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Risk Perceptions and Interpretations of Ambiguity Related to Anxiety During a Stressful Event

Edith Chen[1,2] and Michelle G. Craske[1]

The temporal relationship between anxiety and cognitive bias was examined in 52 college freshmen taking a first-quarter exam. Anxiety and cognitive bias were measured 1 week before the exam (Time 1), immediately after the exam (Time 2), and after grades were posted (Time 3). Changes in anxiety were associated with changes in cognitive bias by Times 2 and 3. Specifically, changes in anxiety were associated positively with changes in risk perception at Time 2 and positively with changes in threatening interpretations of ambiguous information at Time 3. Cognitive bias at Time 1 did not predict anxiety by Time 2 or 3, controlling for initial anxiety. However, when the perceived difficulty of the exam was taken into account, it appeared to moderate the relationship between cognitive bias at Time 1 and later anxiety. That is, among those who perceived the exam to be easy, greater cognitive bias at Time 1 predicted greater anxiety by Time 2. Among those who predicted the exam to be difficult, greater cognitive bias at Time 1 predicted less anxiety by Time 2.

KEY WORDS: anxiety; cognitive bias; risk perception; ambiguity.

INTRODUCTION

Anxious individuals display cognitive biases in processing emotional information (for reviews, see MacLeod, 1991; Williams, Watts, MacLeod, & Mathews, 1988). These biases include selective attention to threatening information (Stroop interference effects: Ehlers, Margraf, Davies, & Roth, 1988; Mathews & MacLeod, 1985; Mathews & Sebastian, 1993), enhanced memory for threatening information (Cloitre & Liebowitz, 1991; McNally, Foa, & Donnell, 1989; however, some studies found no such memory bias in anxious individuals: Mogg, Mathews, & Weinman, 1987), preference for threatening interpretations of ambiguous information (MacLeod & Cohen, 1993; Mathews, Richards, & Eysenck, 1989), and perception of increased probability of the occurrence of future negative life events (Butler & Mathews, 1983).

[1]Department of Psychology, University of California, Los Angeles, Los Angeles, California 90095.
[2]Address all correspondnece to Edith Chen, UCLA Department of Psychology, 405 Hilgard Avenue, Los Angeles, California 90095-1563.

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Some researchers have argued that these cognitive biases result from current mood states. That is, anxious mood states facilitate the processing of information related to anxiety, through activation of a network of emotion nodes (Bower, 1981). Evidence for this relationship lies in previous research demonstrating that Stroop interference effects for threatening information are enhanced during high anxiety (Chen, Lewin, & Craske, 1996; however, mixed findings have emerged on this topic—see Mathews & Sebastian, 1993), that probability ratings for negative events increased a day before a college exam (Butler & Mathews, 1987), and that induction of sad mood increases ratings of the probability of negative events compared to positive events (Bower, 1983; Constans & Mathews, 1993).

Other researchers have postulated an emotional vulnerability model in which anxious individuals possess a stable or dispositional cognitive bias that may be responsible for initiating anxious states (Beck & Clark, 1988). Evidence for the vulnerability model lies in previous research that has shown threatening spellings of homophones to be correlated with trait but not state anxiety among participants with generalized anxiety disorder (Mathews et al., 1989), and induction of physiological arousal in high trait anxious participants to be unrelated to their tendency to impose threatening interpretations on ambiguous sentences, indicating a stable bias (MacLeod & Cohen, 1993).

However, past studies on interpretations of ambiguous information and risk perception have not fully addressed the temporal links between cognitive biases and anxiety by assessing each at multiple time points. The current study investigated the relationship between anxiety and these two measures of cognitive bias by measuring anxiety, interpretations of ambiguous information, and risk perception at three time points surrounding a naturally occurring stressor (a first-quarter college exam for freshmen). Freshmen were selected because they would find the exam very challenging and stressful, particularly during their first quarter in college. Cognitive bias in this study referred to the tendency to endorse negative outcomes or explanations to a greater degree than most other people regarding exam-related events in which past performance is unrelated to the event (e.g., the likelihood of the professor putting trick questions on the next exam). Measures were collected at three time points in order to assess changes in anxiety and cognitive bias over the course of the stressful event. Time 1 occurred 1 week before the exam, when anxiety was expected to be relatively low. This represented a time when students were aware of the upcoming exam but before anxiety had substantially intensified. Time 2 occurred immediately after the exam, before grades were posted. Anxiety was expected to be higher at this point relative to Time 1 because students were uncertain about their grades on the exam. Time 3 occurred after grades were posted, and anxiety at this point was expected to have returned to baseline levels.

