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**COGNITIVE SCIENCE & NEUROSCIENCE | RESEARCH ARTICLE**

# Thinking positively: Optimism and emotion regulation predict interpretation of ambiguous information

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**Abstract:** The way individuals interpret their worlds is influenced by emotion and its regulation. Indeed, negative affect typically increases negative interpretations of ambiguous stimuli and may have a role in dysfunctional psychosocial function. Yet, it is not currently known whether explicit and implicit emotion regulation can counteract this effect. To address this question, undergraduates ($N = 103$) used cognitive reappraisal under angry and control mood states to disambiguate sentences by selecting either a neutral, positive, or negative word. While explicit cognitive reappraisal decreased negative affect, it had no effect on interpretation of ambiguity. Still, reported use of reappraisal predicted decreased negative and increased positive interpretations. Further, dispositional characteristics such as anger and optimism were key factors in how participants interpreted ambiguity. These findings suggest that regulating emotion may not be sufficient for influencing cognitive interpretations. Yet, individuals who are optimistic and are able to successfully regulate their emotions are less prone to negative interpretations even under angry mood states. This has implications for skill development in individuals with emotional disorders.

## ABOUT THE AUTHORS

Nakia S. Gordon earned her doctorate in behavioral neuroscience at Bowling Green State University. While there, she studied emotion in both human and non-human animals using a variety of techniques. She then received additional training in neuroimaging as a postdoctoral fellow in Michigan State University's Neuroscience Program. Prior to joining the faculty at Marquette, Gordon was on faculty at UNC Charlotte.

At the core of her research interests is understanding how emotions influence the way individuals navigate their worlds. Some of her recent, ongoing, and future studies include:

- Investigating how emotional state and emotion schemas influence information processing, especially ambiguous social cues.

- Understanding how past emotional experiences (e.g. trauma) influence current emotional regulation.

- Exploring the intersection of implicit and explicit emotion regulation.

- Identifying and investigating emotion regulation that occurs between individuals.

## PUBLIC INTEREST STATEMENT

Emotion dysregulation often leads individuals to make negative interpretations of ambiguous stimuli, which can lead to poor psychosocial functioning. We tested whether individuals in an angry mood would make negative interpretations of ambiguous scenarios and whether instructions to reappraise mood would change their choices. In these participants, reappraising mood resulted in less anger, but no change in how they interpreted scenarios. Additionally, we found that people who are optimistic are more likely to make positive interpretations (and less likely to make negative interpretations). These findings highlight the intersection of state, trait, and regulatory emotional factors in the way people interpret their worlds.

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## 1. Introduction

Ambiguity requires appropriate interpretation and action for successful psychosocial functioning. Circumstances involving ambiguity are not only imbued with integral emotions resulting from an interpretation of a situation (e.g. feeling anxiety in the face of a social threat) but also incidental emotions (e.g. anger) that we bring to the situation. Since incidental emotions alter the way we interpret ambiguity (Mathews, 2012), regulating our emotions is not only a crucial act for adaptive functioning (Gross, 2002), but may also influence the way we interpret the uncertain world around us. Examining the relationship between emotion regulation (ER) and the interpretation of ambiguity can deepen our understanding of how people resolve uncertainty under varying degrees of emotional influence.

Researchers have established that state emotion influences the resolution of ambiguity, and it is often aligned with the valence and appraisal tendencies of that emotional state (Lerner & Keltner, 2000). A common empirical approach to investigate the resolution of ambiguity is to employ an interpretation bias model. In such models, participants are asked to disambiguate words or scenarios that have multiple meanings, with valenced (i.e. neutral, positive, or negative) choices. When participants tend toward one valence to disambiguate stimuli relative to another, an interpretation bias is said to have occurred (Mathews, 2012). Work in this area demonstrates that in an affectively neutral state, participants tend almost equally toward neutral or positive interpretations (Mathews, 2012). However, in induced emotional states, such as anxiety and anger, increased negative interpretations and decreased positive ones tend to occur (Barazzone & Davey, 2009; Wenzel & Lystad, 2005). Ecologically, the influence of emotional states on interpretation and action could result in either adaptive or maladaptive responses to the environment.

Maladaptive responses often result from the unregulated emotional states that are observed in individuals with unregulated anxiety or depression. It is well established that trait anxiety increases negative and threatening interpretations of ambiguous stimuli (Amin, Foa, & Coles, 1998; Byrne & Eysenck, 1993; Eysenck, Mogg, May, Richards, & Mathews, 1991; Richards, Reynolds, & French, 1993). Similarly, self-report measures of depression (Dineen & Hadwin, 2004) and anxiety (Hindash & Amir, 2012; Huppert, Pasupuleti, Foa, & Mathews, 2007) have been positively correlated with negative interpretations. Additionally, Hirsch and Mathews (1997, 2000) demonstrated that decreased positive interpretations (lack of positivity bias) are also a function of depression and anxiety. These findings suggest that even beyond incidental mood, dispositional mood may be a key factor in how participants interpret ambiguous stimuli. To that end, it would be worthwhile to investigate whether dispositional mood combined with incidental mood could further predict the interpretation of ambiguity. This would provide a better understanding of the emotional composition that leads to different types of interpretations.

