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Understanding emotion in context: how the Boston marathon bombings altered the impact of anger on threat perception

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Abstract

Three studies examine the impact of an anger manipulation on threat perception among Northeastern University students after the Boston Marathon bombings. Data collection for one experiment began within 24 hours of the bombings. Results suggest that the impact of anger on threat perception differed during the week of the bombings compared to 1 and 5 months later. During the week of the bombings only, participants experiencing anger were less sensitive to the distinction between threats and nonthreats, and more biased toward perceiving all stimuli as threatening relative to control participants. We discuss potential mechanisms for these effects and the need for more rapid response research in the wake of incidents of mass violence.

Incidents of mass violence have increased at an alarming rate over the past several decades in America. At least 69 mass shootings took place between 1982 and 2014, and more than 30 of these occurred since 2006 (Follman, Aronsen, Pan, & Caldwell, 2012). Nevertheless, research in the immediate wake of such incidents has remained exceedingly rare, despite calls by the Institute of Medicine (Butler, Panzer, & Goldfrank, 2003; Smelser & Mitchell, 2002) and others (Goodwin, Willson, & Stanley, 2005; Maguen, Papa, & Litz, 2008) encouraging more basic, social psychological study of the effects of mass violence and terrorism. It is clear that the paucity of research in this area stems not from a lack of scientific interest or importance, but from the inherent difficulties in conducting research on time-sensitive phenomena where it may be difficult to access the population of interest.

Not surprisingly, the vast majority of research investigating the impact of such events has relied on large public databases and naturalistic, observational designs (e.g., Bonanno, Galea, Bucciarelli, & Vlahov, 2006; Gigerenzer, 2004; Su, Tran, Wirtz, Langteau, & Rothman, 2009) which are unable to address psychological mechanisms at the level of the individual. More importantly, the vast majority of experiments and studies on the effects of incidents of mass violence have taken place several months after the initial incident (e.g., Bonanno et al., 2006; Fischhoff, Gonzalez, Small, & Lerner, 2003; Galea et al., 2003; Luft et al., 2012; Wormwood, Lynn, Barrett, & Quigley, 2016; although see Garfin, Holman, & Silver, 2015; Silver, Holman, McIntosh, Poulin, & Gil-Rivas, 2002). This is problematic given that we currently do not know how long such incidents acutely impact emotions, judgments and behaviors, particularly among the average community member without overt psychopathology. To augment the sparse literature on the aftermath of these events, we report the results from three exploratory studies examining anger and threat perception among Northeastern University students at three time points following the Boston Marathon bombings of April 15, 2013.

Anger, threat perception, and incidents of mass violence

Previous research has demonstrated that threat perception is affected by exposure to real-world threats (e.g., Fischhoff et al., 2003; Gigerenzer, 2004; Lerner, Gonzalez, Small, & Fischhoff, 2003). For example, Fischhoff et al. (2003) found that white, Republican adult males perceived terrorist-related threats (e.g., being injured in an attack) as more likely if they had been in close proximity to the World Trade Center collapse on 9/11. In a similar vein, Gigerenzer (2004) demonstrated that Americans dramatically reduced their air travel following the terrorist attacks on 9/11, presumably because of heightened dread risk of air travel, which had the apparent effect of an increase in automobile-related accidents and fatalities.

Previous research has also examined how a person's current emotional state, particularly the experience of anger, is related to threat perception (Baumann & DeSteno, 2010; DeSteno, Petty, Rucker, Wegener, & Braverman, 2004; DeSteno, Petty, Wegener, & Rucker, 2000; Loewenstein & Lerner, 2003; Unkelbach, Forgas, & Denson, 2008). For example, across five studies Baumann and DeSteno (2010) demonstrated that participants experiencing anger were more likely to mistakenly identify unarmed, nonthreatening individuals as armed, threatening individuals than vice versa. Moreover, this bias toward perceiving threat was more pronounced among angry participants than those experiencing disgust, happiness, sadness, or those in a neutral control condition. Similarly, DeSteno et al. (2000) found that participants experiencing anger perceived anger-related threats (e.g., being stuck in a traffic jam) as more likely than did participants experiencing other negative emotions, like sadness.

Although the relationship between anger and threat perception and incidents of mass violence and threat perception have both been examined in existing work, there remains a paucity of research examining the relationship between anger and threat perception following the occurrence of incidents of mass violence. Two existing studies suggest a conundrum. First, Lerner et al. (2003) found that those experiencing anger related to the terrorist attacks on the World Trade Center made decreased risk estimates for terrorist-related threats compared to those experiencing fear related to the terrorist attacks. However, Unkelbach et al. (2008) found increased perceptions of threat by angry participants in a task involving visual cues that were associated with terrorism (i.e., individuals wearing turbans; Unkelbach et al., 2008). Here, researchers found that angry participants favored the "shoot" response in a shooting task for all targets, including targets with and without turbans. The inconsistency of results concerning the impact of anger on threat perception, particularly following exposure to incidents of mass violence or reminders of such incidents, suggests that more research about the underlying causes of variability in this relationship is needed.

