
Distortion in Memory for Emotions: The Contributions of Personality and Post-Event Knowledge

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results are kind of complicated..

Undergraduates (N = 189) rated their test anxiety and emotions immediately before a midterm examination and recalled those feelings 1 week later. Students who learned they had done well on the exam underestimated, and those who learned they had done poorly overestimated, pre-exam test anxiety. Personality traits and emotional states together predicted memory distortion. Specifically, traits predicted the intensity of pre-exam states, such as test anxiety, which in turn predicted later distortion in recalling pre-exam negative and positive emotions. Also, students with positive personality traits were particularly likely to be influenced by current feelings when recalling test anxiety. Overestimating pre-midterm test anxiety predicted intentions to study more as well as feelings of unpleasantness just prior to the final exam.

How people recall past emotions is of both practical and theoretical importance. On a practical level, clinical assessment instruments routinely require people to rate the intensity and frequency with which they have experienced affective states such as depression and anger over the past weeks or months. Diagnostic and treatment decisions concerning mental disorders are based partly on self-reports of this type (Rogler, Malgady, & Tyron, 1992). On a theoretical level, autobiographical memories, particularly memories of emotional experiences, are thought to be crucial to the formation of personality (Singer & Salovey, 1993). Conversely, personality may influence how autobiographical memories are reconstructed to incorporate subsequent knowledge and experience (Kihlstrom, 1981). Memories of past emotions also may influence people's future plans and emotional experiences. It thus becomes important to deter-

mine how people recall their past emotions and what factors are associated with accuracy or distortion of these memories over time.

A recurring debate within psychology has been whether emotions are stored indelibly in memory or whether they are subject to forgetting and memory reconstruction as are other aspects of autobiographical events (B. Ross, 1991). A common modern claim is that memories for the emotional significance of events are especially long lasting, vivid, and easily retrieved (e.g., Lang, 1994; LeDoux, 2000; Witvliet, 1997); therefore, feelings should be remembered very accurately. In contrast, studies that have explicitly measured the accuracy of memory for emotion have uncovered inaccuracies that are consistent with partial reconstruction of past emotions (for reviews, see Christianson & Safer, 1996; Levine, 1997; Safer & Keuler, 2002). These studies have examined recall of emotions recorded over weeks and months in diaries (Cutler, Larsen, & Bunce, 1996; Feldman Barrett, 1997; Parkinson, Briner, Reynolds, & Totterdell, 1995; Thomas & Diener, 1990) and recall of emotions experienced at a salient, specific point in time, such as the level of anxiety prior to donating blood (Breckler, 1994) or the intensity of distress when starting psychotherapy (Safer & Keuler, 2002). The results indi-

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cate that although individuals are fairly accurate or consistent in recalling emotions, they often remember past emotional experiences as having been more intense than initially reported.

Given that emotions are not always recalled accurately, what accounts for the extent and direction of memory distortion? The current study investigated whether factors known to influence memory for events and attitudes—post-event knowledge and individual differences in emotional traits and states—also predict distortion in memory for emotions.

Post-Event Knowledge

Post-event knowledge and experiences influence memory for events (e.g., Bartlett, 1932; Loftus, 1992; M. Ross, 1989; M. Ross & Wilson, 2000) and may influence memory for emotions (Keuler & Safer, 1998; Levine, 1997). For example, Levine and colleagues investigated people's memories for their emotional reactions to the announcement of the verdict in the murder trial of O. J. Simpson. People who became more convinced of Simpson's guilt over time overestimated how angry they had felt when Simpson was first acquitted. In contrast, people who became more convinced of Simpson's innocence underestimated how angry they had felt (Levine, Prohaska, Burgess, Rice, & Laulhere, 2001). Holmberg and Holmes (1994) found that memories for the intensity of feelings evoked by positive and negative marital interactions were biased in the direction of current beliefs about the partner's trustworthiness. These studies indicate that emotions can be underestimated as well as overestimated in recall and that the direction of distortion is related to post-event knowledge. Because these studies used correlational designs, however, they could not establish that post-event knowledge caused the memory changes. In the current study, we used an experimental design to assess the effects of post-event knowledge on the accuracy of memory for emotions.

Personality Trait- and Emotional State-Congruent Processing

People preferentially attend to, perceive, judge, and remember emotional stimuli that are congruent in emotional tone with their personality and emotional state (for a review, see Rusting, 1998). Thus, people's enduring personality traits and temporary emotional states also may contribute to distortion in recall of past emotions. For example, Cutler et al. (1996) had participants rate their moods twice daily for a month. Those who scored high on trait anxiety reported greater daily negative affect than those who scored low, and at the end of the study, they recalled having felt even worse than the average of their reports. Similarly, Feldman Barrett (1997) found that participants who scored high on

neuroticism overestimated the average intensity of previously recorded negative emotional states. Safer and Keuler (2002) asked individuals who were terminating psychotherapy to recall their emotional distress just prior to their first session of psychotherapy. People who reported being high on negative traits such as neuroticism and negative emotional states such as current distress and anxiety tended to overestimate in recalling their pre-psychotherapy emotional distress. People who scored high on positive traits such as ego-strength tended to underestimate their pre-psychotherapy distress.

Although many studies have reported personality trait- and emotional state-congruent processing of information, there have been inconsistent findings. Some studies show no evidence for emotional trait or state congruency; others show memory congruence for positive but not negative states; and still others show emotion-incongruent memory. Rusting (1998) argued that these inconsistencies may be clarified by examining the ways in which lasting personality traits and temporary emotional states interact to influence memory and judgment. She proposed two possible models of joint influence that may be relevant to memory for emotions.

In Rusting's mediation model, personality traits predispose the individual to experience certain emotional states, and these states, in turn, affect emotional processing. For example, high levels of neuroticism may increase the frequency or intensity of negative affect, which in turn predicts congruent processing of negative emotional information. In her moderation model, emotional state-congruent processing may occur only for (or especially for) individuals with certain personality traits. For example, Rusting (1999) reported that negative mood-congruency effects on a number of cognitive tasks were stronger for individuals who scored high on both neuroticism and negative affect than for individuals who scored low on these measures. Thus, mediation models may help explain why congruency-related distortion occurs, and moderation models may help specify who shows congruency-related distortion.