Indeed, researchers are identifying that emotional reactivity is but one component of one's emotional composition. ER also influences the way we respond to stimuli (Gross, 2002). For example, it is established that the ER strategy of reappraisal decreases anger (Szasz, Szentagotai, & Hofmann, 2011), and individuals high in trait reappraisal become less angry under experimental conditions (Mauss, Bunge, & Gross, 2007). Since anger increases negativity bias, it would be beneficial to know whether regulating anger minimizes that bias. There are no known studies examining anger regulation and interpretation bias together, but researchers have successfully altered interpretations using related cognitive bias modification paradigms (Hayes, Hirsch, Krebs, & Mathews, 2010; Salemink & van den Hout, 2010). In these paradigms, ambiguous scenarios are presented and their resolutions are experimentally manipulated such that the scenarios become benign, positive, or negative. When participants later resolve novel ambiguous scenarios, they do so consistent with their experimental

condition. Thus, procedures that modify the way participants interpret information appear successful. Identifying a strategy that could decrease negative interpretations in the face of emotional reactivity would have even greater implications for minimizing poor psychosocial outcomes.

Further, there are likely other dispositional traits that reduce rather than increase negative bias. One candidate trait is optimism. Optimism is consistently associated with positive interpretations (Sharot, 2011) and positive psychosocial outcomes (Hershberger, 2005). Yet, it also appears to be heightened in negative states such as anger. For instance, during anger, individuals take more risks, have a greater expectation of success, and are more likely to engage in approach behaviors (Lerner & Keltner, 2001). Anger makes individuals feel optimistic and confident about their decisions, which allows them to take swift action through heuristic appraisal tendencies (Lerner & Keltner, 2001). This optimistic outlook can be advantageous in a scenario where one needs to defend herself and is prepared to do so before she has absolute certainty about the offense. Even still, dysregulated anger is associated with poor social and health outcomes (Denollet, Gidron, Vrints, & Conraads, 2010; Erwin, Heimberg, Schneier, & Liebowitz, 2003; Gouin, Kiecolt-Glaser, Malarkey, & Glaser, 2008; Waller et al., 2003). Exploring the role of trait optimism may illuminate whether an optimistic disposition has a role in counteracting the effects of negative affect and thus minimizing negative interpretations. Given these collective findings, and the gap in the literature that remains, the current study aimed to understand the role of cognitive reappraisal on interpretation bias during an angry mood state, while also considering the context of important dispositional factors such as optimism, degree of negative affect, and ER ability.

## 2. Current study

In the current study, mood induction procedures (MIP) were used to elicit control and angry moods in participants. Immediately following an MIP, participants were cued to regulate the mood by presentation of the word "attend" or "reappraise". Interpretation bias was then tested through a sentence completion task in which participants selected a neutral, positive, or negative word to disambiguate sentences. This method allowed us to determine whether ER decreased explicit self-report of angry mood as well as whether it influenced implicit interpretation of ambiguous scenarios. Evaluating whether ER is effective at managing both mood and cognitions has implications for how to assist individuals who may have dysregulated emotions and poor psychosocial functioning.

Mood was induced via autobiographical recall, and we expected affect to remain relatively unchanged between the baseline and control conditions. However, we expected increased negative and decreased positive affect in the anger-attend condition relative to control and anger-reappraise. In line with previous interpretation bias studies, we expected participants to select approximately equal numbers of neutral and positive words while selecting significantly fewer negative ones to disambiguate sentences at baseline and after the control conditions. After the anger induction, we expected a significant increase in the number of negative interpretations and a decrease in the number of positive interpretations relative to the control state (Barazzone & Davey, 2009; Hayes et al., 2010). We expected that after anger was reappraised, participants would make similar choices to disambiguate sentences as they did in the control state. Specifically, we expected no significant differences between interpretations made during the control and angry-reappraise conditions. However, we expected fewer negative and more positive interpretations when anger-reappraise was compared to anger-attend.

We evaluated scores from self-report measures of anger, anxiety, depression, and optimism to determine how these variables influenced interpretation bias. We expected state and dispositional moods to interact such that negative interpretations would be positively predicted by negative characteristics at baseline and when attending to anger since these traits have been associated with negative bias in past studies (Barazzone & Davey, 2009; Huppert et al., 2007). After reappraisal, we expected anger to no longer significantly predict responses. We expected optimism to directly predict positive responses and inversely predict negative responses across all conditions.

