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Selective interpretation in anxiety: Uncertainty for threatening events

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The role of event uncertainty on inferences predictive of threat was investigated in high and low trait anxious individuals. Participants read context sentences predicting threat or nonthreat outcomes. They subsequently named target words that were consistent with or unrelated to prediction. In Experiment 1, with predictability relatively low, anxious participants showed clear threat bias in their inferences: Although nonthreat targets were unaffected by context, shorter naming latencies were found for threat target words that followed a threat predicting context. A low anxiety group showed an opposite effect, that is, facilitation only for nonthreat words, suggesting an avoidance (of threat) bias. In Experiment 2, under higher predictability, this bias disappeared, as both high and low anxious groups performed similarly. The relevance of these data for different models of selective processing in anxiety is discussed. Of particular pertinence is the finding that, with increasing stimulus threat, low anxious participants no longer show avoidance; instead, they infer threat in a way similar to the high anxious. This suggests that the difference between the high and the low anxious persons resides in the threshold at which stimulus threat input is processed.

Anxious individuals are more likely than the nonanxious to interpret ambiguous stimuli negatively (see reviews in MacLeod, 1999, and Rusting, 1998).[1] Empirical support for this interpretive bias comes from studies using a variety of experimental paradigms: (a) The homophone paradigm, in which ambiguous

[1] In some studies (Constans, Penn, Ihen, & Hope, 1999; Hirsch & Mathews, 1997), the bias for the high anxiety individuals is marked not so much by an outright negative interpretation of ambiguous stimuli, but rather by a failure to show the positive interpretation that characterises low anxiety individuals.

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words must be spelled by participants after auditory presentation (Eysenck, MacLeod, & Mathews, 1987; Mathews, Richards, & Eysenck, 1989; Mogg et al., 1994b); (b) lexical decision tasks, using ambiguous words, that is, homographs (Richards & French, 1992) or ambiguous sentences (Calvo, Eysenck, & Estevez, 1994; Hirsch & Mathews, 1997); (c) a recognition test, in which neutral or threatening sentences are to be rated for similarity of meaning to previously heard ambiguous sentences (Eysenck, Mogg, May, Richards, & Mathews, 1991); (d) a self-paced reading paradigm, in which reading times are collected for a neutral or a threat-related continuation sentence following an ambiguous sentence (Calvo, Eysenck, & Castillo, 1997; MacLeod & Cohen, 1993); and (e) a naming task, in which ambiguous sentences are followed by neutral or threat-related words to be pronounced as soon as possible (Calvo & Castillo, 1997, in press). In all this research, high anxiety is associated with facilitated processing of threat-related verbal stimuli, whether the task is spelling or recognition probability, lexical decision speed, reading time, or naming latency.[2]

Interpretive bias is functionally comparable with attentional bias (i.e., preferential attention to potential threat cues, see reviews in MacLeod, 1999). Both biases are concerned with prioritisation of threat processing, which is assumed to be the critical cognitive function of anxiety. By facilitating detection and evaluation of threat cues, these biases favour preparatory resource mobilisation, potentially aiding the anxious individual's escape from impending danger. Various theories have been proposed to account for cognitive bias in anxiety (Beck & Clark, 1997; Eysenck, 1992, 1997; Mogg & Bradley, 1998; Öhman, 1996; Wells & Matthews, 1994; Williams, Watts, MacLeod, & Mathews, 1988, 1997), but their explanatory models have generally emphasised attentional rather than interpretive bias. As Mathews and Mackintosh (1998) point out, however, "these two biases arise from the same fundamental process—namely, the increased activation afforded by a specialized threat evaluation system to stimuli or meaning associated with danger in anxious individuals" (p. 557). Thus, a theory's basic postulates should encompass both phenomena. The aim of the present study is to examine whether central hypotheses regarding attentional bias can also apply to interpretive bias.

Cognitive theories of attentional bias

Williams et al.'s (1988) model has probably been the most influential view of attentional bias. These authors proposed (1988, 1997) that two mechanisms are responsible for cognitive biases in anxiety: the Affective Decision Mechanism

[2]Complementary, indirect evidence for interpretive bias comes from the risk estimation paradigm: Trait anxiety is associated with subjective perception of increased probability of future-negative events and/or decreased probability of positive events (e.g., Butler & Mathews, 1987; Chen & Craske, 1998; Gasper & Clore, 1998).

(ADM) and the Resource Allocation Mechanism (RAM). The ADM evaluates the threat value of stimuli. Its output depends both on stimulus intensity and on current anxious mood: Appraisal of threat increases as the threat value of the stimulus and/or state anxiety increase. The RAM determines the allocation of processing resources after a stimulus has been detected. It is influenced by a person's level of trait anxiety. High trait anxiety directs resources towards threatening stimuli, whereas low trait anxiety promotes shifting of resources away from threat. High and low trait anxious individuals would not show cognitive differences (i.e., similar and unlikely threat detection, and hence equivalent resource allocation) in response to low threatening stimuli when state anxiety is low (i.e., under nonstress conditions). However, when stimulus threat intensity (and/or current anxious mood) increases, high trait anxiety individuals will be more vigilant and switch resources towards the source of threat. In these same circumstances, individuals low in trait anxiety will become more avoidant and direct processing resources away from threat.

The proposal that the RAM directs the allocation of resources away from threat in low trait anxious individuals has received some support (e.g., MacLeod & Mathews, 1988). Nevertheless, it appears to be inconsistent with normal adaptive functioning. That is, missing or avoiding real danger cues would be maladaptive. Two recent models address this problem (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). For them, an affective decision system (called Valence Evaluation System, VES; Mogg & Bradley, 1998; and Threat Evaluation System, TES; Mathews & Mackintosh, 1998) is directly affected by trait anxiety. This implies that high and low trait anxious individuals would differ in the threshold for appraising threat, which in turn would affect allocation of processing resources. Thus, a high trait anxious person would interpret a fairly innocuous or mild threat stimulus as having high threat value. However, a low trait anxious person would assign a low threat value to this same stimulus, and favour the more hedonic alternative, which suggests an avoidance bias in threat processing. Nevertheless, when stimulus threat increases above a certain threshold of severity, a low trait anxious person would show increased vigilance and resource allocation to threat.