Unfortunately, few studies have measured both emotional traits and states, and those that have measured both typically treat these variables as independent or competing predictors. As a result, Rusting (1998) was unable to find any studies that directly tested a mediation model for any aspect of emotional processing, and she found only a few studies that investigated moderation models. The current study is the first to investigate the applicability of both mediation and moderation models to understanding the combined impact of personality traits and emotional states on the accuracy of memory for emotions.

remind me of recent work from the Yale Lab (Lee?) find that anxious ppl are more inclined to feel anxious emotions?

The Present Investigation

Students experience a complex blend of both threatening and challenging emotions just before an exam (Smith & Ellsworth, 1987). We investigated how post-event knowledge and individual differences were related to the accuracy with which students remembered the test anxiety and emotions that they had experienced prior to a midterm examination. Our goals were as follows: (a) to assess the effects of post-event knowledge and appraisals on memory for past emotions; (b) to assess the possible interactive relationship between individual differences on emotional state and trait measures and accuracy in recalling past emotions; and (c) to determine whether distortion in memory for past emotions persists and influences future plans, behaviors, and affective experiences.

We asked students to rate their test anxiety and emotions as they were experiencing them, immediately before taking their midterm examination, and then to recall these feelings the following week. A random sample of students learned their exam grade before recalling their pre-exam emotions; the remaining students had not yet learned their grade when they recalled their pre-exam emotions. Post-event knowledge of their grade should lead to a reappraisal of the exam-taking experience (Conway, 1990; Keuler & Safer, 1998). We predicted that students who knew that they received a high grade on the exam would underestimate pre-exam negative feelings and test anxiety and overestimate pre-exam positive feelings. Conversely, those who knew that they received a poor grade were expected to overestimate pre-exam negative feelings and test anxiety and underestimate pre-exam positive feelings.

We predicted that recall of pre-exam emotions also would be distorted in the direction of personality trait congruence and emotional state congruence. Thus, students who scored high on negative traits such as neuroticism or low on positive traits such as self-esteem were expected to recall more pre-exam test anxiety and negative emotions, and less positive emotions, than initially reported. Similarly, students experiencing high levels of pre-exam test anxiety were expected to recall higher levels of negative emotions and lower levels of positive emotions than initially reported. In addition to examining the separate contributions of traits and states, we investigated how individual differences in emotional traits and states interact to predict memory for emotions.

Finally, we examined whether misremembering pre-exam emotions and test anxiety predicts future plans and affective experiences. We predicted that students who overestimated their pre-midterm test anxiety would be motivated to study more for the final examination and would report a more negative affective state just

prior to the final. Such findings would demonstrate the continuing impact of the memory distortion.

METHOD

Participants

Undergraduates ($N = 189$) in an introductory psychology class at the University of California, Irvine, participated in the study. Participants included 64 men, 123 women, and 2 who did not report gender. There were no gender differences on the three memory distortion measures; therefore, we combined over gender for all remaining analyses.

Procedure

Data collection took place in four stages: 1 week before the midterm exam, just prior to the midterm exam, 1 week after the midterm, and just prior to the final exam. Students who chose to participate received course credit.

Stage 1. One week before the midterm exam, participants in an introductory psychology course completed a packet with six personality measures at home. It took about 20 min to complete the packet. They returned the packet in the next class session, when they took the midterm exam. The packet included measures of (a) three positive traits: self-esteem (Rosenberg, 1965), optimism (Scheier, Carver, & Bridges, 1994), and extraversion (Costa & McCrae, 1992); (b) three negative traits: neuroticism (Costa & McCrae, 1992), depression (Zung, 1965), and anxiety (Bendig, 1956; J. A. Taylor, 1953); and (c) demographic information. The coefficient alpha reliabilities for the six trait measures were .88, .75, .80, .84, .79, and .54, respectively.¹

Stage 2. In class, immediately prior to taking their midterm exam, participants completed a 5-min questionnaire that asked them to rate their current negative and positive emotions, test anxiety, and appraisals concerning the exam. Participants rated the intensity of their current feelings on a scale from 1 (*not at all*) to 7 (*extremely*) using nine adjectives taken primarily from Smith and Ellsworth (1987). A principal component analysis found that the first component explained 40.14% of the variance, with five adjectives having a negative loading of $-.63$ or less and four adjectives having a positive loading of $.35$ or greater. The five negative adjectives—sad, afraid, nervous, frustrated, angry—were summed into a single scale ($\alpha = .81$), as were the four positive adjectives—relaxed, hopeful, happy, interested ($\alpha = .64$). Participants then completed a 10-item measure of test anxiety, the “worry-emotionality” scale (Morris, Davis, & Hutchings, 1981), which was designed to measure cognitive and physiological anxiety prior to an

exam ($\alpha = .88$). Finally, participants answered a series of questions about their anticipated satisfaction with their performance, their expected grade, and hours spent studying for the exam.

Stage 3. In class, 1 week after the midterm examination, participants attempted to recall their pre-midterm emotions, test anxiety, and appraisals. To examine the effects of post-event knowledge, we arranged the pages in the Stage 3 questionnaire in one of two orders. For the informed group ($n = 132$), the first pages in the packet after the consent form listed the student identification number, number of correct answers, and midterm exam letter grade for each student in the class. Each participant in the informed group was instructed to find and write down his or her score and grade prior to completing the rest of the questionnaire. The informed participants thus learned their grades just before attempting to recall their pre-exam emotional state, and that information was expected to increase recall distortion. Approximately two thirds of the participants were assigned to the informed group to enhance statistical power for analyzing the effects of post-event knowledge. For the uninformed participants ($n = 57$), the grade reports were the final pages in the questionnaire packet, and so they learned their grade after recalling their pre-exam emotional state. The packets were distributed randomly and participants were instructed to answer the questions in order. A few uninformed participants may have disregarded instructions and looked at their grades before recall, which would diminish the impact of the post-event information manipulation.

