2b, anxious individuals did not produce less threat-related items in the baseline condition compared to low anxious individuals. Therefore, a response bias hypothesis cannot explain the absence of a mood congruent implicit memory bias for threat-related information in anxious individuals in the present study.

The lack of memory bias for threat-related information is clearly at variance with the predictions made by the Williams et al. model about the effect of emotions on information processing. Assuming that trait anxiety is instrumental in favoring a better perceptual integration of threat-related targets, it is evident that such a process does not induce a priming bias for this type of information. However, the absence of a bias in implicit memory is not unexpected on the basis of experimental findings in mainstream studies on implicit memory. If, as suggested by the Williams et al. model, the integration of threat-related information in anxious individuals is functionally equivalent to multiple exposures to the same item, then, by the same logic, any item which receives multiple presentations during learning should be better integrated and therefore should be primed more strongly than any item receiving less presentations. However, it has been shown that massed presentations up to 16 times of neutral targets at study does not in fact increase priming effects in a word fragment completion task compared to targets presented only once at study (Challis & Sidhu, 1993). Increased integration should also operate under extended presentation of targets or under conditions in which target items are experienced at study under focused attention. However, the fact is that neither of these variables has a major effect on priming in implicit memory tasks. For example, Neill et al. (1990) found that increasing the presentation time at study from 1 s up to 6.5 s did not affect the magnitude of priming effects in a word fragment completion task. Similarly, Parkin, Reid and Russo (1990; Mulligan & Hartman, 1996) showed that divided attention at study did not affect the overall magnitude of priming effects in word fragment completion.

Thus, there is a large body of evidence indicating that minimal exposure to target items is enough to achieve an optimal level of structural/perceptual integration of target items to support normal priming effects in implicit memory. Thus, while there may well be enhanced perceptual integration of threatening items for high anxious individuals, this enhanced integration is unlikely to be reflected in increased priming effects in implicit memory tasks. Consistent with this view is the lack of an enhanced priming effect for threat-related information in high anxious individuals in almost all of the published studies. Overall, however, we believe that the current findings do not necessarily call for a revision of the Williams et al. model. We think that the predictions made from this model about the presence of an implicit memory bias for threat-related information in anxious individuals reflect an overvaluation of the influence that the possible extra integration of threat-related stimuli can have on performance in implicit memory tasks.

In conclusion, we think that the interest in the study of implicit memory bias in anxiety can be traced to the general interest in the study of implicit memory over the last fifteen years. We also think that this interest was fueled by the Williams et al model's incorrect prediction about the presence of an implicit memory bias for threat-related information in anxious individuals. Threat-related information may well be more extensively integrated in anxious individuals. However, implicit memory tasks are not suitable to detect such integration. In order to address the issue of the perceptual integration of threat-related information in anxiety it is probably more fruitful to analyze the outcome of empirical studies on the status of attentional bias in anxiety.

Acknowledgments

This research was partially supported by a Wellcome Trust research grant (reference no: 045800/Z/95/Z) awarded to Elaine Fox and Riccardo Russo. We are grateful for the help of Nicky Asaf, Tadhg McIntyre, Vicki Morris, Neal Traynor , and Jenny Watson with data collection. Robert J. Bowles is now at the Department of Experimental Psychology of the University of Cambridge.

References

Amir N, McNally RJ, Riemann BC, Clements C. Implicit memory bias for threat in panic disorder: an application of the 'white noise' paradigm. Behaviour Research and Therapy. 1996; 34:157–162. [PubMed: 8741723]

Bower GH. Mood and meory. American Psychologist. 1981; 36:129–148. [PubMed: 7224324]

Bradley BP, Mogg K, Williams R. Implicit and explicit memory for emotional information in non-clinical subjects. Behaviour Research and Therapy. 1994; 32:65–78. [PubMed: 8135724]

Byrne A, Eysenck MW. Individual differences in positive and negative interpretative biases. Personality and Individual Differences. 1993; 14:849–851.