The above analysis of attentional bias can also be applied to the study of interpretive bias (i.e., in predicting threatening event outcomes). The study of threat inferences during reading provides a context for this application (see Calvo & Castillo, 1997, in press; Calvo et al., 1997; Hirsch & Mathews, 1997). Essentially, sentences are presented that are contextually ambiguous, describing situations from which either a neutral or a threatening outcome can result. Following each context sentence, a target word is presented as a probe. This word represents the outcome to be inferred or a nonpredictable outcome. Reduced latency in processing this target word subsequent to an inducing context—relative to a control context—indicates whether the reader has drawn the inference. With this paradigm, Calvo et al. (1997) and Calvo and Castillo

(1997, in press) found biased facilitation for target words representing threatening outcomes in high trait or test anxiety, while Calvo and Castillo (in press), as well as Hirsch and Mathews (1997), found biased facilitation for target words representing nonthreat outcomes in low anxiety.

This paradigm allows us to test predictions concerning interpretive bias, originally formulated to address attentional bias. A key to this analysis is the establishment of an analogue for stimulus threat salience. In this research, it is conceptualised as the degree of outcome predictability, based on the information provided by the inducing context. Low and high predictability of threatening outcomes are considered the equivalent of low and high stimulus threat input, respectively. With relatively low predictability, the three models that we have considered all predict that high trait anxious individuals are more likely to infer threat than nonthreat, at least when state anxiety is enhanced by stress conditions. The reverse is expected for their low anxious counterparts. With higher predictability, Williams et al. (1988, 1997) would make the same predictions as for lower predictability (i.e., low anxiety individuals will avoid threat-related inferences). In contrast, according to Mathews and Mackintosh (1998) and Mogg and Bradley (1998), both high and low anxious individuals would infer both outcomes, threat or nonthreat, consistent with the preceding context.

Paradigm development and operational definitions

Two experiments were conducted to test the above predictions. However, it was first necessary to operationalise the variable of *event-outcome-predictability*, such that it could be anticipated from a context sentence. This was achieved by varying the degree to which context sentences constrained—or were limited to—particular outcomes (i.e., how much a sentence suggests an outcome; Calvo, 2000; Klin, Guzman, & Levine, 1999). According to predictability scores obtained in norming studies (see below), the stimulus context sentences that we used in Experiment 1 possessed lower constraints (i.e., lower predictability) than those in Experiment 2. This was accomplished by removing (Experiment 1) or adding (Experiment 2) short expressions that enhanced the relevance of the target words (e.g., *Irremediably, the plane . . ., or Effusively, the father . . .*; see Table 1). This made the target outcomes (e.g., *crashed*, or *embraced*, more predictable in Experiment 2). Second, in both experiments we presented participants with evaluative stress instructions that have been shown to increase state anxiety both in high and low trait anxiety individuals (Calvo & Castillo, 1997). According to most cognitive models, this is an important manipulation to induce a biased response to low threat stimuli.

The basic procedure in both experiments involved presenting threat-related or nonthreat context sentences, either predictive or nonpredictive (control) of an

TABLE 1
Example of materials and manipulations of threat, context, and target used in Experiments 1 (lower context constraints) and 2 (higher context constraints) (as translated from Spanish into English)

THREAT *PREDICTING Context + Inferential (IF) or Inconsistent (IC) target word:*
With hardly any visibility, the *plane quickly approached the *dangerous *mountain and, at the same time, the *passengers began to *shout in *panic.
... **crashed** (IF) or **swerved** (IC) [Experiment 1].
... *Irremediably, the plane* **crashed** (IF) or **swerved** (IC) [Experiment 2].

THREAT *CONTROL Context + Inferential (IF) or Inconsistent (IC) target word:*
When the *plane took off, the child's *shouts of *panic prevented the *passenger hearing his friend's comments on the *mountain's most *dangerous peak.
... **crashed** (IF) or **swerved** (IC) [Experiment 1].
... *Irremediably, the plane* **crashed** (IF) or **swerved** (IC) [Experiment 2].

NONTHREAT *PREDICTING Context + Inferential (IF) or Inconsistent (IC) target word:*
When the *child saw her *father in the *airport, she ran up to him, and he *bent down over his *daughter.
... **embraced** (IF) or **coughed** (IC) [Experiment 1].
... *Effusively, the father* **embraced** (IF) or **coughed** (IC) [Experiment 2].

NONTHREAT *CONTROL + Inferential (IF) or Inconsistent (IC) target word:*
Before the trip with his *daughter, the *father *bent down to show a scale model of the *airport to the *child.
... **embraced** (IF) or **coughed** (IC) [Experiment 1].
... *Effusively, the father* **embraced** (IF) or **coughed** (IC) [Experiment 2].

Note: Asterisks indicate content words shared by the predicting and the control contexts, to control for word-based priming. Target words are in bold letters. (IF) Inferential target; (IC) Inconsistent target. High context constraints are in italics.

event outcome. These sentences were followed by a target word that the participants were to name (see Table 1). The target word represented either the to-be-inferred outcome or an inconsistent outcome. Short latency in pronouncing the target word is assumed to reveal activation of the corresponding concept (Keenan, Golding, Potts, Jennings, & Aman, 1990). Accordingly, evidence for predictive inferences will consist of facilitation (shorter latencies) in naming the target words that are consistent with to-be-expected sentence outcomes, relative to when the same word is presented after an unrelated, control context (see Keefe & McDaniel, 1993; Klin et al., 1999). Bias in predictive inferencing is defined by a selective facilitation in the predicting condition for target words consistent with threatening outcomes. This facilitation is held to be characteristic of trait anxiety.

