ANGER AND THREAT DETECTION: INCREASED EXPECTANCY FOR EMOTION-RELEVANT STIMULI INFLUENCES OBJECT RECOGNITION

by

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ABSTRACT OF DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Psychology in the Graduate School of Northeastern University
July, 2012
Abstract

Emotions are known to influence judgments and decision making, even on tasks or in situations unrelated to the original source of the emotional experience (Schwarz & Clore, 2007; Clore, Gasper, & Garvin, 2001). However, despite the wealth of research on incidental emotions (those elicited by a source other than the task at hand), it remains unclear whether such emotion effects extend to purely objective judgments for which there is a clear correct and incorrect response. To test this possibility, we had participants complete an emotion induction procedure and then a threat detection task in which they were shown images of White males holding either neutral everyday objects (e.g., wallets, cameras, cellphones, soda cans) or guns. Participants were asked, under time pressure, to identify whether each individual was holding a gun or a neutral object. In a series of background experiments, we showed that participants induced to experience anger demonstrated a bias on the threat detection task whereby they made more errors claiming that neutral objects were guns than vice versa. Neutral participants did not exhibit any such bias. Importantly, the effect appeared to be emotion-specific, as several other positive and negative emotional states (disgust, happiness, sadness) failed to produce any effect on threat detection performance. We believe that, of these emotions, anger alone produced a bias because it was the only emotion that was relevant to the gun/no-gun decision. That is, anger is an emotion that might typically be elicited in situations involving the potential for violence or aggression, and so the experience of anger could more readily be misattributed to the decision at hand.

Building off of these background studies, this dissertation is an extensive investigation into the process by which anger influences performance on the threat detection task. Using signal detection theory, we were able to show that angry participants are not more or less sensitive to the distinction between guns and neutral objects; they did not make more or less errors on the
task overall. Instead, angry participants appear to make more false alarms, mistakenly misidentifying neutral objects as guns, in order to ensure that guns are accurately identified when present. In the background studies, we assumed that the signal distribution (the distribution for the gun trials) and the noise distribution (the distribution for the neutral object trials) were Gaussian distributions of equal variance for both neutral and angry participants. If this assumption is accurate, then angry participants set a lower criterion for deciding that a gun is present. That is, they need less evidence that a threat is present before they are willing to claim that a given trial contains a gun. However, it is also possible that anger influences the variance of the underlying distributions, in which case shifts in the distributions could explain the biased error rates without any movement in the placement of angry participants’ criterions. For instance, past research has suggested an advantage among individuals high in trait anger or trait anxiety on threat detection tasks whereby they attend to threat-relevant stimuli more readily (Mogg et al., 1997; Rinck et al., 2005). If angry participants in our study were able to more effectively attend to the gun stimuli than the neutral object stimuli throughout the task, this could potentially shrink the variance of the signal distribution among angry individuals. We explored this possibility in two experiments by calculating receiver operating characteristics (ROCs) for both angry and neutral participants for the threat detection task. Results failed to reveal any evidence of unequal variance for both neutral and angry participants. Thus, it appears that experiencing anger is indeed causing participants to lower their criterion so that less information is needed in order to declare the presence of a threat.

Three additional studies explored what might cause angry participants to lower their criterion relative to neutral participants. Given past work on the influence of emotions on estimates of the likelihood of encountering emotion-relevant events (DeSteno et al., 2000), we
believed that anger may be causing participants to feel that they were more likely to encounter guns (an anger-relevant stimuli) compared to neutral participants. Two experiments demonstrated that anger does indeed seem to increase participants’ estimates of the number of trials that contain guns in the current threat detection task as well as the perceived likelihood that one will encounter aggressive and violent stimuli in the real world. A final experiment demonstrated that such emotion-based expectancies mediate anger’s impact on threat detection performance. By experimentally manipulating the base rates of guns and neutral objects in the task and explicitly providing that information to participants, we were able to block participants from utilizing their own subjective expectancies for the number of guns in the task. Using this manipulation we were able to block the bias from occurring among angry participants as well as produce a matching bias among neutral participants. In other words, by manipulating the proposed mediator we were able to successfully eliminate the main effect of emotion on threat detection performance.