Calvo MG, Eysenck MW, Castillo DM. Interpretation bias in text anxiety: The timecourse of predictive inferences. Cognition and Emotion. 1997; 11:43–63.

Challis BH, Brodbeck DR. Levels of processing affects priming in word fragment completion. Journal of Experimental Psychology: Learning, Memory and Cognition. 1992; 18:595–607.

Challis BH, Sidhu R. Dissociative effect of massed repetition on implicit and explicit measures of memory. Journal of Experimental Psychology: Learning , Memory, and Cognition. 1993; 19:115–127.

Cohen, J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed.. Hillsdale, N.J.: Erlbaum; 1988.

Cloitre M, Shear MK, Cancienne J, Zeitlin SB. Implicit and explicit memory for catastrophic associations to bodily sensations words in panic. Cognitive Therapy and Research. 1994; 18:225–240.

Craik FIM, Moscovitch M, McDowd JM. Contributions of surface and conceptual information to performance on implicit and explicit memory tasks. Journal of Experimental Psychology: Learning, Memory and Cognition. 1994; 20:864–875.

Eysenck M, Byrne A. Implicit memory bias, explicit memory bias and anxiety. Cognition and Emotion. 1994; 8:415–432.

Fox E. Allocation of visual attention and anxiety. Cognition and Emotion. 1993; 7:207–215.

Frick RW. Accepting the null hypothesis. Memory & Cognition. 1995; 23:132–138.

Gayle Beck J, Stanley MA, Averill PM, Baldwin LE, Deagle EA III. Attention and memory for threat in panic disorder. Behaviour Research and Therapy. 1992; 30:619–629. [PubMed: 1417687]

Logan AN, Goetsch VL. Attention to external threat cues in anxiety states. Clinical Psychology Review. 1993; 13:541–559.

Lundh LG, Ost LG. Explicit and implicit memory bias in social phobia. The role of subdiagnostic type. Behaviour Research and Therapy. 1997; 35:305–317. [PubMed: 9134785]

Lundh LG, Czyzykow S, Ost LG. Explicit and implicit memory bias in panic disorder with agoraphobia. Behaviour Research and Therapy. 1997; 35:1003–1014. [PubMed: 9431730]

MacLeod C, Cohen I. Anxiety and the interpretation of ambiguity: A test comprehension study. Journal of Abnormal Psychology. 1993; 102:238–247. [PubMed: 8315136]

MacLeod C, McLaughlin K. Implicit and explicit memory bias in anxiety: A conceptual replication. Behaviour Research and Therapy. 1995; 33:1–14. [PubMed: 7872931]

Mandler G. Recognizing: The judgement of previous occurrence. Psychological Review. 1980; 87:252–271.

Martin M, Williams RM, Clark DM. Does anxiety lead to selective processing of threat-related information? Behaviour Research and Therapy. 1991; 29:147–160. [PubMed: 2021377]

Mathews A, Klug F. Emotionality and interference in with colour naming in anxiety. Behaviour Research and Therapy. 1993; 31:57–62. [PubMed: 8417729]

Mathews A, Mogg K, Kentish J, Eysenck M. Effect of psychological treatment on cognitive bias in Generalised Anxiety Disorder. Behaviour Research and Therapy. 1995; 33:293–303. [PubMed: 7726805]

Mathews A, Mogg K, May J, Eysenck M. Memory bias in anxiety. Journal of Abnormal Psychology. 1989; 98:236–240. [PubMed: 2768658]

Mathews A, Richards A, Eysenck M. Interpretation of homophones related to threat in anxiety states. Journal of Abnormal Psychology. 1989; 95:15–20. [PubMed: 3700842]

Mogg K, Bradley BP, Hallowell N. Attentional bias to threat: Roles of trait anxiety, stressful events, and awareness. The Quarterly Journal of Experimental Psychology. 1994; 47(A):841–864. [PubMed: 7809399]

Mogg K, Marden B. Processing of emotional information in anxious subjects. British Journal of Clinical Psychology. 1990; 29:227–229. [PubMed: 2364202]

Mulligan NW, Hartman M. Divided attention and indirect memory tests. Memory & Cognition. 1996; 24:453–465.