Finally, we evaluated the ability of individuals to regulate their emotions in general, and to reappraise during the sentence completion task. We expected difficulties with ER to predict negative interpretations when attending to anger and reappraising it. Participants' ability to reappraise during the task was expected to positively predict positive interpretations during the angry-reappraise task.

## 3. Method

### 3.1. Participants
Participants included 103 undergraduate students (18–23 years; $M_{age}$ = 19) recruited through a research participant pool. Sixty-three percent of the sample was white and 56% were female. None of the participants met the exclusion criteria which included being under the care of a psychiatrist or a psychologist or using medication for the treatment of any Axis I mood disorder. This sample size was sufficient for the statistical analyses based on a priori estimation (Soper, 2015). Experimental procedures were approved by the University's Internal Review Board. Written informed consent was obtained from each participant who received partial course credit for their participation.

### 3.2. Self-report measures

#### 3.2.1. Mood and anxiety symptom questionnaire-short form
(MASQ; Watson & Clark, 1991). The MASQ is a 62-item questionnaire that assesses mood and anxiety symptoms. This measure is appropriate for our non-clinical sample as it is able to detect subclinical levels of anxiety and depression. Participants read through a list of feelings, sensations, and problems, and were asked to indicate the degree to which they experienced them in the last week on a five-point Likert scale, 1 indicating "not at all" and 5 indicating "extremely". The MASQ score has four subscales. The General Distress: Anxiety and General Distress: Depression subscales measure non-specific symptoms of anxiety and depression. The Anxious Arousal subscale measures physiological symptoms of anxiety. The Anhedonic Depression subscale examines general negativity and activity level. The MASQ has shown good convergent validity across all subscales ($r > .71$ for all scales (Watson, 2005).

#### 3.2.2. State–trait anger expression inventory-2
(STAXI-2; Spielberger, Sydeman, Owen, & Marsh, 1999) was used to assess feelings of anger. The STAXI-2 is a 57-item measure that examines current feelings of anger, as well as trait displays of anger involving temperament and mood expression. Participants read statements and indicated the amount to which they both currently and typically identify with each statement. Higher scores indicate a greater degree of feelings or expression of anger. This measure has displayed high internal consistency (Spielberger et al., 1999).

#### 3.2.3. Life orientation test-revised
(LOT-R; Scheier, Carver, & Bridges, 1994) is a 10-item questionnaire used to measure trait optimism. Three items are phrased in a positive way and three in a negative manner, while the remaining four items are used as fillers. Participants read each statement and indicated using a five-point Likert scale the degree to which they agreed or disagreed.

#### 3.2.4. Difficulties in ER scale
(DERS; Gratz & Roemer, 2004). The DERS is a 36-item measure that assesses dysfunction in emotion regulation. Participants used a five-point Likert scale to indicate the degree to which each sentence applied to them (1 = "almost never"; 5 = "almost always"). Emotion dysregulation is determined by summing across all sentences, with high scores indicating a greater level of emotion dysregulation. The DERS has high internal consistency ($\alpha$ = .93) and construct validity as measured by statistically significant correlations between the DERS and the Generalized Expectancy for Negative Mood Regulation Scale (Gratz & Roemer, 2004).

### 3.2.5. The ER questionnaire-short form

(ERQ-SF; Egloff, Schmukle, Burns, & Schwerdtfeger, 2006) is a six-item questionnaire used to retrospectively assess the type of ER strategy used when participants were instructed to reappraise anger. The questionnaire has two subscales—Reappraisal and Suppression—three items assessing reappraisal and three assessing suppression. Items were summed to obtain a score for each scale.

### 3.3. Stimuli

### 3.3.1. Mood induction procedure

Each participant underwent angry and control mood induction procedures (MIP). Prior to the experimental tasks, participants were asked to identify two anger-inducing events during which they felt extremely angry, and when recalling the event they still felt strong frustration, irritation, and/or anger. For the control MIP, participants were instructed to identify their typical morning or evening routine (e.g. getting ready for school or work, or eating dinner watching TV).

In each MIP, participants were instructed to write about one of the events in the form of a narrative that would clearly convey to another person the anger (or routine) the participant experienced. Participants were given 5 min to write about the event, but were able to proceed to the next task if they finished before the allotted time. After writing each narrative, participants were given 30 s to reflect on and re-experience the event. Several studies have found that the use of autobiographical recall is an effective technique to induce targeted emotions (Jallais & Gilet, 2010; Lench, Flores, & Bench, 2011). Additionally, the use of multiple memories for the same targeted state is effective at inducing that state (Kross, Davidson, Weber, & Ochsner, 2009).