PRELIMINARY NORMING STUDY: UNCERTAINTY OF PREDICTABLE OUTCOMES

Before performing the experiments, in a sentence-completion study we ensured that the predicting contexts could actually induce the presumed inferences (see Calvo, Castillo, & Estevez, 1999). Most important, this study served to determine the degree of context constraints (i.e., the extent to which information in the context sentences made an event outcome predictable).

A total of 104 psychology undergraduates were: (a) presented with each *predicting* sentence (e.g., *When the child saw her father in the airport, she ran up to him, and he bent down over his daughter*), or *control* sentence (e.g., *Before the trip with his daughter, the father bent down to show a scale model of the airport to the child*), either in a *low constraint* version (e.g., ... *his daughter....*), or in a *high constraint* version (e.g., ... *his daughter. Effusively, the father* ...) (see Table 1), and (b) asked to write the first word that came to mind, after the three dots (...). Thus, participants were expected to indicate ''what happened next'' (see Magliano, Baggett, Johnson, & Graesser, 1993), which typically characterises predictive inferences. The one-word predictions (or synonyms) served as target words for the following experiments.

Two types of target words were selected for each context: inferential (e.g., *embraced*) and inconsistent (e.g., *coughed*). The *inferential* words represented likely events following the predicting contexts (i.e., the to-be-inferred outcomes). After the predicting contexts, these words were mentioned by 56% and 89% of participants in the low and the high constraint versions, respectively. After the control contexts, the respective means for the same words were 10% and 9%. The *inconsistent* words represented unlikely events after both the predicting and the control contexts. They were mentioned by less than 10% of participants in all context versions. There were significant differences between the two constraint versions only for the inferential words after the predicting contexts, $t(39) = 7.86$, $p < .0001$. This confirmed the effectiveness of manipulations: The predictability of the outcomes to be inferred was lower in the low than in the high constraint version. An ANOVA involving threat-related vs. nonthreat contexts and high vs. low constraints revealed only a main effect of constraints, $F(1, 38) = 62.04$, $p < .0001$). This indicates that the threatening and the nonthreat outcomes were similarly predictable, both in the high ($M = 88$ vs. 90%, respectively) and the low ($M = 54$ vs. 59%, respectively) constraint conditions.

EXPERIMENT 1: LOWER PREDICTABILITY

Inducing context sentences, visually presented, described threat-related or nonthreat events from which an outcome could be predicted. There was relatively low predictability (.56 probability score) of a main outcome; that is, only low constraint context sentences were used in Experiment 1 (see norming study). The last word in the context was exposed for 500 ms, followed by a 1-second blank interval.[3] Then a target word appeared, which represented either the outcome to be inferred or an inconsistent outcome. The participants named this word, and response latencies were collected as a concept activation measure.

In these conditions, a bias in predictive inferencing implies that: (a) *high anxiety* participants, but not those low in anxiety, will take less time to name the target word that represents a predictable *threatening outcome* following a *threat-related context,* in comparison with when the same word follows a non-predicting, control context; in contrast, (b) *low anxiety* participants, but not those high in anxiety, will take less time to name the target word that represents a predictable *nonthreatening* outcome following a *nonthreat context,* in comparison with when the same word follows a control context. This will reveal that high anxiety facilitates threat inferences, and that low anxiety facilitates non-threat inferences. These predictions would be shared by all three models that we are considering (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Williams et al., 1997).

Method

Participants and selection criteria. A total of 20 high anxiety and 20 low anxiety psychology undergraduates participated for course credit. They were selected from a group of 96 students. In a pre-experimental phase, they were administered: (a) the trait scale of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1982), which measures individual differences in the proneness to react with state anxiety, and (b) the Marlowe–Crowne Social Desirability Scale (SDS; Avila & Tomé, 1989), which assesses the tendency to give a favourable impression of oneself in self-report measures. Those students with the highest ($M = 57.4$; SD = 5.3) or the lowest ($M = 36.6$; SD = 3.5) STAI scores were selected as high or low anxiety participants, respectively, $t(39) = 14.52$, $p < .0001$, if they scored 20 or less on the SDS (range 0–28; 20% of participants were excluded). The SDS cut-off was performed to avoid a potential confounding influence of this variable on cognitive bias (Eysenck, 1997; Mogg et al., 1994b). To encourage honest responses, participants were asked to use an anonymous code, instead of their names.

At the beginning of the experimental sessions, we simulated *stressful conditions* in order to potentiate the bias (see Calvo & Castillo, 1997). Thus, the

[3] This context-probe interval corresponds to a 1500-ms SOA (Stimulus Onset Asynchrony). It has proved to allow predictive inferences, in contrast with shorter SOAs (1000 or 500 ms), which are insufficient for normal readers to draw these inferences (Calvo & Castillo, 1998; Calvo et al., 1999).

participants were told that the purpose was to measure reading comprehension, that efficient reading was related to intellectual ability and academic success, and that their results would be compared with those of other students. In addition, they were informed of a recognition test, and required to write down his/her name. All agreed to participate.

Design. A 2 (trait anxiety: high vs. low) $\times$ 2 (priming context: predicting vs. control) $\times$ 2 (target type: inferential vs. inconsistent) $\times$ 2 (content of stimuli: threat vs. nonthreat) factorial design was used. Anxiety was a between-subjects factor; the others were within-subjects variables. The predicting context sentence suggested an event outcome (.56 predictability score). The control context did not suggest any particular outcome (all predictability scores $\leq .10$). The inferential target word represented an outcome that was to be inferred in the predicting condition. The inconsistent target word referred to an unlikely outcome. Half of the context sentences were concerned with potentially dangerous situations (i.e., accidents), and the other half with nonthreat situations.