If changes in anxiety are associated with changes in cognitive bias, then change in anxiety from Time 1 to Time 2 should be associated with change in cognitive bias from Time 1 to Time 2. Second, if cognitive bias serves as a vulnerability for experiencing anxiety, then cognitive bias at Time 1 should predict change in anxiety by Time 2, controlling for initial levels of anxiety. Finally, because we predicted anxiety to return to baseline levels after grades were received, we expected little relation between change in anxiety from Time 1 to Time 3 and change in cognitive

bias from Time 1 to Time 3. Additionally, we assessed two different types of cognitive bias—risk perception (the tendency to endorse negative events as being likely to happen to oneself to a greater degree than to most other people in the same situation) and threatening interpretations of ambiguous information.

Finally, we explored the possibility that perceived characteristics of the exam may moderate the relationship between cognitive bias and anxiety. The impact of an environmental stress is influenced largely by perceptual processes; thus the same event can cause widely varying reactions in different individuals, based on their appraisals of the situation (Monroe & Kelley, 1995). Students' appraisals of the exam event in this study are indicated by their perception of the difficulty of the exam, and we expected that the relation between cognitive bias and anxiety might differ based on students' appraisals of the stressfulness of the exam. Among those who perceived the exam to be of low to moderate difficulty, we hypothesized that, cognitive bias would have a large effect on anxiety, such that higher levels of cognitive bias would be associated with higher anxiety during the exam event. On the other hand, we hypothesized that among those who perceived the exam as very difficult, levels of anxiety would be high regardless of level of cognitive bias. That is, cognitive bias might have little effect on anxiety during a highly stressful event (very difficult exam). In addition, we tested students' reports of their grades at Time 3 as another potential moderator of the relationship between cognitive bias and anxiety.

METHOD

Participants

Fifty-four freshmen from an undergraduate introductory psychology class participated in this study. Two participants did not complete participation at all three time points, and thus were excluded from the analyses. The sample included 24 males and 28 females, with an average age of 18.21 years (SD = 0.75). Ethnic composition of the sample was 36% Asian American, 31% Hispanic, 25% Caucasian, 6% African American, and 2% "other." Participants received course credit for their participation.

Measures

Anxiety

Anxiety was measured at each time point. The state portion of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), consisting of 20 questions rated on a 4-point scale, was used as a measure of current anxiety. Physical symptoms of generalized anxiety disorder, as listed in the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed) (DSM-IV; American Psychiatric Association, 1994), were used to measure the presence of symptomatic distress (labeled "Symptoms"). This measure included six questions, each rated on a 0- to 8-point scale (e.g., degree of muscle tension).

Trait measures of anxiety at Time 1 included the trait portion of the STAI (STAI-T), and the Test Anxiety Inventory (TAI; Spielberger, Gonzalez, Taylor, Algaze, & Anton, 1978), consisting of 20 questions rated on a 4-point scale, used to measure worry and autonomic reactions to evaluative situations as a personality trait. Also, participants completed the Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990), consisting of 16 questions rated on a 5-point scale, used to measure chronic worry.