### 3.3.2. Emotion regulation task

To acquaint participants with the ER task, a trained research assistant first explained the difference between "Attend" (to experience emotions that surface without trying to alter them) and "Reappraise" (to reinterpret the content to be less negative) (see procedures in Ray, McRae, Ochsner, and Gross Ray, McRae, Ochsner, & Gross, 2010). Participants practiced the strategies with images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997) so that training was standardized. Participants had four trials (two each of attend and reappraise) with neutral and negative pictures. In the experimental procedures, participants were instructed to attend to or reappraise the emotions that resulted from the MIP. Attend and reappraise prompts were counterbalanced across participants.

### 3.3.3. Sentence completion task

The sentence completion task consisted of 30 first-person sentences modified from existing sentence completion paradigms (Barton, Morley, Bloxham, Kitson, & Platts, 2005; Beard & Amir, 2009; Bloom & Fischler, 1980; Eysenck et al., 1991; Huppert et al., 2007; Loevinger, 1985). Sentences were selected to (1) illustrate ambiguous situations pertaining to physical threat, social threat, or optimism; and (2) only be disambiguated by completion of the last word. Each item of the sentence completion task began with a two-sec fixation point, followed by a screen presenting the sentence for six sec. Items were consistent across participants for each condition (e.g. baseline and/or angry-attend), but randomly presented. Participants were asked to disambiguate each sentence using a forced-choice response style in which they selected a word from a set of three answer choices that included one positive, one negative, and one neutral choice. There were no time constraints on selecting a response.

### 4. Procedure

Participants were asked to attend one, 60-min, experimental session. Upon arrival, they read and signed a consent form. They were then directed to a private room in which all study procedures took place on a 22-inch computer. Participants began by completing the demographics questionnaire, MASQ, STAXI-2, LOT-R, and DERS using Google docs. E-Prime software (Version 2; Psychology Software Tools, Inc.) was used for the remainder of the experimental procedures.

### 4.1. Baseline and training

The experimental procedures began with baseline emotion ratings using an automated 10-cm visual analog scale (VAS), anchored with "not at all" (0) and "extremely" (10). To reduce demand characteristics and to capture the full range of affective states participants experience (Mauss et al., 2007; Salemink & van den Hout, 2010), 10 affect descriptors were presented and rated separately: amused, angry, annoyed, anxious, excited, happy, joyful, negative affect, peaceful, and sad. Next, baseline interpretation bias was assessed with six items from the sentence completion task. Then, participants practiced attending and reappraising with the standardized emotional stimuli.

### 4.2. Testing

Participants completed each ER task (attend and reappraise) for each MIP (control and angry). These were counterbalanced across participants such that there were four conditions. In each condition, the ER order remained constant across MIPs. For example: Condition 1. Control-Attend, Control-Reappraise, Angry-Attend, Angry-Reappraise; Condition 2. Control-Reappraise, Control-Attend, Angry-Reappraise, Angry-Attend. This pattern would follow for conditions 3 and 4 but with Anger being induced first. Participants rated their subjective affect before and after completing the first MIP. Next, they engaged in the first ER task. The word "Attend" or "Reappraise" was displayed for 4 s. Participants were then asked to rate the degree of negative affect they were experiencing on a VAS anchored by weak (0) and strong (10). This was followed by six items from the sentence completion task. Participants then underwent a second MIP in the targeted state. Again, they rated negative affect before and after the MIP, engaged in emotion regulation, and then performed the sentence completion task. Once these tasks were complete, participants viewed the word "RELAX" for 5 s. Participants then followed the same procedures for the other MIP. Once experimental procedures were complete, participants completed the ERQ-SF for both the angry and control MIPs.

## 5. Results

All statistical analyses were analyzed using an alpha level of .05 in SPSS 21.0 (SPSS, 2012). This 2 (mood induction: control, angry) x 2 (emotion regulation: attend, reappraise) mixed model design was counterbalanced such that there were four conditions. There were no order effects of mood (positive, negative, and negative affect) or ER across conditions. Thus, data were collapsed across condition and ER order and analyzed as a repeated-measures design.

### 5.1. Data reduction and manipulation checks

Consistent with other studies (e.g. (Salemink & van den Hout, 2010), ratings of the individual emotion descriptors—angry, annoyed, anxious, and sad—were averaged for a composite "negative" score. Likewise, ratings of amused, excited, happy, joyful, and peaceful were averaged to create a composite "positive" score. Separately, we confirmed that participants experienced the same mean (±SEM) "negative affect" across the two anger MIPs [MIP1: (6.38 ± .21) and MIP2 (6.13 ± .20); $t$ (102), $p$ = 0.24] to exclude the possibility that any differences in the dependent variables were a result of emotional differences in the angry MIPs.