Taken together, these experiments represent a concerted effort to understand how emotions may influence simple, objective decisions like object recognition that are thought to rely primarily on automatic processing. Results suggest that angry participants believe they are more likely to encounter anger-relevant stimuli, like guns, and so they exhibit a bias whereby they need less evidence that a threat is present before they are willing to claim an object is a gun. While this process is meant to serve an adaptive purpose—signaling the presence of actual threats in order to help an individual cope more efficiently—when an emotional state gets carried over from its eliciting situation and is utilized as a source of information in a novel, unrelated situation emotions can introduce sources of error into people’s judgments.
Acknowledgments

First and foremost I would like to thank my advisor, Dr. Dave DeSteno. I would never have been able to accomplish this without your guidance and friendship. I cannot express enough gratitude for all that you have taught me and how you’ve helped me grow both as a scholar and a person. Thank you for taking a chance on me five years ago, and for providing an environment where I felt encouraged to take chances of my own.

I would also like to thank my committee members, Drs. Rhea Eskew and Lisa Barrett, for their helpful comments and revisions on this dissertation project. In particular I would like to thank Rhea for his willingness to suffer through lengthy meetings discussing the intricacies of signal detection theory with me, and for doing it with a smile (most of the time). Thank you for all your kindness and encouragement. As a member of my master’s thesis committee and my teaching mentor, I also would like to thank Dr. Steve Harkins for all his feedback and advice on the original studies off of which I built my dissertation work as well as on life and academia more generally.

I must also thank my lab mates Paul Condon and Leah Dickens for their helpful suggestions on this as well as on many other research projects. It has been a wonderful experience to work and learn with you both. In particular, I would like to thank Leah for putting up with all of my peculiarities, rants, and distractions on a daily basis in the office. I hope you will remember our little office and our time together as fondly as I will.

I would also like to extend my thanks to all of my classmates who have made this journey so enjoyable, especially the ladies on the second floor: Sarah Gunnery, Danielle Hartigan, Krista Hill, Allison Seitchik, and Mollie Ruben. Aside from helping to keep me sane during the most
anxious and challenging of times, your laughter and friendship will certainly color the lasting impression I have of my graduate career. I love you all.

For their unconditional love and support, I would also like to thank my family (Matt, Adam, Kelly, Mom, and Dad). Thank you all for taking a genuine interest in my research, but also for reminding me to stay grounded and find time to enjoy myself. Mom and Dad, thank you for recognizing and nurturing a love of learning in me from a young age, and for teaching me the importance of dedication and hard work. I would not be where I am today without you.

Finally, I would like to thank my incredible fiancée, Ben, whom I love with all my heart: I can’t imagine any of this without you.
# Table of Contents

Abstract 2

Acknowledgments 6

Table of Contents 8

**Part 1. Introduction and Background Experiments** 10

Chapter 1. General Introduction 11
   1. Theories of Emotion 11
   2. Emotion and Threat Detection 19
   3. Overview of Dissertation 25

Chapter 2. Background Experiments 26
   1. Background Experiment 1 26
   2. Background Experiment 2 33
   3. Background Experiment 3 38

**Part 2. Base Rate Estimates as a Mediator of Anger’s Influence on Threat Detection** 45

Chapter 3. Emotion Influences Base Rate Estimates 46
   1. Experiment 4 47
   2. Experiment 5 55

Chapter 4. Base Rate Estimates Mediate Impact of Anger on Threat Detection 59
   1. Experiment 6 59

**Part 3. Signal Variance Does Not Mediate Anger’s Influence on Threat Detection** 67

Chapter 5. ROCs and Variance Differences 68
   1. Experiment 7A 75
Part I

Introduction and Background Studies
Chapter 1

General Introduction

1. Theories of Emotion

Early psychological theories of emotion, including those put forth by William James and Wilhelm Wundt, were penned in the 1800s, though emotion has long been a topic of interest among philosophers dating back even to Aristotle in the 300s BC. Despite the vast history and ample variety of emotion theories, I will be focusing my overview here to three relatively recent theories that have most guided my own thinking about what emotions are and how they function, and so provide the most relevant groundwork for the research to be discussed herein.