Cognitive Bias

Cognitive bias was measured at each time point using the Subjective Probability Questionnaire (SPQ), consisting of 12 questions rated on a 0- to 8-point scale, following the format developed by Butler and Mathews (1983), and made relevant to an exam situation. Participants rated the likelihood of occurrence of exam-related events. Half of the items referred to positive events (e.g., "the exam will be unusually easy") and half to negative events (e.g., "the professor will put trick questions on the exam"). At Times 2 and 3, the questions referred to the next exam participants expected to take. A total score for this questionnaire was created by reverse scoring positive events, and summing all items. Cronbach alpha for the SPQ measure was .69. Also, participants completed the Scenarios Questionnaire (SCEN), consisting of eight scenarios rated on a 3-point scale, following the format developed by Butler and Mathews (1983). Eight brief, ambiguous scenarios were presented (e.g., "Two days after a big exam, you receive a phone message from your TA. What is your first thought?"), followed by three possible explanations, only one of which was judged to be threatening (e.g., "I did so poorly on the exam that my TA wants to discuss my performance with me"). Half of the items were exam-related events and half were non-exam-related events. Participants were instructed to rank the explanations in order of likelihood. Both exam-related and total scores were calculated. Higher scores indicate greater likelihood of selecting the threatening explanation. Cronbach alpha for the SCEN measure was .72.

Other Measures

Participants rated their own and others' expectations of their performance in college on three questions rated on a 5-point scale, based on a measure devised by Brown (1992). Participants also rated on a 5-point scale how difficult they perceived the exam to be at Time 2. Finally, participants reported the grade they hoped for on the exam at Time 1, and the grade they received at Time 3.

Procedure

Participants completed Time 1 measures 1 week prior to the exam, Time 2 measures immediately after the exam, before grades were posted, and Time 3 measures after grades were posted. Each time point was separated by 1 week. Participants were tested in groups of two to ten people, based on students' schedules.

RESULTS

Stressfulness of the Exam

Participants rated the upcoming exam to be quite challenging (M = 3.73; SD = 0.77). Additionally, participants rated expectations for performance to be quite high (M = 13.1; SD = 1.65).

Trait Variables

The mean scores on the trait portion of the State-Trait Anxiety Inventory was 41.56 (SD = 9.94) and on the Penn State Worry Questionnaire was 49.75 (SD = 14.86). However, neither measure was associated with Anxiety at Times 2 or 3, controlling for Time 1 Anxiety.

Anxiety and Cognitive Bias Levels Across Time

Levels of anxiety were examined with two one-way repeated-measures analyses of variance, comparing STAI-S and Symptoms scores at the three time points. A significant main effect was found for STAI-S [F (2, 102) = 3.79, p < .05]. Specific comparisons using Bonferroni corrections to control for alpha inflation (alpha = .017) revealed that participants reported significantly lower anxiety on the STAI-S at Time 3 as compared to Time 2 [F (1, 51) = 7.78, p < .017], indicating that anxiety decreased after grades were received. No differences were found when comparing STAI-S at Times 1 and 2, or STAI-S at Times 1 and 3. Additionally, a significant main effect was found for Symptoms [F (2, 102) = 13.14, p < .001]. Specific comparisons (alpha = .017) revealed that participants' reported significantly more symptomatic distress at Time 2 than Time 1 [F (1, 51) = 22.85, p < .017], and Time 3 [F (1, 51) = 17.44, p < .017], indicating that, relative to the other measured time points, participants' symptomatic distress about the exam was highest immediately after the exam. Participants also reported more symptomatic distress at Time 1 than Time 3 [F (1, 51) = 13.14, p < .017].

The same analytical approach was used to examine levels of cognitive bias over time. A significant main effect was found for SPQ [F (2, 102) = 4.79, p = .01]. Specific comparisons (alpha = .017) revealed that participants' total score on the SPQ was higher at Time 1 than at Time 3 [F (1, 51) = 8.12, p < .017] and marginally higher than at Time 2 [F (1, 51) = 5.76, p < .025], indicating that participants' risk perception was highest before the exam. No difference was found between Time 2 and Time 3 SPQ. No significant main effect was found for exam-related SCEN scores (see Table I).

Relationship Between State Anxiety and Cognitive Bias

The relationship between anxiety and cognitive bias was examined by creating a composite Anxiety (Anx) score, based on the sum of participants' standardized

Table I. Mean Anxiety and Cognitive Bias Scores (N = 52)

	Time 1		Time 2		Time 3	
Measure[a]	*M*	*SD*	*M*	*SD*	*M*	*SD*
STAI-S	39.98	12.44	41.02	12.70	36.81	12.87
Symptoms	12.38	9.68	17.69	10.65	10.44	11.23
SPQ	46.92	11.16	43.73	11.45	43.11	12.45
SCEN	6.58	1.66	6.21	2.23	5.92	2.16

[a]STAI-S = State Trait Anxiety Inventory, State portion; scores range from 20 to 80. Symptoms = symptomatic distress; scores range from 0 to 48. SPQ = Subjective Probability Questionnaire, total score; scores range from 0 to 96. SCEN = exam-related threat scores from Scenarios Questionnaire; scores range from 4 to 12.