To determine whether participants entered the study with the neutral/positive bias often observed in typically healthy participants, a bias scored was calculated. Bias was established by summing each response type (neutral, positive, or negative) across the six sentences. Thus, a positive bias occurred, for example, if a participant endorsed more positive words across the six sentences than neutral or negative. A chi-square goodness of fit test confirmed that participants had a positive/neutral bias at baseline ($X^2$(2) = 26.75, $p$ < .001), with more positive ($N$ = 36) and neutral ($N$ = 35) biases than negative ($N$ = 5) ones.

### 5.2. Effect of mood induction

To evaluate the effect of mood inductions (baseline, control, or angry) on ratings of subjective affect, we conducted two repeated-measures (rm) analysis of variance (ANOVA) tests. There were significant differences between the baseline, control, and angry inductions for both "negative" ($F$ (2, 190) = 134.49, $p$ < .001, partial $\eta^2$ = 0.59) and "positive" ($F$ (2, 190) = 92.31, $p$ < .001, partial

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$\eta^2 = 0.49$) composite scores. Follow-up pairwise comparisons demonstrated the mean (±SEM) negative score was significantly higher during the anger induction (6.17 ± .18) compared to baseline (3.15 ± .18) and control (3.50 ± .18) inductions ($ps < .001$). Conversely, the mean positive score was significantly lower for the angry (3.03 ± .19) induction relative to baseline (5.36 ± .18) and control (5.10 ± .16) inductions ($ps < .001$). These data support the hypothesis that anger induction would increase negative and decrease positive affect both relative to baseline and the control mood inductions. Further, the control induction effectively maintained the participants' baseline state.

### 5.3. Effect of emotion regulation

#### 5.3.1. Negative Affect
Effects of ER on ratings of negative affect were analyzed with a 2 (MIP: control, angry) x 2 (ER: attend, reappraise) rm ANOVA. There were significant main effects of MIP ($F (1, 101) = 122.09$, $p < .001$) and ER ($F (1, 101) = 31.57$, $p < .001$), which were moderated by the significant MIP by ER interaction ($F (1, 101) = 8.98$, $p < .01$, partial $\eta^2 = 0.08$). Figure 1 illustrates that mean [95% CI] negative affect was significantly lower during reappraise compared to attend, for the angry induction ($t (102) = 5.76$, $p < 0.001$) but not the control induction. Thus, as hypothesized, instructed reappraisal effectively decreased negative affect in the angry MIP. It had no effect on the relatively low ratings of negative affect in the control MIP.

#### 5.3.2. Interpretation Bias
To evaluate the effect of mood and ER on interpretation responses (neutral, positive, or negative), three 2 (MIP: control, angry) x 2 (ER: attend, reappraise) rm ANOVA tests were conducted separately. There was a significant main effect of MIP on both the neutral ($F(1,101) = 12.99$, $p < .001$, partial $\eta^2 = .11$) and negative ($F(1,101) = 4.43$, $p = .038$, partial $\eta^2 = .04$) responses. Specifically, there were more mean (± SEM) neutral responses in the control MIPs (2.84 ± .09) relative to angry MIPs (2.49 ± .08) ($p < .001$). Conversely, there were more negative responses in the angry MIPs (1.38 ± .10) relative to the control MIPs (1.17 ± .09) ($p < .05$). There was no significant difference in positive responses ($F(1,101) = 2.39$, *n. s.*) between the MIPs (Control: 2.00 ± .09; Angry: 2.15 ± .11) . None of the other main effects or interactions were significant. Thus, mood, but not emotion regulation, had an effect on interpretation bias.

### 5.4. Interpretation bias and participant variables
To evaluate whether participant characteristics and ER influence interpretation bias in the context of anger, a series of multiple linear regression analyses were conducted. Mood variables including anger measured by the STAXI-2; anxiety measured by the MASQ (general distress: anxiety, anxious arousal); depression measured by MASQ (general distress: depression, anhedonia); optimism measured by LOT-R; ER variables measured by difficulties (DERS); and reported regulation strategy used during the angry-reappraise condition measured by the ERQ-SF were used to predict the three response types (neutral, positive, or negative) endorsed by participants (see Table 1 for descriptives).