The context and target factors may require an additional explanation of their rationale. First, both contexts were lexically similar, in that they shared words that might be related to the target word (42% of content words, which were rearranged in the control context; see Calvo et al., 1999). This lexical equivalence was necessary to determine that facilitation in processing the target word in the predicting condition, relative to the control condition, reflects an inference, i.e., the target concept is activated by the meaning of the whole context sentence. Otherwise, facilitation could simply be due to associations with individual words in the context sentence (i.e., word-based priming; Keenan et al., 1990). The predicting condition was used to induce inferences involving anticipation of likely event outcomes. The control condition served as a baseline to estimate whether and how much the predicting condition facilitated processing of the target word (i.e., how much time was saved in naming it). This control condition was also useful to rule out the possibility of a response bias in naming the target word, and the possibility of attentional bias towards the target word regardless of context meaning.[4]

Second, the inferential target word was included to *directly* assess facilitation effects revealing the inference (i.e., more activation—shorter naming latencies—in the predicting than in the control condition). The inconsistent target was included to assess inferences *indirectly* (i.e., potential interference effects: longer naming latencies in the predicting than in the control condition—the

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[4] Thus, anxious participants could be either slower or faster than nonanxious participants in naming the threatening target word, *regardless of* whether it was preceded by a predicting context or by a control context, which did not occur in our study.

more activated the inferential concept is, the more likely it is that inconsistent concepts are inhibited—). The inconsistent target condition also served to minimise the possibility that participants consciously tried to make inferences across trials, as a strategy to meet the demands of the experiment.

Materials. We used 40 Spanish passages as stimuli. Each was composed of: (a) one predicting context sentence, (b) one control context sentence, (c) one target word that represented the inference concept, and (d) one target word that represented a concept that was inconsistent with the inferential concept (see Table 1 and Appendix). With these passages, four lists of materials were constructed, each consisting of: 10 predicting contexts (5 threat-related; 5 nonthreat-related) followed by inferential targets; 10 control contexts (5+5) followed by inferential targets; 10 predicting contexts (5+5) followed by inconsistent targets; and 10 control contexts (5+5) followed by inconsistent targets. The assignment of targets to the predicting or the control context was reversed across the lists, so that a given participant saw a particular context and target only once. The materials were counterbalanced, and both the high and the low anxiety group received an equal number of each of the four lists. Each participant received one list, with 40 experimental trials in random order.

Procedure. Stimulus presentation on a screen and response collection were controlled by PCs. Sentences were shown word by word with a fixed-pace procedure (see rationale in Calvo et al., 1999). Each word was exposed for 300 ms plus 25 ms per letter, except the last word in the context, or pretarget word, which always appeared for 500 ms; there was a 50-ms interval between words. A trial included one context sentence and one target word. Each trial began when the participant pressed the space-bar. Then the words of the context appeared (and disappeared) on the centre of the screen according to the temporal parameters mentioned above. One second after the offset of the last context word, the target word appeared flanked by two asterisks. Participants had been told to say the target words correctly and quickly. A microphone connected to a voice-activated relay and interfaced with the computer registered the responses. The target word remained on the screen until the participant named it. Naming latencies were timed (in ms) from the onset of the target word to the onset of the participant's response. Then a recognition question on explicit information in the corresponding context sentence was presented; participants responded by pressing one of two keys (*Yes* or *No*). We included the recognition questions to lead the participants to believe that the experiment was about comprehension of explicit information (thus, trying to prevent voluntary inference strategies), and to ensure that they were comprehending the sentences.

Results

Comprehension performance. Recognition of explicit information in the contexts was equivalent for all conditions. High and low anxiety participants got 87% and 88% of the questions correct, respectively.

Naming latencies for correctly pronounced target words (errors $< 2\%$) were analysed in a 2 (Trait anxiety) × 2 (Context) × 2 (Target) × 2 (Threat) ANOVA (see mean scores Table 2). In both experiments, reaction times that were above or below 2.5 standard deviations (SD) from the mean were replaced by the participant's mean score plus or minus 2.5 SD. The effects of Target type, $F(1, 38) = 4.11$, $p < .05$, and of Context × Target, $F(1, 38) = 13.29$, $p < .001$, were qualified by a four-way interaction, $F(1, 38) = 9.49$, $p < .01$.

Difference scores were computed to decompose the four-way interaction, and test the specific predictions proposed in the introduction. To obtain difference scores we subtracted naming latencies for a given target word in the predicting condition from those for the same word in the control condition (i.e., control − predicting; see Table 2). Then we conducted separate ANOVAs for each target type. A Trait anxiety × Threat interaction emerged for inferential words, $F(1, 38) = 9.12$, $p < .01$, and a borderline interaction for inconsistent words, $F(1, 38) = 3.20$, $p = .08$. Follow-up tests revealed which difference scores were significant. Regarding inferential words: (a) *high anxiety* was associated with facilitation in naming (i.e., shorter latencies following the predicting context, relative to the control context) words that represented *threatening* outcomes of

TABLE 2

Mean naming latencies (in ms) for target words following the predicting and the control contexts, and difference scores (control − predicting), as a function of threat content, type of target, and trait anxiety, in Experiment 1

			Predicting		*Control*		
Threat	*Target*	*Anxiety*	*M*	*(SD)*	*M*	*(SD)*	*Difference*
Nonthreat	Inferential	Low	649	(94)	715	(114)	66**
Nonthreat	Inconsistent	Low	727	(142)	678	(107)	−49*
Nonthreat	Inferential	High	619	(91)	629	(74)	10
Nonthreat	Inconsistent	High	678	(116)	662	(78)	−16
Threat	Inferential	Low	728	(124)	726	(104)	−2
Threat	Inconsistent	Low	704	(143)	718	(101)	14
Threat	Inferential	High	628	(76)	681	(72)	53**
Threat	Inconsistent	High	685	(104)	655	(75)	−30

Note: Difference scores indicate to what extent the target concept is activated after reading the predicting context, relative to the control context. Positive scores reveal facilitation (shorter latencies) in the predicting condition; negative scores show inhibition (longer latencies).

**$p < .01$; *$p = .08$.

events, $F(1, 38) = 10.36$, $p < .01$; in contrast, (b) *low anxiety* was associated with facilitation in naming words that represented *nonthreatening* outcomes, $F(1, 38) = 11.64$, $p < .01$. Regarding inconsistent words, there was an opposite (i.e., interference following the predicting context) nonsignificant trend (see Table 2).