The questionnaire first asked participants to rate their current feelings of pleasantness and of arousal (e.g., 1 = *extremely unpleasant* to 7 = *extremely pleasant*). They were then asked to "try to remember, as accurately as possible, what you were thinking and feeling" just before the midterm and to complete the various items as they did then. All participants completed the same emotion, test anxiety, and appraisal items as in Stage 2, although the items within each scale were arranged in a different order. The coefficient alpha reliabilities were .83 for recalling the negative emotions, .75 for recalling the positive emotions, and .91 for recalling test anxiety. Participants completed this questionnaire in 5 min or less.

Stage 4. The final questionnaire was completed 4 weeks later, in class, immediately prior to the final exam. Out of the 189 participants, 171 completed the Stage 4 questionnaire. This 5-min questionnaire first asked participants to estimate how many hours they had studied for the final exam and to rate their current feelings of pleasantness and arousal. Participants were then asked once again to try to remember how they had felt before

the midterm and to answer the same questions about their pre-midterm negative emotions ($\alpha = .87$), positive emotions ($\alpha = .76$), and test anxiety ($\alpha = .92$). Finally, they rated their satisfaction with their performance on the midterm exam.

RESULTS

Participants' ratings of how they felt before the midterm exam were compared to their recall of these ratings 1 week later. The pre-exam values were highly correlated with recalled values for test anxiety, $r(187) = .83$, negative emotion, $r(184) = .78$, and positive emotion, $r(183) = .67$ (all $ps < .001$). Paired t tests showed no significant differences between pre-exam values and recalled values for any of the three measures (all $ps > .25$). Thus, participants were relatively accurate in recalling their pre-exam ratings and, as a group, showed no consistent pattern of overestimation or underestimation.

Nonetheless, there were important differences in recall distortion as a function of post-event knowledge and as a function of individual variability on emotional state and trait measures. To measure recall distortion, a residual change score was calculated for each participant on each of the three measures (test anxiety, negative emotion, and positive emotion) by regressing the recall score for that measure on the values of the initially reported score. The residual change score indicates whether recall was greater than or less than what would be predicted by the initial score.² A positive value for the residual change score indicates that the participant overestimated in recall, and a negative value indicates that the participant underestimated. The mean for a residual change score is 0.

Post-Event Knowledge and Memory for Emotion

To assess whether post-event knowledge influenced participants' memory for their pre-exam emotions, one group of participants was informed of their exam grade before recalling their pre-exam emotions and the other group was not informed. As expected, learning their grades affected participants' current feelings. Current feelings of pleasantness were highly correlated with exam grades in the informed group, $r(129) = .76$, $p < .001$, but not in the uninformed group, $r(55) = .23$, $p > .05$. These correlations were significantly different, $z = 4.71$, $p < .001$.

We predicted that participants' knowledge of, and reaction to, their grades would affect memory for their pre-exam test anxiety and emotions. To test this hypothesis, we calculated a multiple regression for each of our three memory distortion measures using group, grade, and Group \times Grade as predictors. The continuous vari-

able, grade, was centered prior to calculating the interaction term (Cohen & Cohen, 1983).

A significant Group \times Grade interaction was found for distortion of test anxiety, $t(185) = -2.30$, $p < .05$. This interaction resulted because the regression of distortion on grade was significant in the informed group, $b = -.16$, $t(130) = -3.63$, $p < .001$, but not in the uninformed group, $b = .02$, $t(55) = .25$, $p > .05$. For example, those in the informed group who scored below the median (grade of B– or less) overestimated their pre-exam test anxiety ($M = 1.45$, $SD = 5.22$), whereas those scoring B or above underestimated ($M = -1.10$, $SD = 4.76$). Thus, students' knowledge of their grades led to immediate revision of their memory for pre-exam test anxiety.

A significant main effect of group was found for memory distortion of negative emotions, $t(185) = -2.32$, $p < .05$, and positive emotions, $t(181) = 2.24$, $p < .05$. Compared to the informed group, the uninformed participants tended to overestimate pre-exam negative emotions and underestimate pre-exam positive emotions. No significant Group \times Grade interactions were found for distortion of either negative or positive emotions.

Individual Differences in Memory for Emotion

Emotional state-congruent memory distortion. Analyses of whether individual differences in participants' emotional state prior to the exam affected memory distortion were conducted on the total sample (both the informed and uninformed groups) to maximize statistical power.³ Correlations were computed between each of the three pre-exam state measures (test anxiety, negative emotion, and positive emotion) and the remaining two residual change scores. (By definition, a pre-exam emotional state variable has a zero correlation with its corresponding residual change score.) All six correlations demonstrated state-congruent memory distortion (see Table 1). Thus, based on one measure of participants' pre-exam emotional state, it was possible to predict how they would distort in recalling other pre-exam measures.

Personality trait-congruent memory distortion. One week before the exam, participants completed three personality measures of negative self-appraisal (neuroticism, depression, anxiety) and three of positive self-appraisal (self-esteem, optimism, extraversion). We correlated participants' personality traits with their initial, pre-exam ratings of test anxiety and emotions, as well as with their recall of those ratings 1 week later. The initial ratings and the recalled ratings for pre-exam states correlated very similarly and strongly with each trait measure; therefore, Table 2 presents the correlations only for the initial ratings. The mean of the absolute values of the 18 correlations between traits and initial ratings in Table 2 was $r = .36$, and the comparable mean between traits and

TABLE 1: Correlations Between Pre-Exam Ratings and Memory Distortion as Measured by Residual Change Scores ($N = 189$)

Pre-Exam Rating	Residual Change Scores		
	Test Anxiety	Negative Emotions	Positive Emotions
Test anxiety	.00	.29***	-.24**
Negative emotions	.16*	.00	-.23**
Positive emotions	-.25***	-.23**	.00

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

recall ratings was also $r = .36$. As predicted, there was a pattern of congruence between a trait's valence and the direction of initial and recalled ratings. For example, neuroticism correlated .43 with the pre-exam rating of negative emotions and .49 with the recall of negative emotions.