**Figure 1. Effect of ER on mean (95% CI) negative affect scores across MIPs.**
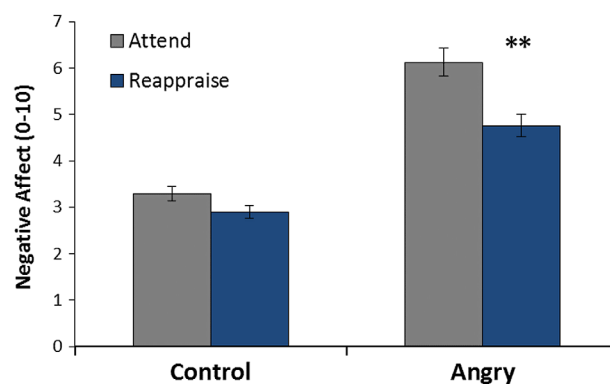
**Level of significant at *p* < .001

| Table 1. Descriptive statistics of dispositional variables | | | |
|---|---|---|---|
| | **Mean** | **SD** | **Obs. range** |
| STAXI | | | |
|    Trait | 16.83 | 4.70 | 10–34 |
|    State | 17.31 | 4.83 | 15–46 |
| MASQ | | | |
|    Anxiety | 21.52 | 7.05 | 11–45 |
|    Anxious arousal | 23.25 | 8.09 | 16–58 |
|    Depression | 24.95 | 9.04 | 12–51 |
|    Anhedonia | 51.00 | 11.01 | 28–84 |
| LOT-R | 15.95 | 4.07 | 4–24 |
| DERS | 76.31 | 18.64 | 37–117 |

All mood, emotion regulation, and participant variables (e.g. age) were analyzed to identify zero-order correlations with each response type (Table 2) Only those variables with significant zero-order relationships at an alpha level of .01 were entered into the regressions as predictors. None of these variables were significantly related to neutral responses in any of the conditions. Thus, regressions predicting only positive and negative responses in each condition are detailed below. The variation inflation factor (VIF) of these variables, for each model, was less than 1.15 indicating little effect of multicollinearity (Hair, Anderson, Tatham, & Black, 1995).

### 5.4.1. Baseline

Since these variables have not previously been used to predict interpretation bias, we first evaluated their relationship to response type at baseline. Given significant zero-order relationships, trait anger, anhedonia, optimism, and difficulties in ER were entered into a linear multiple regression and significantly predicted baseline positive responses ($F_{(4, 91)} = 5.78$, $p < .001$; $R^2 = .20$). State anger, anhedonia, and optimism were included in the regression to predict a significant relationship with baseline negative responses ($F_{(3, 92)} = 4.22$, $p < .01$; $R^2 = .12$). None of the variables in either model were unique predictors.

| Table 2. Zero-order correlations with response type across conditions | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Anger –Trait** | **Anger –State** | **Anxiety** | **Anx. Arousal** | **Dep.** | **Anhed.** | **LOT-R** | **DERS** | **ERQ-SF Reapp.** | **ERQ-SF Supp.** |
| Baseline (*N* = 96) | | | | | | | | | | |
| Positive | −.293** | −.083 | −.078 | .014 | −.097 | −.358*** | .343** | −.381*** | – | – |
| Negative | .225* | .269** | .107 | .033 | .119 | .272** | −.283** | .249* | – | – |
| Neutral | .140 | −.164 | −.005 | −.055 | .005 | .158 | −.132 | .230* | – | – |
| Angry-Attend (*N* = 102) | | | | | | | | | | |
| Positive | −.193 | −.320** | −.098 | .056 | −.177 | −.319** | .477*** | −.235* | – | – |
| Negative | .221* | .374*** | .102 | .049 | .238* | .247** | −.357*** | .265** | – | – |
| Neutral | −.011 | −.026 | .004 | −.116 | −.048 | .106 | −.172 | −.010 | – | – |
| Angry-Reappraise (*N* = 102) | | | | | | | | | | |
| Positive | −.151 | −.166 | −.080 | .083 | −.152 | −.333** | .409*** | −.266** | .286** | −.013 |
| Negative | .219* | .280** | .190 | −.048 | .283** | .321** | −.368*** | .290** | −.383*** | −.079 |
| Neutral | −.092 | −.128 | −.088 | −.013 | −.092 | .088 | −.088 | .006 | .044 | .063 |

*Level of significant at *p* < .05.

**Level of significant at *p* < .01.

***Level of significant at *p* < .001.

### 5.4.2. Angry-attend

A multiple regression analysis was used to predict responses while attending to anger, after first controlling for baseline response tendencies. As such, positive responses were entered into the first block; then, state anger, anhedonia, and optimism were entered into the second block and predicted a significantly larger proportion of the variance in positive responses than the baseline positive responses. Additionally, optimism uniquely predicted increases in positive responses, while state anger uniquely predicted decreases in positive responses (Table 3).

To predict negative responses in this condition, baseline negative responses were entered in the first block and significantly predicted negative responses. Again, state anger, anhedonia, and optimism were included along with difficulties in ER. Optimism and state anger remained unique predictors, but instead predicted decreases and increases in negative responses, respectively (Table 4).