Variability in emotion experience

At a theoretical level, we propose that these inconsistent findings are rooted in an important misconceptualization of the nature of emotion, namely that each emotion represents a physical or cognitive type and thus that variability across instances of a given emotion can be ignored or treated as noise. Indeed, this belief that each emotion represents a "natural kind" is prolific across a variety of prominent emotion theories (for a review, see Barrett, 2006a, 2006b). A "natural kind" belief assumes that each emotion, and indeed every instance of that emotion, can be identified by a consistent and specific set of facial muscle movements (Ekman, 1972; Tomkins, 1962, 1963), a pattern of autonomic physiology (e.g., Ekman & Cordaro, 2011; Lange & James, 1922; Levenson, 2011, 2014), an action tendency (Arnold, 1960; Dewey, 1895; Frijda, 1986), a specific pattern of cognitive evaluations called "appraisals" (e.g., Lazarus, 1991; Roseman, 2001), and/or a dedicated neural circuit (e.g., Ekman, 1994; Panksepp, 1998; Tracy & Randles, 2011).

Despite the prevalence of this "natural kind" view of emotions, heterogeneity in emotional experience has been observed repeatedly over the last century of emotion research, despite increasing analytic sophistication and technical advances in experimentation that were assumed would reduce it (e.g., Barrett, 2004; Ceulemans, Kuppens, & Van Mechelen, 2012; Kuppens, Van Mechelen, Smits, De Boeck, & Ceulemans, 2007; Nezlek & Kuppens, 2008). For example, in a recent study, researchers showed that the experience of anger could lead to *either* increases or decreases in risky decision making depending on the type of anger experienced (Baumann & DeSteno, 2012). Angry participants who received immediate feedback about a series of incremental risky decisions exhibited less risky behavior than nonangry participants, whereas angry participants who made only one, larger risky decision without feedback exhibited riskier behavior than nonangry participants. Presumably, a large obstacle produced riskier behavior, whereas a set of incremental obstacles *actually reduced risky behavior.*

Unlike emotion theories that support the "natural kind" view of emotions, constructionist theories of emotion posit that experiential and contextual variability across instances of the same emotion category not only should exist, but should meaningfully drive behavior. For instance, according to the theory of constructed emotion (TCE; formerly the Conceptual Act Theory; Barrett, 2009, 2012, 2013, in press; Barrett, Gendron, & Huang, 2009; Barrett, Wilson-Mendenhall, & Barsalou, 2014; Lindquist, 2013), emotional experiences are situated conceptualizations. This means that each instance of an emotion is unique because it is both shaped by one's personal history of emotional experiences in similar situations and reflects the expected demands of one's current circumstances. For example, one instance of anger may lead someone to shout if it occurs with a family member in a private residence, but another instance of anger may lead to quiet reflection if it occurs with a supervisor in a work setting. As a constructionist theory of emotions, the TCE is uniquely suited to addressing questions about how the relationship between an emotional state and a behavior may vary across contexts because it explicitly predicts meaningful variability in emotional experience that will be tied to changes in situational demands. For the purposes of the present investigation, the TCE explicitly predicts that the impact of anger on threat perception will depend on the *context* in which anger is experienced, such that an instance of anger experienced in a high-threat environment should be more relevant to threat perception performance than an instance of anger experienced in a lower-threat environment. Thus, we predicted that anger would impact threat perception performance more strongly when experienced in the immediate wake of an incident of mass violence, like the Boston Marathon bombings, compared to when experienced in contexts that are not characterized by imminent or potent threats.