In the recent past, a popular view in emotion theories was that emotions exist as a limited set of physiologically and biologically unique states that are innate and universal (cf. Ekman, 1992; Izard 1977). However, with recent advances in neuroimaging, such claims have largely been discredited, and theories of emotion that focus on explaining the wide variety of emotional experiences and their behavioral outcomes have gained traction. The three theories I will be discussing here (affect-as-information theory, appraisal theory, and the Conceptual Act Model) all work from a belief that emotions evolved to be adaptively functional and that variability in emotional experience and behavior is a necessity for that functionality. While I will note some of the important distinctions between these theories as I describe them, my overall goal is to highlight the larger theoretical claims shared among them. After describing the theories individually, I will again highlight their similarities by integrating the theories into one set of guiding theoretical principles.

Affect-as-Information Theory
According to affect-as-information theory (Schwarz & Clore, 2007; Clore, Gasper, & Garvin, 2001), affect is utilized as a source of information when making judgments or evaluating stimuli in one’s current environment. This theory arose in part in reaction to information processing paradigms that had become popular in social psychology in the late 1970’s and early 1980’s; Norbert Schwarz wanted to develop a theory to explain how moods, frequently thought of as merely an effect or reaction to the environment, could causally influence evaluative judgments. The theory provides a general framework for understanding how current affect and the environment are related. Namely, it suggests that certain environmental conditions have been paired with similar affective experiences over time—both in an evolutionary sense as well as within an individual’s lifetime. Because of these learned or acquired associations, the relationship between affect and the environment is not unidirectional: characteristics of the environment can influence affect, but people can also utilize their affective experiences to help them predict which types of environmental conditions they are likely to encounter. For example, when an environment is safe, that is, when it poses no particular threat to an individual’s safety or goals, it should elicit a positive affective state in the individual. Similarly, positive affect can be a source of information that one is currently safe and that there are potential opportunities for growth and learning. On the other hand, when an environment is unsafe or poses some threat to an individual’s goals, affect-as-information theory suggests that it should elicit a negative affective state in the individual. But again, negative affect can also serve as the source of information, alerting an individual that he or she is likely to encounter potential threats or dangers in the current environment.

In instances where one’s affective state is being caused by a current situation or environment (and this is frequently the case), utilizing affect as a source of information about
likely conditions or outcomes provides a benefit to the individual. That is, negative affect will signal that potential harms are likely when they *are indeed* more likely. As such, affective experiences can help motivate or prepare an individual to act efficiently in his or her environment. It has been suggested, for instance, that positive and negative affect foster systematically different processing strategies that are tuned to meet the requirements apparently posed by the situation (Schwarz, 2010). Put differently, affect-as-information theory holds that emotions evolved to promote adaptively relevant behaviors and outcomes, and that relying on affect as a source of information is commonly beneficial.

Nevertheless, there are times, especially in modern society, when utilizing current affect as a source of information can result in errors that do not appear to serve any kind of evolutionary purpose. That is, when one’s affective state is primarily the result of some other influence or is carried over from a prior situation, it may still be misattributed to the current environment or task. In such instances, the information provided by one’s affective state is certainly irrelevant and potentially detrimental. For example, anger elicited in one situation has been shown to create automatic prejudice toward an outgroup on a subsequent task (DeSteno, Dasgupta, Bartlett, & Cajdric, 2004). Incidental moods have also been shown to affect even highly consequential decisions, like stock market investments (Hirshleifer & Shumway, 2003) and even medical school admission decisions (Redlmeier & Baxter, 2009).