Our primary interest, however, was not in the relationship of personality traits to the initial ratings or recalled ratings but in the relationship of personality traits to memory distortion, as measured by the residual change scores. These correlations would be expected to be less strong because residual scores are much less variable than the corresponding initial and recall scores.⁴

We expected a similar pattern of congruence between the valence of participants' personality traits and the direction of memory distortion. The correlations between the six trait measures and the three residual change scores are presented in Table 3. Two of the three negative traits (neuroticism and depression) were associated with overestimating negative emotions and underestimating positive emotions, and the opposite pattern occurred for two of the three positive traits (self-esteem and optimism) (all $ps < .05$). Trait anxiety and extraversion were not significantly correlated with any of the three residual change scores, and none of the trait measures predicted distortion in recalling test anxiety.

In the next set of analyses, we attempted to find potential mediators and moderators of the correlations shown in Table 3 (Baron & Kenny, 1986). Mediating variables explain how or why a significant result occurs. In contrast, moderator variables specify the conditions or individuals for which a particular result occurs or does not occur; therefore, they are particularly useful in trying to understand weak or inconsistent findings. We investigated whether participants' pre-exam emotional states might mediate the eight significant correlations between personality trait measures and distortion of negative and positive emotions. We also investigated whether participants' emotional state at the time of recall might moderate the six nonsignificant correlations between personality trait measures and distortion of test anxiety.

TABLE 2: Correlations Between Personality Traits and Pre-Exam Ratings of Emotion (N = 189)

Personality Measures	Pre-Exam Ratings of Emotion		
	Test Anxiety	Negative Emotions	Positive Emotions
Negative			
Neuroticism	.47***	.43***	-.36***
Depression	.44***	.39***	-.34***
Anxiety	.40***	.42***	-.30***
Positive			
Self-esteem	-.46***	-.44**	.31***
Optimism	-.38***	-.41***	.38***
Extraversion	-.21**	-.18*	.23***

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

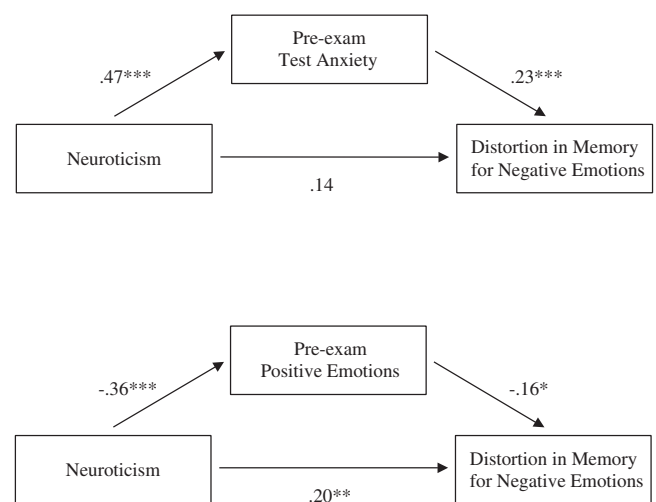
TABLE 3: Correlations Between Personality Traits and Memory Distortion as Measured by Residual Change Scores (N = 189)

Personality Measures	Residual Change Scores		
	Test Anxiety	Negative Emotions	Positive Emotions
Negative			
Neuroticism	.10	.24**	-.23*
Depression	.09	.17*	-.16*
Anxiety	.06	.06	-.07
Positive			
Self-esteem	-.09	-.15*	.16*
Optimism	-.13	-.14*	.23*
Extraversion	.01	-.08	.09

* $p \leq .05$. ** $p \leq .01$.

Mediators of the significant correlations. Rusting (1998) proposed that personality traits may predispose people to experience certain emotional states and these states, in turn, influence emotional processing. Pre-exam emotional states may mediate the effects of personality traits on distortion in memory for negative and positive emotions by being both the effect of personality and the cause of the subsequent memory distortion (see Figure 1).

Demonstrating mediation requires a path model using the results of three multiple regression equations (Baron & Kenny, 1986). The following results are necessary to demonstrate that pre-exam emotions mediate the effects of personality on memory distortion: (a) Personality must significantly predict pre-exam emotional state (β_{21}); (b) personality must significantly predict memory distortion (β_{31}); and (c) when both pre-exam emotional state and personality trait are entered into a regression equation, the regression coefficient for the pre-exam emotional state ($\beta_{32.1}$) must be significant and the regression coefficient for personality trait ($\beta_{31.2}$) must be less in

**Figure 1** Two path models with standardized coefficients showing that pre-exam emotional states mediate the correlation between neuroticism and distortion in memory for negative emotions.

NOTE: The top and bottom figures illustrate two types of relationships. There was no direct path between trait and memory distortion (as in the top figure) for 12 of 16 models; there was a direct path (as in the bottom figure) for 4 of 16 models. See also Table 4.

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

absolute value than when the personality trait is entered alone (β_{31}). For “complete” mediation, personality should no longer predict memory distortion once pre-exam emotion is entered into the equation. The path model uses the standardized regression coefficients from the first and third regression equations. Sobel (1982) provides an approximate, large sample statistical test (z) for the significance of the indirect effect ($\beta_{32.1} \times \beta_{21}$) of the personality trait on memory distortion via the pre-exam emotional state.

For example, we assessed whether two pre-exam emotional state measures, test anxiety and positive emotions, mediated the significant relationship between neuroticism and memory distortion for negative emotions. We found that the significant correlation between neuroticism and distortion in memory for negative emotions was mediated by pre-exam test anxiety (top panel of Figure 1) and by pre-exam positive emotions (bottom panel of Figure 1). Both path models satisfy the Baron and Kenny (1986) criteria. The test of the indirect effect, neuroticism \rightarrow pre-exam test anxiety \rightarrow distortion in memory for negative emotions, was significant, $z = 2.69$, $p < .01$, as was the test of the indirect effect, neuroticism \rightarrow pre-exam positive emotions \rightarrow distortion in memory for negative emotions, $z = 1.94$, $p = .05$.