The present studies

The influence of anger on threat perception is a phenomenon of particular interest in the wake of mass violence incidents, and has implications both for basic theoretical questions about the nature of emotions as well as applied and translational value. For example, understanding how such events can change emotions and threat perception has important implications for workplace training and policies for professions in which threat perception is an integral part of the job, especially where perceptual errors have particularly high costs (e.g., law enforcement officers or military personnel). Crucially, our first study (Time 1) was conducted in the days immediately following the explosion of two bombs at the finish line of the 117th Boston Marathon, which killed three people and injured more than 250 others. This tragedy, which occurred less than a mile from the Northeastern University campus, sent shockwaves through the Boston community that were fueled by further bloodshed and a citywide lockdown during the chase for the perpetrators. We took advantage of this unique opportunity to gather exploratory data concerning the causal impact of anger on threat perception in a context characterized by salient and high intensity threats (our Time 1). Then, because the TCE posits that there is meaningful variability in emotional experience across different contexts even for emotions labeled with the same word ("anger"), we explored whether the impact of anger on threat perception would change when assessed in a context not characterized by salient threats. Therefore, we examined comparable groups of undergraduate participants over the summer semester (our Time 2) and at the beginning of the Fall semester (our Time 3) after the immediate violence related to the Boston Marathon bombings and subsequent manhunt was no longer ongoing. We hypothesized that anger's impact on threat perception performance would be more pronounced at Time 1 than at Times 2 or 3 because, according to constructionist theories of emotion like the TCE, instances of anger constructed in a context characterized by potent violent threats should be uniquely tuned to helping the individual meet the expected demands of that context (i.e., perceiving and responding to violent threats). That is, the goal was not to examine continuous changes in anger or threat perception ability as time from the bombings increased, but to compare the impact of anger across contexts that differed in threat saliency.

Methods

For conciseness and because methods were identical, we describe the overall sample and methods, rather than separately by study. We analyze results across the three studies within a single analysis with Study (1–3) as the between-subjects Time factor.

Participants

One hundred and sixty-two undergraduates (79 males; $M_{age} = 19.31$) participated in partial fulfillment of an introductory psychology course requirement in a study advertised as pertaining to cognitive processing ability at one of three time points following the Boston Marathon bombings on April 15, 2013: Time 1 was completed 1–9 days after the bombings (April 16–April 24, 2013; $N = 48$), Time 2 was completed 1-2 months after the bombings (May 9–June 25, 2013; $N = 52$), and Time 3 was completed approximately 5 months after the bombings (September 9–13, 2013; $N = 62$). At each time point, participants were randomly assigned to complete either an anger induction or a control (neutral) induction. A total of 15 participants were removed across time and emotion conditions based on criteria outlined below, leaving final samples of: $N = 46$ (24 anger, 22 control) at Time 1, $N = 44$ (20 anger, 24 control) at Time 2, and $N = 57$ (25 anger, 32 control) at Time 3. At Time 1, the final sample had a mean age of 19.20 years ($SD = 1.13$) and included 26 male and 19 female participants, with one participant not reporting gender. At Time 2, the final sample had a mean age of 20.32 years ($SD = 1.46$) and included 28 male and 16 female participants. At Time 3, the final sample had a mean age of 18.75 ($SD = 1.29$) and included 17 male and 40 female participants.[1] Sample sizes were determined based on power analyses from data obtained during previous experiments utilizing an identical emotion induction procedure and a similar threat detection task (cf. Baumann & DeSteno, 2010), which suggested final sample sizes of at least 40 within each Time condition should provide sufficient power.

Manipulation and measures

Emotion induction

Participants completed a memory task where they had 4 minutes to recall and record a detailed written description of

[1]Results for bias and sensitivity are not affected by including age and gender as covariates in analyses.

an event from their past. Participants in the anger conditions were asked to recall an event that made them feel angry, and participants in the control conditions were asked to recall their daily routine. This task has been shown to successfully induce anger in a series of previous experiments (e.g., Baumann & DeSteno, 2010, 2012). Participants' written descriptions were reviewed after the completion of the experiment to make sure they were in accord with the instructions given. Descriptions that explicitly mentioned violence, guns, or the Boston Marathon bombings were marked for further investigation during analysis.

Threat perception task

Participants completed a threat perception task in which they were asked to identify whether individuals shown on a computer screen were holding guns or nonthreatening everyday objects. They were told that the task was a measure of visual processing ability and involved the identification of guns because the processing of threatening stimuli, like guns, is known to be particularly efficient. The task was a modified version of the Shooter Bias Task developed by Correll, Park, Judd, and Wittenbrink (2002, 2007)[2]; all stimuli were obtained from Joshua Correll and are described in detail in Correll et al. (2002). Visual noise was added to these original images to increase the difficulty of the task (sample stimuli are depicted in Figure S1 in the Supporting information; see also Wormwood et al., 2016). Original images from the Shooter Bias Task were reduced to a contrast range of 35%–65% of the maximum luminance available, and then the RGB values at each pixel were altered by adding a multivariate normally distributed random RGB triplet ($M = 0$, $SD = 17.5\%$, truncated at ± 2 *SD*s). Each image was then gamma-corrected for the luminance nonlinearity of the monitor. Four versions of each image were created using this technique and the program randomly sampled (with replacement) from the four versions for each stimulus presentation. Images were displayed on a 24″ computer monitor at a resolution of 1024 × 768. Participants sat with their face approximately 26″ away from the computer monitor.