Table II. Correlations Between Anxiety and Cognitive Bias Measures

	STAI-1	STAI-2	STAI-3	Symptoms 1	Symptoms 2	Symptoms 3
SCEN-1	.18	.15	.21	.36[b]	.24	.23
SCEN-2	.09	.16	.13	.37[b]	.23	.20
SCEN-3	.09	.15	.29[b]	.18	.10	.23
SPQ-1	.13	.28[b]	.26	.36[b]	.24	.17
SPQ-2	.11	.40[b]	.36[b]	.24	.33[b]	.31[b]
SPQ-3	.14	.29[b]	.29[b]	.17	.17	.14

[a]STAI = State Trait Anxiety Inventory, State portion. Symptoms = symptomatic distress. SPQ = Subjective Probability Questionnaire. SCEN = exam-related threat scores from Scenarios Questionnaire. [b]$p < .05$.

scores on the STAI-S and Symptoms questionnaires. Because each cognitive bias measure might have a distinct relation to Anx, the cognitive bias measures of total SPQ scores and exam-related SCEN scores were analyzed separately.[3]

Correlations among the measures of this study revealed that participants' scores on the same measure across time were relatively high (mean r = .52), as were correlations between the measures within the Anx composite and between the two cognitive bias measures (mean r = .44). Intercorrelations across anxiety and cognitive bias measures were lower (mean r = .26), and correlations between exam difficulty and measures of anxiety and cognitive bias were mostly nonsignificant. These correlations indicate that findings in the primary analyses, described below, are not attributable to high intercorrelation, or shared attributes, across the different types of self-report measures. Thus multicollinearity among the self-report measures did not appear to be a concern for analyses (see Table II).

Regression analyses were conducted to predict Time 2 and Time 3 Anx from each cognitive bias measure. Anx at Time 1 and the cognitive bias measure at Time 1 were entered as first steps in the regression equations to control for initial levels. Then, to test the first hypothesis that changes in Anx predicted changes in cognitive bias by Time 2, each cognitive bias measure at Time 2 was regressed upon Anx at Time 2. After controlling for Time 1 Anx and SPQ, Anx at Time 2 was associated with SPQ at Time 2 (R^2 change = .14, F change = 7.98, $p < .01$). Furthermore, this relationship remained significant after controlling for trait variables, including

[3]Regression analyses were repeated using total SCEN scores. These analyses produced the same pattern of significant and nonsignificant results as reported for the exam-related SCEN scores.

Table III. Regression Models Predicting Anxiety and Cognitive Bias (N = 52)

Criterion and predictor[a]	Beta	R^2 change	F change	p
Change in SPQ T2				
Change in Anxiety T2	.37	.14	7.98	< .01
Change in SCEN T2				
Change in Anxiety T2	.05	.00	< 1	ns
Change in SPQ T3				
Change in Anxiety T3	.07	.00	< 1	ns
Change in SCEN T3				
Change in Anxiety T3	.26	.07	3.62	.06

[a]SPQ = Subjective Probability Questionnaire. SCEN = exam-related threat scores from Scenarios Questionnaire. T1 = Time 1; T2 = Time 2; T3 = Time 3. Initial levels of all variables were controlled.

the STAI-T, TAI, and PSWQ (R^2 change = .14, F change = 7.61, $p < .01$). However Anx at Time 2 was not associated significantly with SCEN at Time 2.[4]

To test the second hypothesis, that cognitive bias at Time 1 predicted change in Anx by Time 2, Anx at Time 2, controlling for Anx at Time 1, was regressed upon each of the cognitive bias measures at Time 1. Neither cognitive bias measure at Time 1 predicted Anx at Time 2.