There were two possible pre-exam emotional state mediators for each of the eight significant correlations between personality traits and distortion in memory for

TABLE 4: Values Used to Calculate Direct and Indirect Effects of Personality on Memory Distortion for the 16 Path Models

Personality (Variable 1)	Pre-Exam State (Variable 2)	Memory Distortion (Variable 3)	Direct Effect		Indirect Effect	
			$\beta_{31.2}$	β_{21}	$\beta_{32.1}$	$\beta_{32.1} \propto \beta_{21}$
Neuroticism	Test anxiety	Negative emotion	.14	.47***	.23**	.11**
Neuroticism	Positive emotion	Negative emotion	.20*	-.36***	-.16*	.06*
Neuroticism	Test anxiety	Positive emotion	-.15	.47***	-.16*	-.06
Neuroticism	Negative emotion	Positive emotion	-.17*	.44***	-.16*	-.07
Depression	Test anxiety	Negative emotion	.05	.44***	.27***	.12**
Depression	Positive emotion	Negative emotion	.11	-.34***	-.19*	.07*
Depression	Test anxiety	Positive emotion	-.07	.44***	-.20*	-.09*
Depression	Negative emotion	Positive emotion	-.09	.39***	-.20*	-.08*
Self-esteem	Test anxiety	Negative emotion	-.02	-.46***	.28***	-.13**
Self-esteem	Positive emotion	Negative emotion	-.10	.31***	-.20**	-.06*
Self-esteem	Test anxiety	Positive emotion	-.07	-.46***	-.21*	.10**
Self-esteem	Negative emotion	Positive emotion	.07	-.44***	-.20*	.09*
Optimism	Test anxiety	Negative emotion	-.04	-.38***	.28***	-.10**
Optimism	Positive emotion	Negative emotion	-.07	.38***	-.20**	-.08*
Optimism	Test anxiety	Positive emotion	.16*	-.38***	-.18*	.07*
Optimism	Negative emotion	Positive emotion	.17*	-.40***	-.16*	.07*

NOTE: The indirect effects are tested using Sobel's (1982) method. The first two rows of the table are illustrated in Figure 1.

* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

negative and positive emotions in Table 3. All of the resulting 16 path models (of which two were illustrated in Figure 1) satisfied the Baron and Kenny criteria. The indirect or mediational effect was significant in 14 of the 16 models ($ps < .05$) and was marginally significant in the other two ($ps < .06$) (see Table 4, Column 7). Complete mediation occurred in 12 of the 16 models, including the top panel of Figure 1 where neuroticism no longer has a significant direct effect on distortion in memory for negative emotions. In contrast, the bottom panel of Figure 1 illustrates one of the four models where the trait continued to have a significant direct effect on distortion (see Table 4, Column 4).

In summary, there was very strong support across different measures of personality, mediators, and memory distortion that pre-exam emotional states mediated the eight significant correlations between personality traits and distortion in memory for negative and positive emotions. Thus, participants' personality traits predisposed them to experience particular emotional states prior to the exam. These positive or negative pre-exam emotions were in turn associated with emotion-congruent distortion when participants recalled their feelings after a delay.

Furthermore, neither midterm grade nor Stage 3 pleasantness ratings were alternative mediators of the correlations between personality and memory distortion. None of the six personality variables was significantly correlated with grade or with Stage 3 pleasantness ratings ($ps > .05$). Also, in the total sample, Stage 3 pleasantness was not significantly correlated with any of the three memory distortion measures ($ps > .05$).

Moderators of the nonsignificant correlations. Rusting (1998) also proposed that personality may moderate the relationship between emotional state and emotional processing such that emotional state-congruent processing occurs only for certain types of individuals. No personality trait measure was significantly correlated with distortion in memory for pre-exam test anxiety (see Table 3). Students' knowledge of their grade did influence their memory for pre-exam test anxiety, however. We therefore examined whether the emotional state associated with student's knowledge of their grade was moderated by personality traits to predict distortion of test anxiety. All participants rated their feeling of pleasantness on a 7-point scale just before attempting to recall their pre-exam test anxiety and emotions (i.e., at Stage 3). Participants in the informed group had just learned their grade, and those in the uninformed group did not yet know their grade.

Moderating variables are indicated by significant interactions that can be investigated further by plotting the interaction of the simple effects of one variable across levels of the other and then conducting post hoc statistical tests (Baron & Kenny, 1986). Testing the interaction of two continuous variables requires multiple regression. The personality trait measure and pleasantness rating were first "centered" with means of zero to reduce multicollinearity and increase interpretability. The centered values were then entered along with their product (representing the interaction) into a multiple regression to predict the residual change score for test anxiety. A significant interaction was then examined further by plotting the simple slopes of the regression on

one of the interacting predictors (e.g., pleasantness) at representative values of the other predictor (e.g., personality trait). By convention, three representative values were plotted: the mean, one standard deviation below the mean (low values), and one standard deviation above the mean (high values) of the second predictor (Aiken & West, 1991; Cohen & Cohen, 1983).