In each trial of the task, participants were shown 1–4 background scenes (e.g., parks, subway stations, street corners), each for a randomly chosen duration between 500 and 1000 ms. The final image of each trial (the target image) was a repeat of the final background scene but contained a person. To the participant, this looked as if a person appeared in the final background scene. Each target person was a white male who was holding either a gun or a nonthreatening everyday object (e.g., camera, wallet). The target image was shown for 500 ms followed by a backwards mask. Participants were instructed to respond once the backwards mask appeared, and there was no time limit to respond. Participants responded on each trial by pressing one of two keys on a keyboard to indicate whether they believed the individual in the target image was holding a gun or a nonthreatening object. That is, they made a simple, object recognition decision on each trial (cf., Baumann & DeSteno, 2010), not a shooting decision.

There were 40 trials of the task (10 target individuals each shown 4 times: twice armed and twice unarmed). Participants also completed 10 practice trials of the threat perception task prior to the emotion induction task to familiarize themselves with the instructions and controls. Upon inspection of the raw data, two participants were removed from all analyses as multidimensional outliers; their performance on the threat perception task fell beyond 2*SD* of the mean response on multiple measures relating to their tendency to favor the "gun" response (i.e., false alarm rate, bias, and number of gun responses).[3]

Manipulation check

Following the threat perception task, participants completed a brief questionnaire where they rated how strongly they were currently experiencing 16 different emotions on 5-point Likert scales (from 1 = "not at all" to 5 = "very much"). Anger was measured as the mean response to four items: angry, frustrated, irritated, and annoyed (Cronbach's $\alpha = .85$). As previously done in other studies with similar emotion inductions (e.g., Baumann & DeSteno, 2010, 2012; Lerner & Keltner, 2001, Study 4; Mauss, Cook, & Gross, 2007, Study 2), we removed 13 participants for whom the induction was not successful prior to all analyses (Study 1, $n = 1$; Study 2, $n = 7$; Study 3, $n = 5$). We excluded 10 participants in

[2]Modifications were meant to (1) change the task into a more straightforward measure of object recognition as opposed to of aggressive action tendencies (cf. Baumann & DeSteno, 2010); and (2) eliminate several analytic and interpretational problems arising from the use of a limited response time window (as has typically been done with the original Shooter Bias Task; e.g., see Correll et al., 2002, 2007). For instance, response time and stimulus presentation time are confounded in the original paradigm such that quicker responses involve viewing the target stimuli for less time. In addition, the meaning of responses outside the given response window are unclear and thus those trials cannot be included in analyses. To the extent that these failures to respond are nonrandom (i.e., they occur more frequently on trials with armed or unarmed targets for a given participant), their exclusion from analyses may mask meaningful differences in performance across individuals. The modified paradigm utilized here standardizes the stimulus presentation time and eliminates concerns about how to handle trials where participants respond outside the response window. The modifications also successfully increase task difficulty, as is apparent when comparing average sensitivity values in the present study to those of previous studies using a timed response window (e.g., Baumann & DeSteno, 2010; Correll et al., 2002, 2007).

[3]The exclusion of these two outliers did not impact the general pattern of results. Inferential and descriptive statistics for bias and sensitivity with these outliers included can be found in the Supporting information in Table S2.

the anger condition with a value of 1 on the anger measure (indicating that they selected the lowest point on the Likert scales, "not at all," for all four individual items measuring anger), and three participants in the control condition with a value higher than 3 on the anger measure (indicating that they selected options greater than "a little angry" on average for the four individual items measuring anger).[4]

The other 12 emotion items in the manipulation check were filler items meant to hide the specific focus on anger-relevant items, and included measures of happiness (items: happy, content, pleasant, good; Cronbach's $\alpha = .90$), sadness (items: gloomy, down, sad, negative; Cronbach's $\alpha = .87$), disgust (items: queasy, sick, disgusted; Cronbach's $\alpha = .74$), and arousal (item: activated).

Procedure

The procedure for all three studies was identical. Participants came to the lab in downtown Boston and completed the experiment in groups of one to four. Each participant was seated at an individual computer station separated by dividers from the view of the other stations. Participants first received instructions for and completed practice trials of the threat perception task. Participants then completed the emotion induction task. Finally, participants completed the critical trials of the threat perception task, followed by a brief questionnaire where they reported on their current emotional state and provided demographic information.