Regression analyses were conducted in the same manner for Time 3 variables. Controlling for Anx and SPQ at Time 1, Anx at Time 3 was not associated significantly with SPQ at Time 3. However, controlling for Time 1 Anx and SCEN, Anx at Time 3 tended to be associated with SCEN at Time 3 (R^2 change = .07, F = 3.62, p = .06). After trait variables (STAI-T, TAI, and PSWQ) were controlled, Anx at Time 3 produced an R^2 change of .14 in SCEN at Time 3 (F change = 7.61, $p < .01$).

Neither cognitive bias measure at Time 1 predicted Anx at Time 3 after controlling for Time 1 Anx, thus not supporting the hypothesis that initial cognitive bias levels would predict change in Anx over the course of the study (see Table III for a summary).

Moderating Variables

Perceived difficulty of the exam (DIFF) was tested as a possible moderator of the relationship between cognitive bias at Time 1 and change in Anx by Time 2, using Baron and Kenny's methods (1986). The interaction between SPQ at Time 1 and DIFF significantly predicted Anx at Time 2, after controlling for Anx at Time 1, SPQ at Time 1, and DIFF (R^2 change = .09, F = 4.94, $p < .05$). Also the interaction between SCEN at Time 1 and DIFF significantly predicted Anx at Time 2, after controlling for Anx at Time 1, SCEN at Time 1, and DIFF (R^2 change = .09, F = 4.70, $p < .05$). This result suggests that DIFF moderated the relationship

[4]Regression analyses were repeated with SPQ-Positive (SPQ-P) and SPQ-Negative (SPQ-N) scores to assess whether anxiety predicted cognitive bias for negative events differently than positive events. Controlling for Anx and SPQ-P at Time 1, Anx at Time 2 negatively predicted SPQ-P at Time 2 (R^2 change = .19, $p < .005$). Anx at Time 2 positively predicted SPQ-N at Time 2 (R^2 change = .08, $p < .05$).

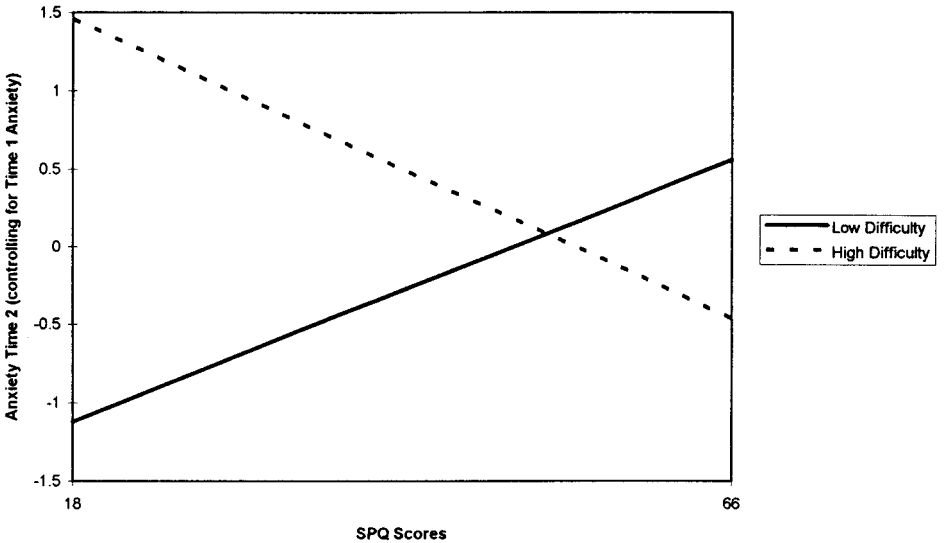

Fig. 1. Relationship between Time 2 Anxiety (controlling for Time 1 Anxiety) and Subjective Probability Questionnaire (SPQ) scores separated by participants who rated the exam as high versus low level of difficulty.

between both cognitive bias measures at Time 1 and Anx at Time 2. For both cognitive bias measures, cognitive bias at Time 1 related positively to Anx at Time 2 among those who rated DIFF as low (betas = .32 and .44). That is, greater cognitive bias at Time 1 predicted greater Anx at Time 2 among those who perceived the exam to be easy. However, contrary to predictions, cognitive bias at Time 1 related negatively to Anx at Time 2 among those who rated DIFF as high (betas = −.36 and −.37). That is, greater cognitive bias at Time 1 predicted less Anx at Time 2 among those who perceived the exam to be difficult (see Figs. 1 and 2).