Neill TW, Beck JL, Bottalico KS, Molloy RD. Effects of recollection versus incidental learning on explicit and implicit tests of memory. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1990; 16:457–463.

Nugent K, Mineka S. The effect of high and low trait anxiety on implicit and explicit memory tasks. Cognition and Emotion. 1994; 8:147–164.

Otto MW, McNally RJ, Pollack MH, Chen E, Rosenbaum JF. Hemispheric laterality and memory bias for threat in anxiety disorders. Journal of Abnormal Psychology. 1994; 103:828–831. [PubMed: 7822587]

Parkin AJ, Reid TK, Russo R. On the differential nature of implicit and explicit memory. Memory & Cognition. 1990; 18:507–514.

Perruchet P, Baveaux P. Correlational analyses of explicit and implicit memory performance. Memory and Cognition. 1989; 17:77–86.

Rapee RM, McCallum SL, Melville LF, Ravenscroft H, Rodney JM. Memory bias in social phobia. Behaviour Research and Therapy. 1997; 32:89–99. [PubMed: 8135726]

Reidy J, Richards A. Anxiety and memory: A recall bias for threatening words in high anxiety. Behaviour Research and Therapy. 1997; 35:531–542. [PubMed: 9159977]

Richards A, French CC. Effects of encoding and anxiety on implicit and explicit memory. Personality and Individual Differences. 1991; 12:131–139.

Richards A, French CC. An anxiety related bias in semantic activation when processing threat/neutral homographs. Quarterly Journal of Experimental Psychology. 1992; 45A:503–525. [PubMed: 1308736]

Roediger, HL.; McDermott, KB. Implicit memory in normal human subjects. In: Spinnler, H.; Boller, F., editors. Handbook of Neuropsychology. Vol. 8. Amsterdam: Elsevier; 1993.

Russo R, Andrade J. The directed forgetting effect in word fragment completion: An application of the process dissociation procedure. Quarterly Journal of Experimental Psychology. 1995; 48A:405–423.

Russo R, Patterson N, Roberson D, Stevenson N, Upward J. Emotional value of information and its relevance in the interpretation of homophones in anxiety. Cognition and Emotion. 1996; 10:213–220.

Schacter, DL. Priming and multiple memory systems: Perceptual mechanisms of priming. In: Schacter, DL.; Tulving, E., editors. Memory Systems 1994. Cambridge: MIT press; 1994. p. 233-268.

Spielberger, CD.; Gorusch, R.; Lushene, R.; Vagg, PR.; Jacobs, GA. Manual for the Stay-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychology Press; 1983.

Wells, A.; Matthews, G. Attention and Emotion. Hove: LEA; 1994.

Williams, MG.; Watts, FN.; MacLeod, C.; Mathews, A. Cognitive Psychology and Emotional Disorders. I edition. Chichester: Wiley; 1988.

Williams, JMG.; Watts, FN.; MacLeod, C.; Mathews, A. Cognitive Psychology and Emotional Disorders. II edition. Chichester: Wiley; 1997.

Williams JMG, Mathews A, MacLeod C. The emotional Stroop task and psychopathology. Psychological Bulletin. 1996; 120:3–24. [PubMed: 8711015]

Europe PMC Funders Author Manuscripts

Europe PMC Funders Author Manuscripts

Table 1

Summary of published studies on mood congruent bias in implicit memory.