Results

Emotion manipulation check

As expected, a two-way analysis of variance (ANOVA) with time and emotion condition as between-subjects factors revealed a significant main effect of emotion condition on self-reported anger, $F(1, 141) = 22.87$, $p < .001$ (See Figure 1). Participants in the anger conditions reported experiencing more anger than participants in the control conditions. There was no significant main effect of time condition ($F(2, 141) = 1.39$, $p = .25$) nor any significant interaction between emotion and time condition on self-reported anger ($F(2, 141) = 0.71$, $p = .49$), indicating that the anger induction was not more powerful or effective during the week of the Boston Marathon bombings (i.e., at Time 1) and that participants overall were not experiencing more anger at Time 1 relative to Times 2 and 3. Supplemental analyses on filler items from the manipulation check can be found in the Supporting information.

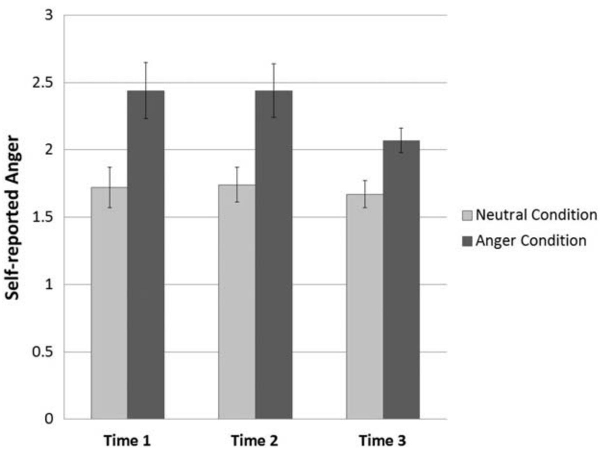

Figure 1 Mean self-reported anger by emotion and time condition. Error bars represent ±1 *SE*.

Threat perception

Performance on the threat perception task was analyzed using Signal Detection Theory (Wickens, 2002). For each participant, we calculated two performance parameters: bias and sensitivity. Bias (c) is a measure of a participant's tendency to identify the target as holding a gun vs. a nonthreatening object regardless of the stimulus shown. Bias was calculated as $c = -0.5(zH + zF)$, where zH and zF represent the inverse of the standard normal cumulative distribution for the hit rate and false alarm rate, respectively. Sensitivity (d') is a measure of a participant's ability to discriminate between armed and unarmed targets, and was calculated as $d' = zH - zF$.[5,6]

Bias

A two-way ANOVA failed to reveal a main effect of time condition ($F(2,141) = 0.72$, $p = .49$) or emotion condition

[4]This analytic decision represents a trade-off between examining naturally occurring variance in the intensity of anger experienced in response to our induction procedure and a more focused investigation of only participants who self-report experiencing the target emotion within each condition. Because testing our principal hypothesis centers on examining how the influence of anger on threat perception differs across contexts (and not differences in the intensity of anger experienced), we felt it was critical that participants for whom the emotion induction procedure was not effective were removed prior to any analyses on the primary dependent measures. Raw data can be made available upon request for researchers interested in utilizing the data to address questions unrelated to the present hypotheses.

[5]Because five participants possessed a false alarm rate of 0 or a hit rate of 1, and these extreme values result in infinite z-scores, we used a procedure recommended by Wickens (2002) and utilized in similar prior work (e.g., Baumann & DeSteno, 2010) to set a minimum false alarm rate of $1/(n+1)$ and a maximum hit rate of $1-(1/(n+1))$, where n represents the number of valid object or gun trials, respectively. In addition, the inclusion or exclusion of the five individuals for whom a correction was necessary did not influence the overall pattern of results.

[6]Because we had no specific hypotheses regarding reaction time data, we have included descriptive statistics and exploratory inferential statistics on reaction time data in the Supporting information.