Discussion

These findings suggest that the high anxious group made inferences predictive of threat, but not of nonthreat outcomes, whereas the reverse applied to the low anxious group. It follows that there was selective threat processing in high trait anxiety. This converges with most prior research on interpretation or judgement biases (e.g., see MacLeod, 1999, and Rusting, 1998). It also follows from our findings that there was selective nonthreat processing in low trait anxiety, which has received less support in prior research (Calvo & Castillo, in press; Hirsch & Mathews, 1997). Both findings are consistent with the models proposed by Mathews and Mackintosh (1998), Mogg and Bradley (1998), and Williams et al. (1988, 1997). All three predict preferential processing of threat in high trait anxiety, and avoidance of threat processing in low trait anxiety, when stimulus threat value is low or mild. This is assumed to correspond to relatively low predictability of threatening outcomes in our stimulus materials.

Nevertheless, the mechanisms that account for these effects may be relatively different for each of these models. Thus, for Williams et al. (1988, 1997), the effects might be primarily due to activation of the appraisal mechanism (ADM) because of enhanced *state* anxiety under stress conditions. For Mogg and Bradley (1998), the effects would be due to a lowered threshold for threat appraisal (in the VES) as a function of *trait* anxiety. For Mathews and Mackintosh (1998), the effects would also be due to a lowered threshold for threat estimation (in the TES) primarily caused by *state* anxiety, though this effect is enhanced by *trait* anxiety. The present study does not allow us to discriminate between these specific aspects. Rather, once we have found support for the basic proposals made by these three models using low threat stimuli (and stress conditions), the next step involves testing their different predictions when stimulus threat input is increased (while keeping stress conditions).

EXPERIMENT 2: HIGHER PREDICTABILITY

This experiment investigated the interpretive bias when there is relatively low uncertainty about the probability (i.e., .89 predictability score) of an event outcome to be inferred. For this purpose, context constraints were enhanced by an additional short expression preceding the target word. This expression referred to the subject (e.g., *the father*) and a relevant quality (e.g., *effusively*) of the to-be-inferred outcome (e.g., *embraced*; see Table 1 and Appendix).

In these conditions, the bias we found in Experiment 1 will remain or even increase, according to Williams et al.'s model (1988, 1997). In contrast, the bias will disappear, according to the models developed by Mogg and Bradley (1998) and by Mathews and Mackintosh (1998). In this case, *both* high and low trait anxiety participants will draw inferences predictive of *both* threat and non-threat events. More specifically: (a) high *and* low anxiety participants will take less time to name the target word that represents a predictable *threatening outcome* following a *threat-related context,* in comparison with when the same word is not predictable by the context (i.e., following a control context); similarly, (b) low *and* high anxiety participants will take less time to name the target word that represents a predictable *nonthreatening outcome* following a *nonthreat context,* in comparison with when the same word is not predictable by the context.

Method

Participants. A total of 40 psychology undergraduates participated for course credit. They were selected from a group of 87 students, with the same criteria as in Experiment 1. The mean STAI score for the 20 high trait anxiety participants was 55.8 (SD = 5.4), and 35.0 (SD = 4.2) for the 20 low trait anxiety participants, $t(39) = 13.6$, $p < .0001$.

Design, materials, and procedure. The same experimental design and procedure as in Experiment 1 were used, as well as evaluative stress instructions. The materials in Experiment 2 differed only in the additional prime at the end of the context, regarding the subject and a quality of the action predicted by the context (see above). In Experiment 2, the target word to be named appeared 1000 ms after the last word of this additional prime. This word was exposed for 500 ms, thus using a 1500-ms SOA, as in Experiment 1.

Results

Comprehension performance. There were no significant differences in the recognition of explicit information. Low and high anxiety participants answered 86% and 87% of the questions correctly, respectively.

Naming latencies (see Table 3) were analysed in a 2 (Trait anxiety) × 2 (Context) × 2 (Target) × 2 (Threat) ANOVA. The effects of Context, $F(1, 38) = 20.93$, $p < .0001$, and Target, $F(1, 38) = 40.92$, $p < .0001$, were qualified by their interaction, $F(1, 38) = 26.48$, $p < .0001$. The four-way interaction did not reach statistical significance, $F(1, 38) = 2.82$, $p = .10$. Most important, when the ANOVA was performed on latencies for inferential target words separately (thus, dropping the target factor), the Anxiety × Context × Threat interaction was not significant either ($p = .18$); only the context effect was significant, $F(1, 38) = 43.47$, $p < .0001$.[5]

Difference scores (i.e., control − predicting; see Table 3) were computed, and follow-up tests were used to analyse the relevance of the two-way interaction for the specific predictions proposed in the introduction. For the inferential words: (a) *high anxiety* was associated with facilitation in naming (i.e., shorter latencies following the predicting context, relative to the control context) words that represented threatening outcomes of events, $F(1, 38) = 8.41$, $p < .01$, *and* words representing nonthreat outcomes, $F(1, 38) = 4.85$, $p < .05$; similarly, (b) *low anxiety* was associated with facilitation in naming words that represented threatening outcomes, $F(1, 38) = 5.35$, $p < .05$, *and* words representing nonthreat outcomes, $F(1, 38) = 20.42$, $p < .001$. No difference for the inconsistent words ($M = -6$ ms) was significant, $F < 1.0$.

TABLE 3
Mean naming latencies (in ms) for target words following the predicting and the control contexts, and difference scores (control − predicting), as a function of threat content, type of target, and trait anxiety, in Experiment 2

			Predicting		*Control*		
Threat	*Target*	*Anxiety*	*M*	*(SD)*	*M*	*(SD)*	*Difference*
Nonthreat	Inferential	Low	548	(98)	641	(114)	93**
Nonthreat	Inconsistent	Low	623	(83)	615	(86)	−8
Nonthreat	Inferential	High	587	(100)	632	(116)	45*
Nonthreat	Inconsistent	High	702	(128)	705	(140)	3
Threat	Inferential	Low	570	(80)	616	(87)	46*
Threat	Inconsistent	Low	637	(84)	633	(115)	−4
Threat	Inferential	High	590	(100)	647	(126)	57**
Threat	Inconsistent	High	682	(108)	669	(112)	−13

Note: Difference scores indicate to what extent the target concept is activated after reading the predicting context, relative to the control context. Positive scores reveal facilitation (shorter latencies) in the predicting condition; negative scores show inhibition (longer latencies).