Six multiple regressions were calculated, each one testing the interaction of pleasantness at the time of recall (i.e., Stage 3) with one of the six personality traits. The interactions were significant for neuroticism, $t(184) = 2.18, p < .05$; depression, $t(184) = 3.30, p < .001$; and optimism, $t(184) = -2.26, p < .05$. Figure 2 depicts the significant interaction between pleasantness at the time of recall and neuroticism in predicting memory distortion for test anxiety. A significant negative slope was found for low values of neuroticism, $b = -.69, t(184) = -2.82, p < .01$, and no significant slope was found for either mean or high values of neuroticism. Post hoc analyses of the other two significant interactions revealed the same pattern of results. Namely, pleasantness was congruently related to memory distortion for low values of depression, $b = -.83, t(184) = -3.54, p < .001$, and no significant slope was found for either mean or high values of depression. Pleasantness was congruently related to memory distortion for high values of optimism, $b = -.70, t(184) = -2.86, p < .01$, and no significant slope was found for either mean or low values of optimism. Thus, participants who scored low on the negative traits of neuroticism or depression, or high on the positive trait of optimism, tended to underestimate test anxiety if feeling pleasant at the time of recall and overestimate test anxiety if feeling unpleasant. In contrast, participants who scored high on neuroticism or depression, or low on optimism, tended to overestimate their pre-exam test anxiety regardless of their rating of pleasantness at the time of recall. In summary, personality moderated the relationship between the emotional state at retrieval and memory distortion for test anxiety. Only those with "positive" personality traits showed congruence between their retrieval state and memory distortion.⁵

Memory Distortion and Future Plans and Emotions

After recalling their pre-exam emotions, participants were asked whether they planned to study less, about the same, or more for the final exam, and 94% indicated that they planned to study more (ratings of 5 or greater on a 7-point scale). Overestimating the intensity of test anxiety induced by the midterm was positively correlated with plans to study more for the final, $r(177) = .23, p < .01$, and the correlation was still significant after partialing out the midterm grade, partial $r = .16, p < .05$.

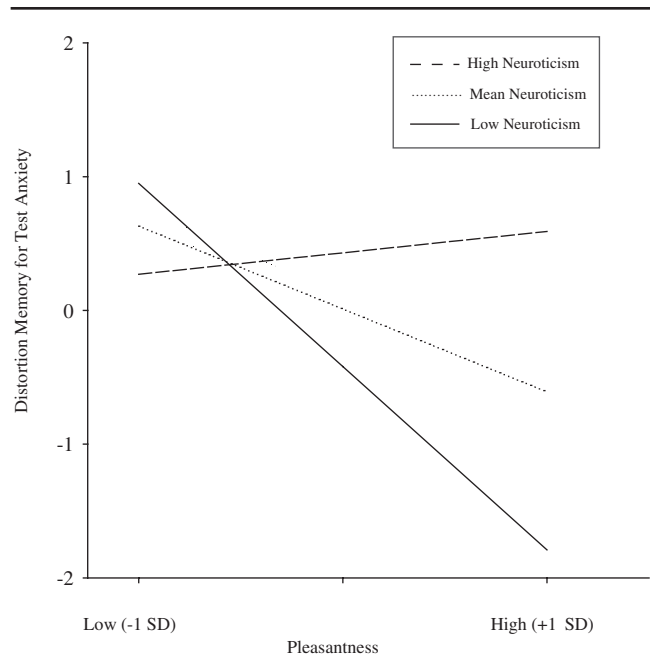


Figure 2 Neuroticism moderated the relationship between feelings of pleasantness at the time of recall (Stage 3) and distortion in memory for test anxiety.

NOTE: For participants who scored low on neuroticism, memory for test anxiety was distorted in a direction congruent with feelings of pleasantness at the time of recall. No significant slope was found for mean or high values of neuroticism. Participants who scored high on neuroticism overestimated test anxiety slightly regardless of their current feelings. The standard deviation was 8.04 for neuroticism and 1.99 for pleasantness.

We also examined whether memory distortion a week after the midterm (Stage 3) predicted ratings of pleasantness 4 weeks later, just prior to taking the final exam (Stage 4). The results indicated that the more participants overestimated in recalling test anxiety, the lower they rated their feelings of pleasantness just before the final exam, $r(166) = -.20, p < .01$. Similarly, the more they overestimated in recalling negative emotions, the lower they rated their feelings of pleasantness just before the final exam, $r(164) = -.16, p < .05$. Both correlations remained significant even after removing the effects of the midterm grade (partial r s = $-.17$ and $-.16$, respectively, p s $< .05$). The correlation between distortion in recall of test anxiety and Stage 4 feelings of pleasantness also remained significant after partialing out personality for each of the six personality measures (all six p s $< .05$), but the correlation of distortion of negative emotions and Stage 4 pleasantness was no longer significant after partialing out five of the six personality measures (all but anxiety, $p > .05$). In sum, distorted recall of their pre-midterm emotional state predicted students' emotional state prior to the final exam, and this suggests that the distortion persisted over time.

Persistence of Memory Distortion

A final set of analyses was conducted to assess more directly whether memory distortions persisted over time. At Stage 4, just before beginning their final exam, 171 participants attempted once again to recall how they had felt before the midterm. For each participant, residual change scores were calculated for test anxiety, negative emotions, and positive emotions by regressing the Stage 4 recall scores on the initial, pre-midterm scores. The Stage 3 residual change scores (1 week after the midterm) were highly correlated with the Stage 4 residual change scores (5 weeks after the midterm). The correlations were $r(169) = .54$ for test anxiety, $r(165) = .62$ for negative emotions, and $r(166) = .46$ for positive emotions (all $ps < .001$). These results indicated that participants' memory distortion remained relatively consistent over time. Because residual scores have means of 0, it was necessary to compare recall-minus-initial-difference scores to determine whether the magnitude of memory distortion changed over time. Using paired t tests, none of the three comparisons of Stage 3 versus Stage 4 difference scores was significant (all $ps > .05$). Thus, there was no evidence that memory became more or less accurate over time.

Pre-exam emotional states continued to mediate the memory distortion. Of the 12 correlations between personality traits and Stage 4 memory distortion for negative and positive emotions, 8 were significant (all $ps \leq .05$), similar to Stage 3. As described above, there were two possible mediators for each significant correlation. The indirect effect of a personality trait on Stage 4 memory distortion, as mediated by pre-midterm emotional state, was significant in 12 of the 16 possible path models (all $ps < .05$).