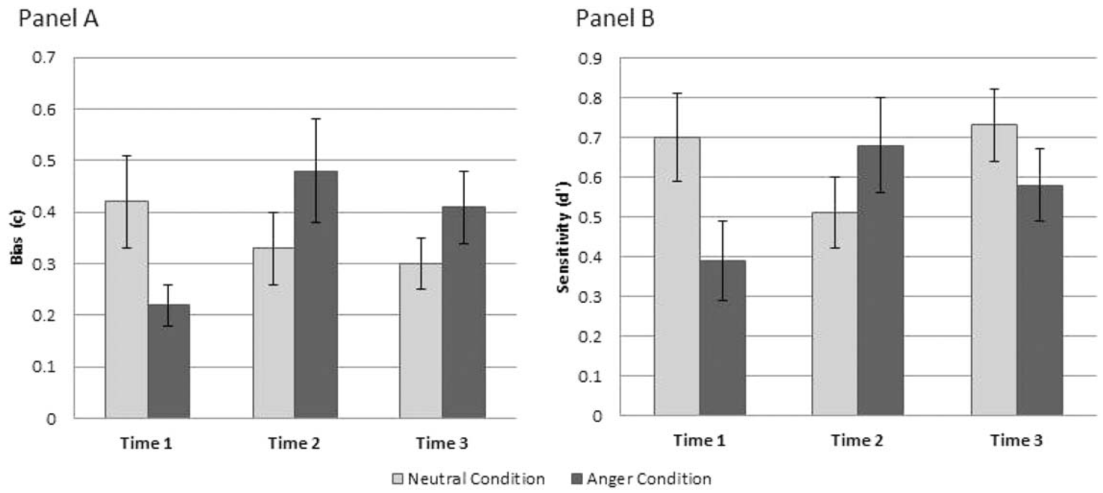

Figure 2 Mean bias (Panel A) and sensitivity (Panel B) by emotion and time condition. Error bars represent ±1 *SE*. Bias (*c*) represents the tendency for a participant to favor one response over the other, regardless of what stimulus is shown. Higher numbers indicate a more conservative bias (favoring the "not gun" response), while 0 represents a neutral response bias (not favoring one response over the other) and lower numbers indicate a more liberal bias (favoring the "gun" response). Sensitivity (*d'*) represents a participant's ability to distinguish guns from nonthreatening objects with higher numbers indicating greater sensitivity and lower numbers indicating lesser sensitivity.

($F(1,141) = 0.11$, $p = .74$) on bias, but did reveal a significant interaction, $F(2, 141) = 3.49$, $p = .03$. To investigate this interaction, we examined the effect of emotion condition on bias for each time condition (i.e., study) separately using independent samples *t* tests (Figure 2A). At Time 1, participants in the anger condition had a significantly less conservative bias than participants in the control condition, $t(44) = 2.08$, $p = .04$, indicating a greater tendency to select "gun" by participants in the anger condition. There was not a significant effect of emotion condition on bias during Time 2 ($t(42) = 1.27$, $p = .21$) or Time 3 ($t(55) = 1.22$, $p = .23$). As another way to investigate this same interaction (See Figure 2A), we also examined the impact of time condition on bias within each emotion condition separately using one-way ANOVAs. This analysis failed to reveal a significant effect of time condition on bias for participants in the control conditions, $F(2, 75) = 0.74$, $p = .48$, but did reveal a significant effect of time condition on bias for participants in the anger conditions, $F(2, 66) = 3.59$, $p = .03$. A post hoc Fisher's Least Significant Difference (LSD) test revealed that, for participants in the anger conditions, bias at Time 1 was significantly less conservative than at Time 2, $p = .01$, and marginally less conservative than at Time 3, $p = .06$. Bias at Times 2 and 3 did not differ significantly for participants in the anger conditions, $p = .46$.

Sensitivity

A two-way ANOVA failed to reveal a main effect of time condition ($F(2, 141) = 0.71$, $p = .49$) or emotion condition ($F(1, 141) = 1.41$, $p = .24$) on sensitivity, but did reveal a marginally significant interaction, $F(2, 141) = 2.90$, $p = .06$. We again investigated this interaction using independent samples *t* tests for each time condition separately (Figure 2B). During Time 1, participants in the anger condition had significantly lower threat sensitivity than participants in the control condition, $t(44) = 2.15$, $p = .04$, indicating that participants in the anger condition were less able to discriminate between armed and unarmed targets. There was no effect of emotion condition on sensitivity during Time 2 ($t(42) = 1.25$, $p = .22$) or Time 3 ($t(55) = 1.16$, $p = .25$). As another way to investigate this same interaction (See Figure 2B), we also examined the impact of time condition on sensitivity within each emotion condition separately using one-way ANOVAs. This analysis failed to reveal a significant effect of time condition on sensitivity for participants in the control conditions, $F(2, 75) = 1.61$, $p = .21$, but did reveal a marginally significant effect of time condition on sensitivity for participants in the anger conditions, $F(2, 66) = 2.14$, $p = .13$. A post hoc LSD test revealed that, for participants in the anger conditions, sensitivity was significantly lower at Time 1 than at Time 2, $p = .05$. Sensitivity at Time 1 was also lower than at Time 3 for participants in the anger conditions, though this comparison failed to reach conventional levels of significance, $p = .17$. Sensitivity between Times 2 and 3 did not differ significantly for participants in the anger conditions, $p = .48$.