**$p < .01$; *$p < .05$.

[5] These nonsignificant trends in the three- and four-way interactions probably result from the fact that there was a tendency: (a) for low anxiety participants to make nonthreat inferences (i.e., facilitation for inferential nonthreat words in the predicting condition) more readily than threat inferences, and (b) for low anxiety participants to make nonthreat inferences more readily than high anxiety participants. Nevertheless, neither the former difference (47 ms) nor the latter (48 ms) were statistically significant ($p = .13$, and $p = .11$, respectively).

Comparison across experiments. A 2 (Experiment 1 vs. 2) × 2 (Anxiety group) ANOVA was performed on explicit information *comprehension* scores, showing no significant differences (all $Fs < 1.0$, including the interactive effects). In a similar ANOVA on raw scores of *trait anxiety* (see Subjects section), only the effect of anxiety group was significant, $F(1, 76) = 395.5$, $p < .0001$ ($F = 0.0$, for the interactive effects). This is important to confirm that the two experiments were equivalent in comprehension and trait anxiety.

A 2 (Lower vs. Higher Context Constraints) × 2 (Anxiety group) × 2 (Target) × 2 (Threat) ANOVA on naming latency *difference scores* yielded an Anxiety × Target × Threat interaction, $F(1, 76) = 12.00$, $p < .001$; the four-way interaction was not reliable, $F(1, 76) = 2.00$, $p = .15$. Follow-up tests were conducted to analyse the specific predictions of the models at issue. We compared each anxiety group across context constraints. Thus, low anxiety participants showed increased activation (i.e., shorter naming times in the predicting than in the control condition) of threat concepts in the higher constraint level, relative to the lower constraint level, $F(1, 38) = 4.03$, $p < .05$. Differences between context constraint levels were not significant for the low anxiety group regarding non-threat concepts, nor for the high anxiety group regarding either threat or non-threat concepts. Figure 1 provides an integrated picture of the results from both experiments.

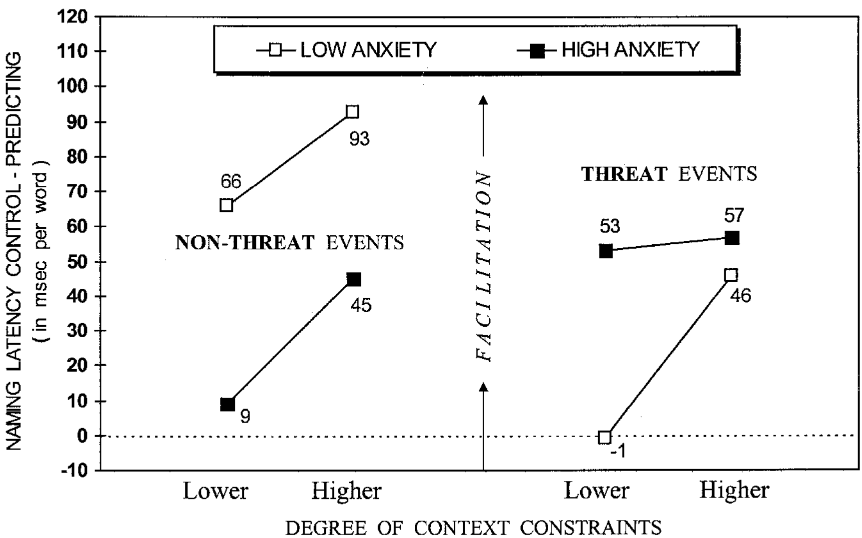

Figure 1. Estimated activation of the inferential concept (i.e., naming latency for the inferential target words in the control condition minus the predicting condition), as a function of anxiety and threat, under lower (Experiment 1) and higher (Experiment 2) context constraints. Positive scores indicate facilitation in the predicting condition.

Discussion

In Experiment 2, the strong interaction between context and target (and the context effect for inferential target words), with no interactions involving anxiety or threat, indicates that *both* the high and the low anxiety groups made inferences predictive of *both* threatening outcomes (when induced by threat-related contexts) and nonthreat outcomes (when induced by nonthreat contexts). Therefore, the bias in predictive inferences no longer appeared when the uncertainty regarding a predictable outcome decreased. Furthermore, low trait anxiety participants showed increased, rather than decreased, activation of threat concepts when high constraint sentences made threatening events more predictable.

These findings are favourable to Mathews and Mackintosh's (1998) and Mogg and Bradley's (1998) views of anxiety. According to these authors, as stimulus threat input increases, attention is more likely to be allocated to the salient stimulus by individuals low in trait anxiety. If we extend this hypothesis to interpretive processes, it implies that low anxiety individuals will draw inferences predictive of threat when the probability of threatening outcomes increase (which was the case in Experiment 2), but not when these outcomes are less predictable (as in Experiment 1). These findings would be contrary to Williams et al.'s (1988, 1997) hypothesis that, as stimulus threat input increases, low anxiety individuals would exhibit increased avoidance of threat processing. If so, low anxiety participants should not have generated threat inferences in Experiment 2; moreover, these participants would not have shown increased activation of threat concepts in the high constraint condition, in comparison with the low constraint condition.