Nevertheless, researchers have demonstrated that many affect-based effects on judgments and decisions can be diminished or even reversed simply by drawing participants’ attention to the source of their current affect (e.g. Schwarz & Clore, 1983; Clore et al., 2001). According to affect-as-information theory, affect influences judgments or evaluations about which people are uncertain because, in situations of uncertainty, people assume that how they feel is related to the
task at hand and utilize those feelings as a source of information for judgments pertaining to the
task. However, if you draw attention to the unrelated source of an individual’s affective state, he
or she will realize that it is irrelevant to the task at hand and seek to discount it. For example, in
an experiment by Schwarz and Clore (1983), participants were asked to report their current mood
in a phone survey that either took place on the first warm, sunny day of spring, or the first cold,
dreary day of winter. Those who took it on the sunny spring day reported more positive affect
and reported greater life satisfaction than those who took it on the dreary winter day. However,
another group of participants were told prior to the survey that the weather might affect their
mood. With their mood attributed to a source unrelated to the survey, no differences in reported
affect or life satisfaction were found between participants who completed the study on spring and
winter days.

While affect-as-information theory provides a general framework for understanding how
affect can influence judgments and decisions, its focus is on affective valence (positive versus
negative experiences) and it fails to account for differential effects of more specific emotional
experiences. Nevertheless, the idea that positive and negative experiences can be differentiated
into more specialized emotional experiences is not incongruent with the fundamental claims of
affect-as-information theory. That is, there are many different kinds of potential harm and there
are many different kinds of potential opportunities where efficient responding to avoid the harm
or take advantage of the opportunity requires more than mere positive or negative categorization.
For example, getting into a fight with a co-worker and coming across a dangerous predator while
hiking are both affectively negative experiences, but they call for very different behavioral
responses. As such, it would make sense that specialized sets of environmental conditions (e.g.,
particular types of harm or opportunity) were associated with affective experiences of hedonic valence as well as with cognitive or conceptual experiences.

**Appraisal Theory**

There has been a great deal of research that has investigated the importance of conceptual or cognitive components of emotional states. Appraisal theories of emotion, for instance, posit that cognitive assessments of one’s current environment guide which emotion an individual experiences and that such appraisals play a decisive role in differentiating more specific discrete emotional states from one another (Ellsworth & Scherer, 2003). According to Lerner and Keltner (2001), appraisals are the “cognitive dimensions underlying different emotions” (p. 147). While the specific number and type of appraisal dimensions put forth vary across more specific appraisal theories, there is nevertheless a large amount of agreement about several of the more central appraisal dimensions. These major dimensions include novelty, pleasantness, agency, certainty or probabilities, and goal relevance.² Emotional states, then, are primarily the result of how individuals evaluate their current environment along these dimensions (Ellsworth & Scherer, 2003).

In line with this view, researchers have sought to explain how emotional states can impact behavior by focusing on how individual appraisal dimensions can influence behavior. For instance, researchers have frequently compared the effects of anger and fear because, although both emotions are negatively-valenced, anger is associated with heightened appraisals of control and certainty while fear is associated with lowered appraisals of control and certainty (Lerner & Tiedens, 2006). According to appraisal theory, individuals experiencing anger believe that they have greater control over their environment and that potential outcomes are more predictable or more certain. As a result, angry individuals predict good things are more likely to
happen to them and bad things are less likely to happen to them while the opposite appears to be true of fearful individuals (Lerner & Keltner, 2001). This work is commonly taken as evidence by appraisal theorists that the cognitive dimensions underlying emotional experience are better predictors of how an emotional state will ultimately impact behavior than is affective valence.

The focus on underlying cognitive dimensions in appraisal theories also provides a means for explaining the observed variability in emotional experiences. In contrast to categorical theories of emotion (cf. Ekman, 1992; Izard 1977) appraisal theorists have by and large disavowed the notion that there exist only a limited number of distinct basic emotions (Ellsworth & Scherer, 2003). Instead, appraisal theorists believe that emotional experience is made up of more basic elements that correspond to the different appraisal dimensions. Thus, variability in emotional experience can be understood as variability in the pattern of activated appraisals. Since the appraisal dimensions themselves represent non-categorical distinctions, this reasoning precludes any belief in the existence of a limited number of qualitatively discrete emotional states.