Personality continued to moderate the relationship between emotional state at the time of retrieval and distortion in memory for test anxiety. None of the six personality traits correlated significantly with Stage 4 distortion in memory for test anxiety. Of interest, pleasantness at Stage 4 did not interact significantly with any personality trait to predict distortion in memory for test anxiety. However, participants' ratings at Stage 4 of satisfaction with their performance on the midterm did interact significantly with neuroticism, depression, self-esteem, and extraversion to predict distortion in memory for test anxiety (all $ps < .05$). Thus, after a delay of 1 month, students' specific appraisal of their midterm exam performance, rather than their general affective state, was associated with memory distortion. Post hoc analyses indicated that satisfaction with their midterm exam performance predicted underestimation of test anxiety only for students who scored low on neuroticism and depression and high on self-esteem and extraversion (all four $ps < .01$). At other values of these traits, participants tended to overes-

timate pre-exam test anxiety regardless of current level of satisfaction with their performance on the midterm. Thus, the moderating effects of personality on perceived satisfaction with one's midterm performance at Stage 4 were similar to the moderating effects of personality on feelings of pleasantness at Stage 3.

DISCUSSION

Although students as a group recalled rather accurately how they had felt before their midterm exam, both post-event knowledge and individual differences on trait and state measures predicted memory distortion. Memory distortion persisted over time and influenced students' emotional state prior to the final exam.

Post-Event Knowledge and Memory Distortion

The present study demonstrated experimentally that revision of memory for prior emotions can occur immediately following the introduction of relevant post-event information. A random sample of students learned their exam grade prior to recalling their pre-exam emotions. In contrast to uninformed students, those who learned that they had done well on the exam underestimated, and those who learned that they had done poorly overestimated, their pre-exam test anxiety. Thus post-event knowledge led to immediate revision of memory for test anxiety.

Students in the present experiment were asked to remember rather mild emotional states that they had explicitly rated 1 week earlier. Correlational and case studies suggest, however, that even memories of powerful emotions are subject to distortion over time and with changing experience and self-conceptions. For example, reports of having ever experienced suicide ideation paradoxically decline with age as individuals, particularly those with good self-concepts, appear to forget or reinterpret prior suicidal feelings, thoughts, and actions (Klimes-Dougan, 1998). A decline with age also occurs for self-reports that one has ever experienced symptoms of severe depression (Rogler et al., 1992). Similarly, alleged and actual victims of sex abuse may use post-event knowledge of their lives to reconstruct memories of abuse (Lindsay & Read, 1994). Memories of combat-related experiences also are modifiable by post-war experiences (Southwick, Morgan, Nicolaou, & Charney, 1997). Thus, even memories for intense emotions can be modified and updated much like other autobiographical memories.

Why are memories of past emotions reconstructed in directions consistent with current knowledge? The primary function of memory for emotion may be to guide goal-directed action rather than to serve as an indelible record of the past (M. A. Conway & Pleydell-Pearce,

2000). Recalling past emotions alleviates the need to store detailed descriptions of events while providing information about whether to engage in similar behaviors in the future or seek alternatives (Levine et al., 2001). For example, we found that overestimating pre-midterm test anxiety predicted students' intentions to study more for the final exam. If memories for emotions serve to guide goal-directed action, then updating these memories based on current experience makes them a more useful guide, much like updating a map to reflect current road openings and closings makes it more accurate and useful. Thus, reconstruction of memories of past emotions based on current knowledge may represent a flexible, adaptive process (Hoffrage, Hertwig, & Gigerenzer, 2000).

Individual Differences in Memory Distortion

The present study demonstrated both personality trait-congruent and emotional state-congruent distortion in memory for emotions. In addition to examining the separate contributions of traits and states, we also found that pre-exam emotional states mediated the relationship between personality and memory distortion for positive and negative emotions. For example, the more neurotic students were, the more test anxious they felt before the exam; in turn, the more test anxious they felt, the more they overestimated when later recalling negative emotions. This mediational model of the joint impact of traits and states held for all significant correlations between personality traits and distortion in memory for emotions. In 12 of 16 models, a pre-exam emotional state completely mediated these correlations, whereas in the other 4 models, there was evidence of both trait congruence and state congruence effects. Further research is needed to explain why complete mediation occurred in some models but not all. In summary, our findings provide striking evidence for Rusting's (1998) proposed mediation model and should encourage attempts to investigate whether emotional states also mediate, either completely or partially, individual differences in perceiving, judging, and recalling emotional stimuli.

We also investigated moderation models to elucidate the combined impact of personality traits and emotional states at the time of retrieval. We found that students' memory for test anxiety was distorted in a direction congruent with their feelings of pleasantness at the time of recall and with their later feelings of satisfaction with their exam performance. This occurred, however, only for students with positive personality traits (e.g., students who scored high on optimism or low on neuroticism or depression). These positive-trait individuals underestimated their pre-exam test anxiety if they were currently

feeling pleasant or satisfied and overestimated pre-exam test anxiety if they were currently feeling unpleasant or dissatisfied. In contrast, participants with negative personality traits overestimated test anxiety slightly regardless of their current feelings.

These findings are consistent with prior research showing that individuals who self-report positively on personality trait measures often display greater flexibility in their representations of events, and greater responsiveness to environmental contingencies, than those who self-report negatively (Aspinwall, 1998; Isen, 1990; Lyubomirsky, 2001; Schneider, 2001). Individuals who self-report negatively on trait measures tend to perceive experiences with less bias (S. E. Taylor & Brown, 1988). The greater flexibility of positive-trait individuals in recalling the past may allow them to construe the world in a manner more favorable to themselves or in a manner that motivates appropriate action for coping with environmental challenges.

In summary, the present study was the first to show the combined impact of personality traits and emotional states on distortion in memory for emotions. The mediation and moderation effects were robust. They occurred for positive and negative emotional traits, positive and negative emotional states, and after both brief and extended delay periods. Future research might explore whether, as in the current study, mediation models describe the role of emotions at the time of encoding, whereas moderation models describe the role of emotions at the time of retrieval.