### 5.4.3. Angry-reappraise

Baseline positive or negative responses were entered into the first block of multiple regressions to significantly predict positive and negative responses, respectively, after anger reappraisal.

**Table 3. Summary of multiple regression analysis for participant variables predicting positive responses ($N = 96$)**

| | Angry-Attend | | | | | | Angry-Reappraise | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | | | Model 2 | | | Model 1 | | | Model 2 | | |
| | $B$ | $SE\ B$ | $\beta$ | $B$ | $SE\ B$ | $\beta$ | $B$ | $SE\ B$ | $\beta$ | $B$ | $SE\ B$ | $\beta$ |
| Baseline positive responses | .47 | .12 | .39*** | .32 | .11 | .27** | .25 | .11 | .22* | .07 | .12 | .07 |
| State Anger | | | | −.06 | .03 | −.20* | | | | – | – | – |
| Anhedonia | | | | .01 | .01 | .08 | | | | −.01 | .01 | −.08 |
| Optimism | | | | .13 | .04 | .38*** | | | | .07 | .04 | .21 |
| DERS | | | | – | – | – | | | | −.01 | .01 | −.09 |
| ERQ-SF | | | | – | – | – | | | | 0.1 | .05 | .21* |
| $R^2$ | | .15 | | | .33 | | | .05 | | | .21 | |
| $F$ for change in $R^2$ | | 16.50*** | | | 8.25*** | | | 4.65* | | | 4.63** | |

*Level of significant at $p < .05$.
**Level of significant at $p < .01$.
***Level of significant at $p \leq .001$.

**Table 4. Summary of multiple regression analysis for participant variables predicting negative responses ($N = 96$)**

| | Angry-Attend | | | | | | Angry-Reappraise | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | | | Model 2 | | | Model 1 | | | Model 2 | | |
| | $B$ | $SE\ B$ | $\beta$ | $B$ | $SE\ B$ | $\beta$ | $B$ | $SE\ B$ | $\beta$ | $B$ | $SE\ B$ | $\beta$ |
| Baseline negative responses | .37 | .13 | .28** | .17 | .13 | .13 | .37 | .13 | .29** | .12 | .13 | .1 |
| State Anger | | | | .07 | .03 | .27** | | | | .01 | .03 | .04 |
| Depression | | | | – | – | – | | | | .03 | .02 | .21 |
| Anhedonia | | | | −.01 | .01 | −.07 | | | | −0.01 | .01 | −.07 |
| Optimism | | | | −.10 | .04 | −.30** | | | | −0.06 | .04 | −.19 |
| DERS | | | | .01 | .01 | .08 | | | | .00 | .01 | .04 |
| ERQ-SF | | | | – | – | – | | | | −.12 | .04 | −.29** |
| $R^2$ | | .08 | | | .26 | | | .08 | | | .29 | |
| $F$ for change in $R^2$ | | 7.66** | | | 5.58** | | | 8.37** | | | 4.11** | |

*Level of significant at $p < .05$.
**Level of significant at $p < .01$.

Anhedonia, optimism, difficulties in ER, and reappraisal were entered into the second block to significantly predict positive responses. To predict negative responses, all variables except anxiety and anxious arousal were entered to significantly predict negative responses. After controlling for baseline responses, reappraisal was the only unique predictor for the increased positive and decreased negative responses (Tables 3 and 4).

## 6. Discussion

The purpose of this study was to investigate whether ER changed how angry participants interpreted ambiguous stimuli. Additionally, this study aimed to elucidate the relationship between dispositional variables (e.g. optimism) and the types of interpretations individuals make in angry states. We first confirmed that participants entered the study with the typical positive/neutral interpretation bias found in non-clinical samples. When an angry mood was induced, participants increased their endorsements of negative responses, and decreased the number of neutral ones, relative to the control induction. This pattern of responses was uniquely predicted by state anger and optimism. When participants actively used reappraisal, subjective negative affect decreased, but there was no effect on interpretation bias. Still, positive and negative resolutions of ambiguity were uniquely predicted by reported use of reappraisal.

Overall, these findings are consistent with the current literature and extend the findings on interpretation bias in the context of emotion. As expected, angry mood led to increased negative interpretations of ambiguous scenarios (Barazzone & Davey, 2009; Wenzel & Lystad, 2005). However, in contrast to our hypothesis, we did not observe a reduction in negative interpretations once participants reappraised their negative affect. Thus, although participants explicitly reported less negative affect after reappraisal, which is consistent with other studies (Mauss et al., 2007; Memedovic, Grisham, Denson, & Moulds, 2010), this did not result in an implicit change in the way that they cognitively processed ambiguous information. One possibility for this finding is that affective networks had already been accessed (Bower, 1981), and the brief reappraisal period could not override the cognitive processing that had already been initiated. Although researchers have found success modifying interpretations through cognitive means, such changes require repetitive active engagement (Hoppitt, Mathews, Yiend, & Mackintosh, 2010). Hence, changing interpretation bias in the context of anger may require both active affective and cognitive changes (Standage, Ashwin, & Fox, 2010). Future studies might choose to engage participants in an active manipulation of both ER and cognitive bias to determine whether there is an additive effect of managing affect and cognitions.