Written content from emotion induction

Detailed review of participants' written descriptions from the emotion induction task revealed that a total of eight participants explicitly mentioned violence, weapons, terrorism, or the Boston Marathon bombings ($n = 5$ at Time 1, $n = 2$ at

Time 2, and $n = 1$ at Time 3). A Chi-Square test revealed that the distribution of these stories across time conditions did not differ from what would be expected by chance, $X^2(2) = 3.24$, $p = .20$. Thus, we find no evidence that the anger manipulation specifically primed violence or weapon-related threats during the week of the bombings. Further, threat perception results were not altered when we removed the data from these eight participants. Nevertheless, this null effect should be interpreted with caution, particularly given the small number of observations included in the analysis.

Discussion

Results suggest that the influence of an anger manipulation on threat perception was altered during the week of the Boston Marathon bombings relative to one and five months after the event. Relative to participants in the control condition, participants in the anger condition exhibited a less conservative threat perception bias (i.e., were more biased toward perceiving nonthreatening stimuli as threats) and had reduced threat sensitivity (i.e., were less able to distinguish threats from nonthreats), but only during the week of the bombings. Neither bias nor sensitivity was affected by the anger manipulation when implemented at one or five months after the bombings. Interestingly, results suggest that this interaction is not driven by differences in naturalistically experienced anger at the time of the study because participants did not report significantly heightened anger overall during the week of the bombings relative to the other time points. Further, the anger manipulation was not more effective during the week of the bombings nor did it elicit more explicit violence or weapons-related autobiographical content during the week of the bombings.

This pattern of results is inconsistent with classical theories of emotion that posit that each emotion category is a physical type with a single pattern of autonomic nervous system (ANS) activity, a dedicated neural circuit, a prescribed facial expression, and specific action tendencies (for reviews, see Barrett, 2006a, 2006b, in press; Barrett et al., 2014). Such "natural kind" theories of emotion predict that different experiences of a given emotion across individuals or within individuals over time should have more or less identical impacts on perception and behavior, barring error. In such theories, variability in emotional experience is either ignored or seen as a product of processes outside the emotional response such as display rules or regulatory mechanisms. Conversely, constructionist views of emotion, like the theory of constructed emotion (TCE), posit that variability in emotional experience not only exists, but is causally meaningful in determining how one's emotional experiences influence perception and behavior across contexts (Barrett, 2009, 2012, 2013, in press; Barrett et al., 2009, 2014; Lindquist, 2013). For instance, the TCE posits that each instance of an emotion is unique because it is both shaped by one's personal history of emotional experiences in similar situations and reflects the current and expected upcoming demands of one's circumstances. Indeed, the present findings are directly predicted by such constructionist theories: even without being of greater *intensity*, instances of anger experienced at Time 1 should be more *relevant* to the perception of potential violent threats than instances of anger experienced at Times 2 and 3 because of the broader context in which they were elicited (i.e., the environment in Boston during the week of the bombings). Consistent with this interpretation, our results revealed changes in threat perception that would indeed be functional for an angry individual in such a high-threat environment: a more pronounced bias toward identifying stimuli as threatening.

There are, however, several other potential causal mechanisms that the present exploratory data are unable to test directly. For example, it is possible that the participants experienced greater fatigue or cognitive depletion during the week of the bombings, and that this lack of cognitive resources may have interacted with the anger manipulation to produce the observed pattern of threat perception results. Indeed, a previous study demonstrated that poorer working memory was related to decreased performance on a similar threat perception task but only when participants were experiencing heightened arousal following a threat-eliciting video (Kleider, Parrott, & King, 2010). Future work should include measures of working memory or fatigue to explore this possibility.

It is also possible that participants at Time 1 experienced greater direct exposure to the bombings than participants at the latter two time points and that exposure interacted with the anger induction to influence threat perception. Consistent with this reasoning, a recent study using Boston community members revealed that how affected participants reported feeling by the bombings during the week they occurred interacted with a negative threat-eliciting induction to produce poorer threat sensitivity on a threat perception task similar to that reported here (Wormwood et al., 2016). Conversely, it is possible that individuals who were more impacted by the bombings or who had more direct exposure to the bombings were *less* likely to participate at Time 1 because the study involved threat perception and was located in downtown Boston less than a mile from the Boston Marathon bombings. However, this seems unlikely given that the study was advertised as pertaining to cognitive processing abilities, not as relating to threat perception or the Boston Marathon bombings, and all participants were students who were already living and working in downtown Boston at the time of the study. Nevertheless, future research should examine whether biased sample selection could contribute to the observed differences in anger's impact on threat perception over time following incidents of mass violence. For instance, a future study could recruit the full sample and then randomly assign participants to participate at different time points after an incident of mass violence.