Despite this purported advantage in explaining variability in emotional experience and behavior, appraisal theories are still limited in the sense that they focus so heavily on the cognitive dimensions underlying emotional states. Indeed, appraisal theories of emotion are unable to account for many findings that have come from researchers in support of the affect-as-information model. For instance, studies have repeatedly shown that anger is associated with increased predictions that negative, anger-relevant events are more likely to occur (Baumann & DeSteno, 2010; DeSteno, Petty, Wegener, & Rucker, 2000). As mentioned above, however, appraisal theory predicts that anger will result in more optimistic risk estimates and has demonstrated this to be true under certain experimental conditions (Lerner & Keltner, 2001;
Loewenstein & Lerner, 2003). Thus, like affect-as-information theory, appraisal theories of emotion are unable to account for the full range of variability in emotional experience and behavior. While both theories have many redeeming qualities, both fall short because they promote the importance of one component of emotional experience by discounting the importance of another. Constructionist theories of emotion, like the Conceptual Act Model proposed by Barrett and colleagues (Barrett, in press; Barrett, 2009; Lindquist & Barrett, 2008), highlight the significant contribution of both affective and cognitive factors in emotional experience.

**Conceptual Act Model**

Like appraisal theory, the Conceptual Act Model posits that emotions are emergent phenomenon composed of more basic components (Barrett, in press; Barrett, 2009; Lindquist & Barrett, 2008). However, while appraisal theory focuses solely on different cognitive components, the Conceptual Act Model claims that emotional states are comprised of both affective and conceptual components. That is, the Conceptual Act Model theorizes that the experience of a discrete emotional state includes an experience of core affective valence and arousal (i.e., sensations of pleasure/displeasure and activation/deactivation arising from the body) as well as activation of conceptual knowledge concerning the specific emotion in question (i.e., learned associations with a given emotion word). Importantly, these components are theorized to be independent of one another, and so should be associated with their own predictive validity in terms of an emotional state’s influence on decision making or behavior (Lindquist & Barrett, 2008).

However, because emotional experiences are theorized to be emergent phenomenon, one cannot fully explain how an emotion will influence behavior by merely studying the components
of emotions in isolation from one another. Put simply, emergence implies that the whole is more than the sum of its parts. As an example, consider water which has many emergent properties (like cohesion) that are not explainable in terms of the properties of uncombined hydrogen and oxygen atoms. Similarly, studying the affective and conceptual components of an emotional state in isolation to learn about the properties of that emotional state would be like studying hydrogen and oxygen atoms separately to learn about the properties of water. I do not wish the downplay the importance of researching the individual components of emotional experience; undoubtedly research exploring how these components combine to form ‘full blown’ emotions will ultimately make a significant contribution to our understanding of what emotions are and how they influence behavior. Instead, what I am attempting to highlight is the necessity of considering both components in conjunction in order to predict how an emotional experience might influence behavior.

*Review of Theoretical Principles Guiding Current Research*

Taken together, these theories highlight the principles that underlie the research on anger and threat detection discussed in this dissertation. Despite some important distinctions among these theories, I feel that they agree on many of the broader claims about what emotions are and how they function. That the three theories share so much of the same underlying philosophy concerning emotions is important because it speaks to the amount of cumulative evidence in support of such views. The disagreements among the different theories should be thought of as more minor distinctions that are currently lacking in empirical support. My goal in this section, then, is to integrate the theories into a single set of guiding theoretical principles by highlighting the consistencies across theories more clearly and succinctly.
Emotions are emergent phenomenon comprised of both affective and conceptual components. Affective states become paired with certain types of environmental conditions or circumstances over time—both in an evolutionary sense as well as within one’s lifetime; positive affect is associated with safe or advantageous conditions while negative affect is associated with dangerous or threatening conditions. However, because there are many different types of threats and many different types of opportunities that require differentiated strategies or behaviors for optimal outcomes, conceptual or cognitive evaluations of these more specific environmental features become learned associations over time as well. In many cases, people or cultures have identified certain sets of affective and cognitive associations that seem to commonly occur together (e.g., negative, high arousal affect paired with appraisals of heightened control and certainty) and have assigned them an emotion category label (e.g., “anger”, “fear”, “happiness”). Thus, an emotional state is an affective state paired with some set of cognitive evaluations of one’s environment that are perceived to commonly occur together, and that have been given a common label with which one can categorize the experience. This verbal categorization allows an individual to more efficiently accumulate additional associations with the labeled emotional state.