Students' reports of their grades on the exam at Time 3 were tested as a moderator of the cognitive bias measures at Time 1 and change in Anx by Time 3. No significant interaction effect was found between either cognitive bias measure at Time 1 and students' grades.

Exam Grade and Anxiety

There were no significant correlations between either cognitive bias measure and grade received on the exam. However, the greater the discrepancy between the grade a student had hoped for at Time 1 and the grade he/she received on the exam, the higher the Anx at Time 3, controlling for Anx at Time 1; $r = .34$, $p < .02$. Thus in our sample, there was some indication that, rather than actual grades, students' perceptions of their performance influenced Anx. That is, students who felt they did very poorly relative to their expectations showed the most Anx at Time 3.

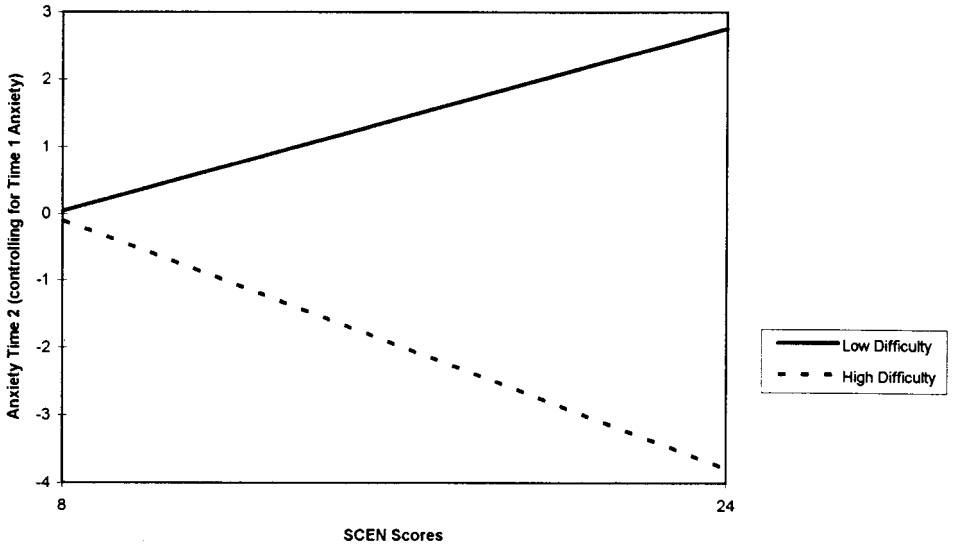

Fig. 2. Relationship between Time 2 Anxiety (controlling for Time 1 Anxiety) and Scenarios Questionnaire (SCEN) scores separated by participants who rated the exam as high versus low level of difficulty.

DISCUSSION

The results of this study showed that changes in anxiety were associated with changes in risk perception immediately after an exam and with threatening interpretations of ambiguous information after grades were received, controlling for initial levels of anxiety and cognitive bias. In contrast, pre-exam cognitive bias did not predict state anxiety immediately after the exam or after grades were received. These findings provide indirect (i.e., correlational) support for the notion that heightened state anxiety may increase cognitive biases for endorsing threatening outcomes.

The study extends the effects of state anxiety from enhanced Stroop interference for threatening information (Chen et al., 1996; Mogg, Mathews, Bird, & Macgregor-Morris, 1990) to biases in the interpretation of ambiguous information and biases in risk perception. Furthermore, the results of the repeated-measures analyses of variance indicate that changes in anxiety may produce changes in judgments of risk and threat related to ambiguous information.