GENERAL DISCUSSION

In Experiment 1, under *lower predictability* of events, the findings revealed a bias towards predicting threat in a high trait anxious group, and towards non-threat processing in a low anxious group. Evidence for such bias(es) comes from the fact that: (a) high anxiety was associated with faster naming responses for target words that represented threatening outcomes when they followed a predicting context than when they followed a control context, whereas there was no difference between the predicting and the control condition for words that represented nonthreat outcomes; and (b) the opposite applied to low anxiety (i.e., selective facilitation for nonthreat relative to threat words). However, in Experiment 2, under *higher predictability*, both aspects of the bias disappeared: The high and the low anxiety groups inferred both threat *and* nonthreat outcomes (i.e., faster responses for the threat and for the non-threat target words following the predicting context, relative to the control context).

Comparisons between models of selective processing in anxiety

The results from Experiment 1 are consistent with the three models at issue (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Williams et al., 1988, 1997). The results from Experiment 2 are consistent with Mathews and Mackintosh's (1998) and Mogg and Bradley's (1998) hypothesis: As stimulus threat input increases (i.e., predictability of danger, in our study), both the high and the low anxiety person will become vigilant (i.e., activation of threat inferences, in our study). More specifically, the three models differ primarily in their consideration of low trait anxiety. For Williams et al. (1988, 1997), it should be associated with avoidance of threat processing both under lower and higher threat predictability. Moreover, threat avoidance could even increase under higher predictability (i.e., with higher stimulus threat input). In contrast, for Mogg and Bradley (1998) and Mathews and Mackintosh (1998), cognitive avoidance should only occur with mild threat stimuli. Our results regarding low trait anxiety individuals reveal that: (a) they show significant activation of nonthreat concepts, but not of threat concepts, under lower predictability; (b) under higher predictability (i.e., increased threat), however, activation of threat concepts does increase in low anxiety participants.

Prior research using verbal stimuli has found some evidence for an avoidance bias in low anxiety, either in attention (MacLeod & Mathews, 1988; MacLeod & Rutherford, 1992; Mogg, Bradley, & Hallowell, 1994a) or interpretation (Calvo & Castillo, in press; MacLeod & Cohen, 1993; Richards & French, 1992). Nevertheless, this evidence is not very compelling, as, in most cases, the trends were not statistically significant. However, in neither of these studies were stimulus threat intensity or degree of ambiguity manipulated. In contrast, recently (unpublished research, cited in Mogg & Bradley, 1998), Mogg, Bradley and their collaborators have investigated attentional bias for pictorial stimuli, using mild (e.g., man behind bars) versus high (e.g., mutilated bodies) threat scenes. Essentially, the results indicated that low trait anxiety was associated with avoidance of the mild threat scenes, but with enhanced vigilance of the higher threat scenes; high trait anxiety was associated with greater vigilance for threat (relative to neutral) scenes than low trait anxiety. These findings are consistent with Mathews and Mackintosh (1998) and Mogg and Bradley's (1998) theoretical approach.

Nevertheless, rather than opposed, the models may be complementary. Avoidance in low anxiety as a function of stimulus threat intensity might actually depend on where the threshold is settled. Thus, Calvo and Castillo (in press) used stimulus materials with an .82 predictability score (in comparison with the .56 and .89 scores in the present experiments). With the .82 score, high trait anxiety facilitated threat inferences, relative to nonthreat inferences, while low trait anxiety facilitated nonthreat inferences, relative to threat inferences.

Furthermore, the activation of threat concepts was not significant for low anxiety participants. This would be consistent with Williams et al.'s model. Thus, despite the fact that the .82 predictability score represented a significant increase in context constraints in comparison with the .56 score, $t(39) = 6.73$, $p < .0001$, the former was not sufficient to induce *threat* inferences in low anxiety. In addition, the fact that these participants were able to make *nonthreat* inferences in the .82 constraint condition suggests that they still had difficulties in processing threat.[6]

Biased interpretation and predictive inferencing of threat

The present findings make a contribution to research on bias in interpreting ambiguous information. Most prior studies (e.g., Eysenck et al., 1987; MacLeod & Cohen, 1993; Richards & French, 1992, etc., see introduction) dealt with lexical ambiguity (i.e., words that possess both threat-related and neutral meanings). Our study extends the notion of biased interpretation of ambiguity to the representation of situations (see also Hirsch & Mathews, 1997). What constituted ambiguity in our materials was not something inherent to the verbal stimuli (e.g., the words or the sentences were not ambiguous themselves), but rather the uncertainty about the outcomes that could be predicted from a situation to which the stimuli referred. Therefore, the bias occurs not only with lexical ambiguity, but also with mental-model ambiguity, such as uncertainty about predictable events (see Fincher-Kiefer, 1993). It is reasonable that predictive inferences might be biased by anxiety, as *anticipation* of potential harm is assumed to be a central function of anxiety in most cognitive conceptualisations (Eysenck, 1992; Öhman, 1996).

Prior studies have investigated the relationship between anxiety and prediction of potential danger. Some of them have used subjective probability judgements (e.g., Butler & Mathews, 1987; Chan & Lovibond, 1996). A general conclusion from these studies is that individuals high in trait anxiety judge negative future events as more likely to happen to them than do non-anxious individuals. This represents convergent support for a bias in threat prediction as a function of anxiety. Other studies have used objective methods to investigate a bias in on-line predictive inferences. Thus, Calvo and Castillo (1997) and Calvo et al. (1997) found that a high test anxious group named (or read) target words (or a post-target region) confirming predicted ego-threat consequences faster than a low test anxious group, whereas both groups showed similar facilitation

[6] Therefore, with the .82 threshold (the predictability scores of which have proved to differ from the .89 threshold scores, $t(39) = 3.92$, $p < .01$), the results would be favourable to Williams et al.'s (1997) model. In contrast, with the .89 threshold, the results would support Mathews and Mackintosh's (1998), and Mogg and Bradley's (1998) models.

effects for nonthreat words. In contrast, Hirsch and Mathews (1997) found that a low trait anxious (about interviews) group made grammatical and lexical decisions for words representing positive outcomes faster than a high anxious group, with no differences for words representing threatening outcomes.