An individual’s emotional state and his or her immediate circumstances have a bidirectional relationship in terms of information flow. People’s immediate environmental conditions can elicit affective states as well as more specific emotional states. This elicitation is meant to prepare individuals to act more efficiently in their environment by motivating certain types of cognitions or behaviors that have proven useful in similar situations in the past. Similarly, one’s emotional state can be drawn upon as a source of information about likely environmental conditions when there is some uncertainty or ambiguity being experienced
concerning one’s current circumstances. While this process is largely adaptive, emotional states can be misattributed to unrelated situations or judgments when the source of the emotional state is not apparent. In some instances, such misattributions can result in errors or biases in the decision making process.

Understanding the original adaptive purpose of an emotion’s influence on behavior or decision making is important to uncovering when and how misattribution of that emotion may result in problematic biases in judgment. In the present dissertation, we will explore the role of the emotion anger (typically a negative, high arousal affective state paired with cognitive appraisals of heightened control and certainty) in the crucial process of threat identification, and the theoretical framework laid out above will guide this investigation. We will turn now to a more narrow discussion of how and why emotions may contribute to threat identification specifically.

2. Emotion and Threat Detection

The death of 23-year old Amadou Diallo, who was shot and killed on February 4, 1999 by New York City Police officers, stands in most people’s memories as a tragic example of rapid threat-detection gone wrong. When the young African American man reached into his jacket to produce his wallet and identification, police officers—believing that he was in fact reaching for a gun—opened fire, shooting Diallo 19 times. Unfortunately, this incident and the subsequent upheaval it sparked do not represent an isolated event of the past. As a recently released video from a US Army engagement in 2007 shows, threat detection based on the erroneous identification of objects seems to be capable of happening in any charged environment. In this case, an Army Apache helicopter crew mistakenly attacked and killed a Reuters photographer, Namir Noor-Eldeen, during a conflict in Baghdad. The leaked video clearly shows the helicopter
gunners identifying Noor-Eldeen as holding a weapon before requesting permission to engage, when in fact he was merely holding a camera with a telephoto lens (Carey, 2010).

In cases such as Mr. Diallo’s and Mr. Noor-Eldeen’s, research has begun to illuminate the ways that race and racial stereotypes may exert influence on threat detection (Correll, Park, Judd, & Wittenbrink, 2002; Correll, Park, Judd, Wittenbrink, Sadler, & Keesee, 2007; Payne, 2001; Payne, Shimizu, & Jacoby, 2005). In such cases, people appear to rely on information contained in racial or ethnic stereotypes, which suggest higher likelihoods of violence or aggression, when making rapid decisions about danger. However, stereotypes are not the only factors that can provide information, accurate or not, about the actions of others in one’s environs. For example, what if Diallo or Noor-Eldeen had been social actors of White-European descent? Might there be other elements of the situation that could impact judgments of their threat-level and lead to similarly grievous outcomes?