Study	Participants	Task	Encoding	Priming scores		Criteria		
						A	B	C
Richards & French (1991)	H vs. L	WFC	self-referred	H	2.50 items *	−	−	+
				L	0.87 items			
			read only	H	−0.12 items	−	−	−
				L	3.25 items *			
Nugent & Mineka (1994)	H vs. L	WSC	liking task	H	− 0.10 items	−	−	−
(Experiment 1)				L	− 0.64 items			
Eysenck & Byrne (1994)	H vs. L	WSC	reading vs. generating	H	3.2 items *	+	+	+
			(results collapsed)	L	− 1.0 items			
Bradley et al. (1994)	H vs. L	LEX	self-referred	H	−18 ms	−	−	−
			subliminal presentation	L	−10 ms			
			self-referred	H	5 ms	−	−	−
			supraliminal presentation	L	15 ms			
Mathews et al. (1989)	GAD vs. L	WSC	self-referred	GAD	0.70 items	+	+	−
				L	−1.2 Items			
Mathews et al. (1995)	GAD vs. L	WSC	counting Es	GAD	−0.09 items	−	−	−
				L	0.09 Items			
	GAD vs. L	WID	reading	GAD	1.37 items	+	+	?
MacLeod & McLaughlin (1995)				L	−1.24 items			
Otto et al. (1994)	GAD vs. L	WSC				−	−	−

Note. H = High trait anxiety participants; L = Low trait anxiety participants; GAD = Generalised Anxiety Disorder patients; WFC = Word fragment completion; WSC = Word stem completion; LEX = Lexical decision; WID = Word identification; Encoding = Encoding conditions; Priming Scores = Primed − Unprimed performance. Starred priming scores are significantly different from zero ($p < .05$). The column criteria refers to the criteria to decide on the presence of a mood congruent implicit memory bias. The sign "+" indicates that a criterion was passed. The sign "−" indicates that a criterion was not passed. The sign "?" indicates that no information was provided in the original study. Criteria are specified in the main text.

No specific information was available in Otto et al. (1994) study. In note it was simply written that there was 'no evidence of differential implicit memory performance as a function of word type or group'. No data were reported.

Europe PMC Funders Author Manuscripts

Table 2

Experiment 1. Number of primed and unprimed threat-related and neutral word fragments completed by high and low trait participants.

	Threat-related		Neutral		Priming Scores	
	Primed	**New**	**Primed**	**New**	**Threat**	**Neutral**
High trait	12.68	7.79	11.93	7.21	4.89	4.71
Low trait	13.08	7.21	12.71	7.38	5.88	5.33

Note. Priming scores were obtained by subtracting the number of correct identifications in the unprimed condition from the primed condition.

Cogn Emot. Author manuscript; available in PMC 2008 February 13.

Europe PMC Funders Author Manuscripts

Table 3

Experiment 2a. Number of primed and unprimed threat-related and neutral word identified by high and low trait participants.

	Threat-related		Neutral		Priming Scores	
	Primed	**New**	**Primed**	**New**	**Threat**	**Neutral**
High trait	18.74	17.26	19.15	16.63	1.48	2.52
Low trait	18.38	16.08	18.13	15.96	2.29	2.17

Note. Priming scores were obtained by subtracting the number of correct identifications in the unprimed condition from the primed condition.

Cogn Emot. Author manuscript; available in PMC 2008 February 13.

Europe PMC Funders Author Manuscripts

Table 4

Experiment 2b. Number of primed and unprimed threat-related and neutral words identified by high and low trait participants using self-referenced and read-only encoding conditions.

	Threat-related		Neutral		Priming Scores	
	Primed	**New**	**Primed**	**New**	**Threat**	**Neutral**
High trait						
Self	14.69	12.25	14.00	11.69	2.44	2.31
Read	13.75	11.63	12.94	11.38	2.13	1.56
Low trait						
Self	14.56	12.25	14.31	11.31	2.31	3.00
Read	13.06	10.81	12.75	10.63	2.25	2.13

Note. Priming scores were obtained by subtracting the number of correct identifications in the unprimed condition from the primed condition.