One interesting observation from this study was that changes in anxiety were associated with changes in risk perception immediately after the exam, and changes in threatening interpretations of ambiguous information after grades were posted. Possibly in this sample of first-quarter college freshmen, lack of previous experiences with college examinations may have generated considerable uncertainty regarding the outcome (i.e., their grades), which in turn led to an overestimation of negative outcomes and elevated anxiety immediately after taking the exam. After grades were posted, rather than finding no relation between anxiety and cognitive bias, we found a positive relation between changes in anxiety and changes in threat-

ening interpretations of ambiguous information. Receiving grades might have constituted a negative event for some students who did not get their expected grades. These students may have become more anxious after seeing their grades and may have been more likely to interpret other situations that were ambiguous as negative, thus resulting in the Time 3 relationship between anxiety and threatening interpretations of ambiguous information. In support of this explanation, the discrepancy between expected and actual grade was associated with change in anxiety from Time 1 to Time 3.

Finally, perceived difficulty of the exam moderated the relationship between pre-exam cognitive bias and change in anxiety. Among those who perceived the exam to be easy, greater pre-exam cognitive bias predicted greater anxiety immediately after the exam (controlling for initial levels of anxiety). In this case, with a relatively low perceived stressfulness, individuals' cognitive bias may carry more weight. That is, among those with low cognitive bias, a mildly stressful exam would not produce anxiety; however, among those with high cognitive bias, even a relatively small or mild stressor might be enough to produce increases in anxiety.

On the other hand, greater pre-exam cognitive bias predicted less anxiety after the exam (controlling for initial anxiety) among those who perceived the exam to be difficult. Perhaps when a stressor is extremely threatening, those who perceive greater risk (high cognitive bias) become overwhelmed by the upcoming stressor, and experience depression, resignation, or emotional detachment, rather than anxiety. This explanation is speculative, and the reasons for this negative relationship warrant further investigation.

One limitation of the present study involved the reliance on self-report measures. Self-report measures of cognitive bias may reflect response bias more than the true interpretations about a situation. Computerized procedures, such as that used by MacLeod and Cohen (1993), in which comprehension latencies for ambiguous sentences were measured, provide sensitive measures of interpretations of ambiguity that are less subject to response bias. Although future studies would benefit from these computerized procedures, it was not feasible to implement these procedures in the current study, given the time constraints of a relatively brief stressor, which necessitated group administration of study procedures. An additional limitation was that the cognitive bias measures were unvalidated and unstandardized, thus making the results difficult to interpret. However, the measures in the present study were modeled after those used by Butler and Mathews (1983, 1987) and resulted in findings similar to theirs. Future studies utilizing these types of cognitive bias measures would benefit from reliability and validity analyses.

Another limitation in the interpretations of the findings is that the change in anxiety that occurred over the course of this study was small (particularly the change in state anxiety from Time 1 to Time 2). The small changes may partially account for the lack of relationship between initial levels of cognitive bias and changes in anxiety. Future studies would need to examine more stressful events that might produce larger changes in anxiety.

In the present study, a college student sample was chosen in order to study a standard stressor experienced by all participants. Exams provide a naturalistic, stressful event with the possibility of both negative and positive outcomes. More-

over, exams can be separated into phases (e.g., preparation, uncertainty about the outcome, and reactions to the outcome) over which changes in anxiety and cognitive bias can be monitored. Future studies should examine a comparable paradigm with a sample of clinically anxious individuals. Future studies also could monitor more detailed changes in anxiety over the course of the exam stressor. For example, daily measures of anxiety and cognitive bias might provide clearer information regarding the pattern of changes in anxiety and cognitive bias, and the influence of each on the other. Daily monitoring may reveal a pattern to exam-related anxiety, whereby anxiety initially is low, gradually rising until it peaks the day before the exam, and then dipping slightly (but still remaining high) until grades are revealed, and finally, returning to baseline levels once grades are received. If this is the case, the measures in the present study would have missed the peak level of anxiety although it still may have tapped high levels of anxiety at Time 2. Daily monitoring of anxiety and cognitive bias would provide clearer depictions of the temporal relation between anxiety and cognitive bias that were difficult to draw in the present study, given the correlational nature of some of the analyses.

In summary, changes in anxiety immediately after an exam and after grades were received were associated positively with changes in risk perception of negative events and changes in threatening interpretations of ambiguous information, respectively. Additionally, students' pre-exam cognitive biases predicted elevations in state anxiety immediately following the exam when perceived exam difficulty was included as a moderator.

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