Situations involving the need to assess threats can frequently occur in the presence of heightened emotional states. What if police officers were angered by chasing the suspect first, or had just come from a particularly heated argument with a superior? What if on the battlefield, the soldiers were feeling quite angry or afraid when they had to judge whether another combatant was a potential danger? It seems probable that individuals’ emotional states might constitute a primary influence on threat detection, particularly in situations where an intuition or feeling could mean the difference between life and death. As such, conflict-relevant emotions might well be expected to push individuals’ judgments toward favoring the existence of a threat, thereby leading them to actively aggress against others who may not have posed an actual danger.
When encountering environs that may pose some kind of threat, especially a threat to physical safety, people likely draw upon all informational resources available to them. Moreover, detection of threat often occurs automatically, without conscious awareness or control, as the body prepares an organism for rapid action in the face of relevant dangers (Ellsworth & Scherer, 2003; Fazio, 2001; Ohman, Hamm, & Hugdahl, 2000). Many posit that emotions evolved to function in just this manner: to provide pertinent information about one’s immediate surroundings and to help people to act efficiently to address threats or to gain rewards. Emotions are theorized to “sensitize organisms to stimuli and give priority to responses of relevance to the particular state” (Wiens & Ohman, 2007, p. 257; cf. Frijda, 1986; LeDoux & Phelps, 2000). That is, emotions provide an evaluative gauge for one’s surroundings and recruit one’s resources for appropriate action (Barrett, Mesquite, Ochsner, & Gross, 2007; Clore et al., 2001; Ellsworth & Scherer, 2003; Schwarz & Clore, 2007). Emotions, therefore, may play an important role in automatic threat detection, acting first as an alarm system and second to prepare the mind and body to deal with what comes next. In short, once evoked, a central function of emotions is to provide information meant to “tune” subsequent thought and action to address potential challenges in one’s environs (Barrett et al., 2007; Clore et al., 2001; Schwarz & Clore, 2007; Smith & Lazarus, 1990).

Situational Influences on Automatic Threat Detection: Is it a Gun or Not?

As previously noted, recent work has demonstrated how stereotypes associated with racial categories of individuals influence rapid threat detection (Correll et al., 2002; Correll et al., 2007; Payne, 2001; Payne et al., 2005). For example, Correll and colleagues, utilizing a task frequently termed the “shooter bias paradigm,” have shown that a target’s membership in social groups associated with stereotypes of violence leads to increased erroneous judgments that the
target may pose a threat. In the paradigm, participants play a perceptual game where they are forced to make rapid judgments about whether or not to “shoot” different target individuals. The stimuli depict target individuals embedded within complex background street scenes who are either holding a gun or an everyday object (e.g., a wallet, a camera, a soda can, or a cell phone). Participants are given less than a second to decide whether to shoot each target person, the goal being to shoot armed targets while not shooting unarmed targets as they appear.

In accord with other findings on race and weapons misidentification (e.g., Payne, 2001), Correll and colleagues found that participants’ performance differed based on the race of the target individual (Correll et al., 2002). When given a very limited time to make a decision, participants made more errors shooting unarmed African American targets than unarmed White targets, and made more errors not shooting armed White targets than armed African American targets. In other words, participants more often mistakenly evaluated African American targets as threatening compared to White targets, and more often mistakenly evaluated White targets as nonthreatening compared to African American targets. Ostensibly, the automatic activation of stereotypes (i.e. spontaneously associating African American target individuals with violence) interfered with participants’ ability to accurately evaluate potentially threatening individuals throughout the task. That is, activating beliefs associated with the stereotype increased participants’ expectancy of encountering a threatening or violent stimulus, leaving participants more willing to “shoot” regardless of what stimulus actually appeared. Accordingly, it appears that the race of individuals like Mr. Diallo and Mr. Noor-Eldeen may have, in essence, set the priors for what the police officers and soldiers expected to encounter at those crucial moments, thereby increasing the likelihoods for certain interpretations and ensuing actions.
Social categories such as race undoubtedly influence expectancies for interactions in any given situation. Yet, information regarding the nature of one’s environs stems from other psychological sources as well. As noted, providing information about threats and challenges in the immediate environment is a primary function of emotions (Schwarz & Clore, 2007). Accordingly, we believe it likely that the emotional states of perceivers will directly impact rapid decisions involving threat assessment.