The studies conducted by Calvo and his collaborators, and by Hirsch and Mathews showed biased predictive inferencing, though their findings are not totally consistent with those obtained in the present study. Thus, Calvo and Castillo (1997) and Calvo et al. (1997) did not observe that low anxiety participants did better than those high in anxiety at predicting nonthreat events (which we did in the present study). On the other hand, Hirsch and Mathews (1997) did not note that high anxiety participants were superior to their low anxiety counterparts at predicting threat outcomes. Nevertheless, Hirsch and Mathews admitted this possibility when they said that ''since all subjects were faster to respond to positive probes, it could be argued that the results are best described as showing that anxious subjects are (relatively) more likely to make threatening inferences than were the other subjects'' (p. 1129). This hypothesis could have been tested if Hirsch and Mathews (1997) had included (non-predicting) control contexts (and, therefore, estimates of the relative facilitation induced by their predicting contexts *within* each anxiety group). The important limitation in all these studies, preventing strict comparison with the present research, is that the degree of outcome predictability was not determined.

Limitations and further research

There is an important issue for cognitive models of anxiety that our study has not directly addressed. Does the bias in predictive inferences involves automatic or strategic processing? More specifically, does the contribution made by stimulus threat value, or the degree of predictability, affect either of these processes? Williams et al. (1988, 1997) and Mogg and Bradley (1998) have emphasised that anxiety biases the initial (even preattentional) automatic encoding of threat, rather than its strategic elaboration. This hypothesis makes sense if we assume that the cognitive function of anxiety is to facilitate *early* detection of danger, in order to help the organism to mobilise defensive resources and responses *promptly*. Nevertheless, although it is reasonable that anxiety prioritises automatic initial encoding of threat, it is possible that it also promotes later strategic processing. A function of this strategic processing would be to either make sure that the stimulus is not harmful, or to exhaustively explore its nature (probability, time of occurrence, severity, etc.) and alternative coping actions.

Wells and Matthews (1994) and Matthews and Harley (1996) have emphasised the role of these strategic processes in cognitive biases associated with anxiety. Furthermore, the model put forward by Beck and Clark (1997) further explores the idea of multistage processes, from initial automatic recognition of the threat valence of stimuli to later strategic semantic analysis. Mathews and Mackintosh (1998) have also included strategic processes involving controlled effort to counter (or to enhance) activation of threat-related representations. The present findings are not specifically relevant to this question. However, the fact that the bias appeared as late as one second after the end of the inducing context is compatible with the idea that strategic processes might be involved, at least according to the resource consumption criterion (see Wells & Mathews, 1994). More direct evidence shows that this bias does not appear as early as 550 ms or 50 ms after the context (Calvo & Castillo, in press), thus suggesting that it is not automatic. Moreover, even with short ambiguous stimuli such as single words, Richards and French (1992) found a bias at SOAs of 750 ms and 1250 ms, but not of 500 ms.

Therefore, according to the time criterion to define automaticity, the interpretive bias in anxiety seems strategic, whereas a lot of evidence indicates that the attentional bias can occur automatically (see, for example, Williams et al., 1997). However, the fact that the interpretive bias might be strategic in the sense of not being capacity-free (i.e., it takes time) is not incompatible with the possibility that it is involuntary and nonconscious (see McNally, 1995). Furthermore, rather than representing an inconsistency, this reveals information processing continuity in the construction of meaningful cognitive representations of emotional stimuli. Robinson (1998) has stressed the relative advantages of automatic and strategic biases in processing emotional information. Thus, the automatic attentional bias would involve global processing of stimuli, in terms of their affective valence (‘‘good or bad’’). This would ensure *parallel* and *quick* detection of relevant stimuli. In contrast, the strategic interpretive bias would involve more exhaustive and detailed extraction of information from stimuli. This would favour a more *flexible* and *precise* adjustment of defensive responses to the actual demands of stimuli. Thus both biases are complementary to each other.

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APPENDIX

Example of experimental passages (as translated into English)

THREAT PASSAGES

Predicting context
While Maria *walked *barefoot over the rocks, she *put her foot *down, without realising, on a piece of *glass which had been left on the *ground.

Control context
In order to avoid *putting her dirty shoes *down on the *ground, Maria *walked *barefoot up to the *glass display cabinet to place the present in it.

Context constraints and target words
(Lower constraints—Experiment 1): . . . **cut herself** (IF); **slipped** (IC)
(Higher constraints—Experiment 2): *Unfortunately, Maria* **cut herself** (IF); **slipped** (IC).

Predicting context
The *child dropped the *ball and went *running after it, but, while he was *crossing the *road, a *van *suddenly appeared.

Control context
While the *child was *crossing the *road, *suddenly he realised that the *ball was in the *van, and *ran after it to get it back.

Context constraints and target words
(Lower constraints—Experiment 1): . . . **ran over** (IF); **stopped** (IC)
(Higher constraints—Experiment 2): *Without brakes, the van* **ran over** (IF); **stopped** (IC).

NON-THREAT PASSAGES

Predicting context
The woman went into the *church, spoke with the *priest for a few minutes and afterwards *knelt down in front of the *altar.

Control context
After having spoken with the *priest for a few minutes, in front of the *church's *altar, the woman *knelt down to do up her shoe.

Context constraints and target words
(Lower constraints—Experiment 1): . . . **prayed** (IF); **wrote** (IC)
(Higher constraints—Experiment 2): *With devotion, the woman* **prayed** (IF); **wrote** (IC).

Predicting context
Three days before the *examination the *student went to the *library, looked for a separate *table and opened his *notebook.

Control context
The *student, who was very tired after finishing his *examination, forgot his *notebook and left it on a *table in the *library.

Context constraints and target words
(Lower constraints—Experiment 1): . . . **studied** (IF); **fell asleep** (IC).
(Higher constraints—Experiment 2): *Trying to concentrate, the student* **studied** (IF); **fell asleep** (IC).

Note: Target words are in bold letters. (IF) Inferential target; (IC) Inconsistent target. Asterisks indicate content words shared by the predicting and the control contexts, to control for word-based priming. High context constraints are in italics.