Future research would also benefit from more elaborate manipulation checks than employed in the present studies. For instance, it is possible that the presence of other heightened emotional states like stress or anxiety interacted with the anger manipulation to produce the observed pattern of threat perception results or that participants experienced more stress or anxiety during the week of the bombings, affective reactions that our manipulation checks did not capture. However, analyses on the filler manipulation check items in the present study suggest that interactions with some emotional states (e.g., experienced disgust, sadness, happiness, and arousal) are unlikely to be causally contributing to the present pattern of threat perception findings (see Supporting information). Future work could also benefit from a manipulation check that probed for conceptual features of the participants' emotional experiences including measures assessing appraisals of threat and control that would help address some of the theoretical assumptions underlying the TCE as an interpretational framework for the present findings. Namely, the TCE would predict that anger experiences that were more threat-relevant would predict threat perception performance better than anger experiences that were less threat-relevant, even if the anger experiences were otherwise rated identical in intensity (i.e., both as "very angry"). In addition, our manipulation check took place after the threat perception task, and thus it is possible that self-reported emotion was influenced by engaging in the task itself which involved exposure to images of guns. For instance, it is possible that participants who believed they saw more guns (i.e., individuals with a less conservative bias) felt more angry after the task than participants who believed they saw fewer guns, or that participants who performed particularly poorly on the task (i.e., those with lower sensitivity) were frustrated and thus reported more anger following the task than individuals who performed better. Although it is unclear why the threat perception task would preferentially impact self-reported emotion at Time 1, this is an interesting possibility for exploration in future research.

Finally, future research should also examine how methodological features of the threat perception task itself could be an important context that influences anger's impact on threat perception bias and sensitivity. In the present studies, participants were asked to make simple object recognition decisions on each trial by indicating whether or not each target individual was holding a gun. However, many previous studies have utilized similar tasks but instead asked participants to make a "shoot" vs. "non-shoot" decision instead of an object recognition decision (e.g., Correll et al., 2002, 2007; Unkelbach et al., 2008; Wormwood et al., 2016). It seems likely that the experience of anger would differentially impact these two kinds of behaviors (i.e., detection vs. the aggressive action of shooting). For example, although we found that anger impacted both threat perception bias and sensitivity at Time 1 in the present research, the Unkelbach et al. (2008) study examined the impact of anger on shooting decisions and found that experiencing anger led to an increased bias toward the "shoot" response for all targets (with or without turbans), but did not impact sensitivity.

Because we used an object detection methodology here, we originally predicted that our findings would replicate those of Baumann and DeSteno (2010), who used an object recognition threat perception task, where participants in the anger conditions had a more liberal threat perception bias than control participants. Instead we found this pattern only at Time 1 and failed to replicate it at Times 2 and 3. We believe that the addition of visual noise to images and the open-ended response window likely increased error rates by making the task more challenging and caused participants to adopt a very conservative bias (favoring the "no gun" response) on average. Conversely, in the object recognition task utilized by Baumann and DeSteno (2010), with clear images and responses under time pressure, participants adopted a neutral average response bias. The current findings indicate that more threat-relevant anger experiences may be required to produce changes in threat perception bias under task parameters that themselves very strongly influence this bias. Similarly, differences in threat perception sensitivity across emotion conditions may have emerged in the present studies but not in the Baumann and DeSteno (2010) studies because error rates here were much more pronounced and may have been near the floor in prior work with clear images. These potential methodology-based differences offer fruitful avenues of inquiry for future research on the intersection of emotion and threat perception in the wake of mass violence events.

Conclusions

The present experiments make an important contribution to the existing literature on the effects of mass violence within an impacted community despite limitations inherent to studying time-critical phenomena. Indeed, the present research favored collecting time-sensitive data, starting within 24-hours of the bombings, at the expense of either including a large number of exploratory dependent variables (e.g., measures of working memory or event exposure) or making pronounced changes to the existing experimental protocol (e.g., changing from a cross-sectional to longitudinal design), both of which would have required a significant delay in the start of data collection. Although this choice leaves several provocative questions unanswered about the causal mechanisms underlying the interaction of mass violence, emotion, and threat assessment, it also allowed for a number of important discoveries about the nature of mass violence events. This work suggests that such events create potent contexts that extend their influence into lab-based experiments and impact the relationship between experienced emotion and behavior, even for average community members without clear signs of overt psychopathology. Critically, these findings also emphasize the need for fast-response research in the immediate wake of mass violence incidents because the observed effects were no longer present in Boston community members as early as 1 month after the bombings.

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Supporting Information

Additional Supporting information may be found in the online version of this article at the publisher's web-site:

Table S1 Descriptive and inferential statistics for filler manipulation check items by emotion and time conditions.

Table S2 Analyses on threat perception bias and sensitivity with threat perception outliers included.

Table S3 Mean reaction times in milliseconds by time condition, emotion condition, and response type.

Figure S1 Sample stimuli from the threat perception task.

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