Future Consequences of Memory Distortion

An important consequence of distortion in memory for emotion may be its effects on future or continuing experiences of emotion (Karney & Coombs, 2000; Safer, Bonanno, & Field, 2001). Distortion in recalling pre-midterm emotions was undiminished at the time of the final exam. Moreover, distortion in students' memory for their pre-midterm test anxiety at Stage 3 predicted their emotional state just before taking the final exam, 4 weeks later. This suggests that the relationship between distortion in memory for emotions and individual differences in emotional states may be bidirectional and self-perpetuating.

Safer and Keuler (2002) argued further that systematic patterns of memory distortion for emotion may help to define personality and be a basis for self-ratings of personality. For example, people who self-report as high on neuroticism are likely to overestimate in recalling the intensity of negative emotions and underestimate in recalling the intensity of positive emotions. In turn, people who consistently recall their past feelings in this manner are likely to develop an autobiographical memory

"data base" that will lead them to self-report as high on neuroticism. Particularly for social interactions where situational influences are powerful, memories of how one acted and reacted may be more consistent with self-reported traits than are the actual behaviors and emotional reactions (Kulik & Mahler, 1986; Pietromonaco & Feldman Barrett, 1997).

Further research should more directly investigate this cyclical relationship between distortion in memory for emotions and future affective experiences as well as methods to break the cycle when it tends in a progressively more negative direction. For example, Breckler (1994) suggested that having novice blood donors explicitly rate their level of pre-donation anxiety might reduce the tendency to later exaggerate in recalling that anxiety. Exaggerated recall likely reduces future donations. Distortion in memory for prior emotional experience may be a particularly important factor in research on coping with repeated stressful events, such as university examinations and medical procedures (Chen, Zeltzer, Craske, & Katz, 1999).

Factors that lead to distortion in recalling past emotions, such as post-event knowledge and individual differences in emotional traits and states, also may contribute to distortion in predicting future emotions. People typically overestimate when they are asked to predict the duration or intensity of their emotional responses to future events, such as not receiving tenure or the victory of a favorite sports team (Buehler & McFarland, 2001; Gilbert, Pinel, Wilson, Blumberg, & Wheatley, 1998). Overestimation of future emotions occurs because people underestimate the impact of post-event experience. Thus, in forecasting emotions, people tend to focus too narrowly on the affective consequences of salient events and neglect the impact of peripheral, post-event factors that also influence their emotions. They also fail to appreciate how post-event coping efforts, such as positive reappraisal of negative events, can mitigate the intensity of negative emotions. Thus, underestimating the impact of post-event changes in knowledge and appraisal can lead to distortion in both retrospective and prospective judgments of emotion. We suspect that the interaction of emotional states and traits also may influence prospective judgments of emotion. For example, sad individuals with low self-esteem are more likely than sad individuals with high self-esteem to believe that their negative mood will persist. Paradoxically, because they are less motivated to try to change their negative mood (Heimpel, Wood, Marshall, & Brown, 2002), the individuals with low self-esteem might well be more accurate in estimating the intensity and duration of future negative emotions.

Conclusions

The current study demonstrated that individual differences in emotional traits and states, and post-event knowledge, are associated with distortion in remembering past emotions. At a practical level, these findings indicate that one must be cautious in treating self-reports of past emotions as accurate records of the past. For example, the well-publicized *Consumer Reports* survey of satisfaction with psychotherapy relied heavily on long-term retrospective reports of one's emotional state at the beginning of therapy (Seligman, 1995), without considering how individual differences or post-therapy experiences might affect recall. At a theoretical level, Kihlstrom (1981) wrote that "what a person can and cannot remember, and the way in which personal experiences are reconstructed, may be more revealing of the individual's personality than the most sophisticated trait measure" (p. 137). We would emphasize that memory reconstruction of prior emotions complements, rather than competes with, trait measures as ways to describe personality. Trait measures describe how individuals reconstruct memories of emotions and how individuals reconstruct these memories quite likely leads to differential self-reports of traits and states.

NOTES

1. The relatively low reliability for Bendig's brief version of the Taylor Manifest Anxiety scale may explain why anxiety did not predict as well as the other trait measures.

2. The residual change score is a more reliable measure of memory error than a simple difference score (i.e., recall – initial) in this data set for two reasons (Zimmerman & Williams, 1982). First, for each of the three dependent measures there was a significant negative correlation between the initial pre-exam value and the simple difference score. The correlations ranged from $-.15$ to $-.37$. Thus, the initial level would predict or limit the possible memory error. In contrast, the initial score is, by definition, uncorrelated with the corresponding residual change score. Second, for each of the three measures, the correlation between the initial and the recall scores (range of $.67$ to $.83$) was less than the standard deviation of the initial measure divided by the standard deviation of the recall measure (range of $.91$ to $.96$).

3. To find out whether it was appropriate to combine the informed and uninformed groups, we recalculated all significant correlation and regression findings in the article using a two-block hierarchical regression procedure whereby group was entered in the first block followed by the variables of interest in the second block. In all analyses, the resulting p values for the coefficients of interest were within $\pm .02$ of the values reported in the text. Thus, removing variance attributable to group had little impact on the observed pattern of correlations and regressions.

4. The strong correlations of personality with the initial and recall measures may reflect, in part, an artifact of a consistent rating style across different measures. Residual change scores have less variability because they minimize variance resulting from an individual's style of using consistently low or consistently high numbers on rating scales. Statistically, the residual change score represents that part of the variance of the recall score that is unexplained by the initial, pre-exam rating. If, for example, the variance of the recalled test anxiety score is 80.34 and the correlation of the initial and recalled test anxiety is $.83$, then the variance of the residual change score for test anxiety must be $80.34 \times [1 - (.83)^2]$ or approximately 24.85 .

5. There are two complementary interpretations of the interaction between personality and pleasantness in predicting memory distortion for test anxiety. The interpretation presented was that emotion-congruent memory distortion for test anxiety occurs, but only for people who score high on positive personality traits or low on negative personality traits. The alternative interpretation is that personality-congruent memory distortion for test anxiety occurs, but only when people are feeling pleasant (e.g., see Figure 2). Because personality and emotional state are at the same causal level in a moderation model, it does not matter statistically which is the moderator and which is the predictor.

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