Currently, we observed the combined influence of affect and cognition by measuring dispositional factors. The linear combination of anger, anhedonia, and optimism predicted positive and negative responses at baseline, although none were unique predictors. This is consistent with Barazzone and Davey (2009) and Huppert et al. (2007) who demonstrated correlations between negative interpretations and trait anger and depression, respectively. Notably, our anxiety measures were not significantly related to response type. A fair amount of work in this area has targeted individuals with clinically elevated anxiety/anxiety disorders, given their tendency to make negative interpretations of ambiguous stimuli (Franklin, Huppert, Langner, Leiberg, & Foa, 2005; Huppert et al., 2007). The current findings suggest anxiety is not a driving factor in a non-clinical sample of undergraduates with low anxiety. This is supported by Hirsch & Mathews, (1997), who demonstrate that general negative affect, not anxiety specifically, appears to influence interpretation bias. Indeed, as one would expect, state anger uniquely predicted increases in negative interpretations and decreases in positive ones above baseline responses when participants attended to anger. Yet, as predicted, it was no longer a unique predictor once participants engaged in reappraisal.

Optimism also emerged as a unique predictor for positive and negative responses when participants attended to anger. Optimism predicted increased positive responses and decreased negative ones. This is generally consistent with Lerner and Tiedens Lerner & Tiedens, (2006) assessment of the interaction between anger and optimism. Angry individuals increase their perception of positive outcomes as they pertain to the self (as was the case with the current stimuli). So, although the

number of negative interpretations increased during anger, positive interpretations remained consistent with control conditions and were still overall more abundant. An alternative explanation is that feelings of certainty and control during anger, as predicted by the appraisal tendency theory (Lerner & Keltner, 2000), may be interacting with trait optimism such that positive responses become more salient. Either way, dispositional optimism appears to counteract the influence of negative affect during anger (Ausbrooks, Thomas, & Williams, 1995) by decreasing negative and increasing positive interpretations.

With regard to the effects of ER on interpretation, the current findings indicate that active reappraisal predicts increased positive and decreased negative responses. Interestingly, optimism is not a unique predictor during the reappraisal condition. We suspect the cognitive mechanisms that contribute to dispositional optimism are involved with explicit reappraisal. Indeed, in exploratory analyses (see supplemental data), when dispositional variables and ER variables are entered in separate models, optimism uniquely predicts responses in the angry reappraise condition. The current analyses demonstrate that this variance is likely accounted for by explicitly reappraising—or thinking positively.

This study demonstrates that ER and dispositional factors, like optimism, influence interpretation bias in the face of angry emotion. While these findings extend the current literature, there are a few limitations that should be noted. For instance, we are unable to separate implicit ER from the explicit instructions in this study. Yet, it is reasonable to assume that whatever implicit processes participants used were occurring throughout. Additionally, the range for depression and anxiety was limited in this sample so those characteristics may have a greater effect on these findings than we are able to test for.

Still, this study demonstrates that not only does emotion and its regulation influence the way individuals process information, but personality characteristics such as optimism also have a significant influence on interpretations of ambiguous scenarios. These findings extend work conducted with clinical populations that show those with depression (Hindash & Amir, 2012) and difficulties regulating anger (Erwin et al., 2003) are more likely to endorse negative interpretations. It suggests that even in typically healthy participants, an overall negative disposition leads to increased negative interpretation of ambiguous scenarios. While this, perhaps, has been presumed, this is the first study to use a combination of personality characteristics to understand the dispositional influences on the interpretation of ambiguity in the context of negative mood.

This study also adds to the current interpretation bias and ER literature by demonstrating that cognitive reappraisal is an effective tool to reduce negative emotionality in angry mood states. Individuals who experience high state anger or typically struggle to engage in healthy ER experienced greater negative emotionality and an increased negativity bias following instructed reappraisal. Yet, despite efficacy of regulating negative emotionality in anger, cognitive reappraisal is not sufficient for modulating snap judgments once mood is initiated. Therefore, for individuals who present for treatment with difficulties related to anger and everyday negativity bias, clinicians may need to provide additional ER skills that could include enhancing positive perspective-taking.

**Competing interests**
The authors declare no competing interests.

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