Much research has examined the influence of emotions on perceptions of the risk or probability that specific events will occur, with results repeatedly demonstrating a clear impact of affective states on the computation of such likelihood estimates (DeSteno et al., 2000; Johnson & Tversky, 1983; Lerner & Keltner, 2001; Loewenstein & Lerner, 2003). To arrive at such estimates, individuals often utilize the cues provided by their emotional states as a gauge for the status of their surroundings. For example, the experience of sadness leads people to inflate estimates for the occurrence of future events possessing an emotionally-congruent overtone (e.g., losing a loved-one to disease); similarly, anger leads people to inflate estimates for events possessing angering overtones (e.g., being stuck in traffic) (DeSteno et al., 2000).

From a functional standpoint, it makes great sense that emotions bias such judgments as, once evoked, emotions subsequently prepare organisms to respond adaptively to salient or emerging challenges. Under canonical circumstances (though certainly not all), the evocation of an emotion, such as anger or fear for example, would stem from a source in one’s immediate environment. Thereby, any subsequent emotion-induced increase in expectancies for aggressive or dangerous events would prepare individuals to respond more efficiently to the respective challenges posed by their surroundings. Indeed, Clore and colleagues have convincingly argued
that information provided by emotions is meant to facilitate immediate action by helping individuals seize valuable opportunities or cope with ensuing dangers (Clore et al., 2001).

Presuming that emotions are functional, we theorized that emotional states should influence threat detection only to the degree that they provide information about the costs or opportunities of acting in a given environment. In essence, applicable emotions should set the priors for threats the mind “expects” to see and thus introduce a bias that is characterized by increased vigilance for the relevant threat. To demonstrate the specificity of any influence emotions may have on automatic threat detection, we designed an initial experiment to compare the effect of an applicable negative emotion (i.e., anger) to the effect of a non-applicable emotion (i.e., happiness) using the shooter bias paradigm (Correll et al., 2002) with only White targets. In this way, we could assess the impact of emotion as distinct from intergroup prejudices. Such separation is necessary as recent work has shown that happiness, long known to increase heuristic processing and thereby reliance on stereotypic knowledge (Bodenhausen, Mussweiler, Gabriel, & Moreno, 2001; Fredrickson & Branigan, 2005), can increase judgments that minority targets such as Arabs possess guns, resulting in more frequent mistaken “shootings” of Arab males within the context of the shooter paradigm (Unkelbach, Forgas & Denson, 2008). When stereotypic knowledge or group prejudices are removed from consideration, we believe that anger, through signaling conflict in the environment, will increase perceptions of threat for any generic social targets (i.e., those not associated with stereotypes indicative of violence). That is, we expect that angry individuals will more frequently misidentify a neutral object as a gun than the converse. However, given that stereotypes based on social group differences in violent behavior are not associated with our targets, we expect that happiness as well as other non-applicable emotional states will fail to systematically bias threat detection.
3. Overview of Dissertation Work

In the present dissertation, I will first review three background studies that describe the methods for the shooter bias paradigm utilized throughout this project and establish the existence of the emotion-specific bias in threat detection mentioned above. The third background study also demonstrates an important boundary condition for the effect. Then I will describe a series of 5 experiments that constitute the primary efforts of this dissertation. In these studies, I use signal detection theory as a guide to explore potential mechanisms behind the basic effect found in the background studies. I hope to demonstrate that experiencing an emotional state can increase the number of emotion-relevant stimuli that an individual expects to encounter (Experiments 4 and 5), and that it is this bias in expectancies that drives emotion’s influence on threat detection (Experiment 6). To this end, I also conducted a number of studies designed as direct tests of a possible alternative mediating variable. Experiments 7A and 7B are designed to examine the possibility that anger causes participants to more readily and thus more successfully accumulate knowledge about stimulus identity on gun trials compared to neutral object trials. Together, the two experiments demonstrate that this is unlikely to be the case. Moreover, by providing information about the underlying shape of the gun and neutral object distributions in the task, these final two experiments also provide evidence supporting the choice of theoretical signal detection model (the equal variance Gaussian model) utilized for analyses throughout this dissertation.
Chapter 2

Background Experiments

1. Background Experiment 1

Given that a primary function of emotions is to shape cognition toward adaptive ends, the influence of emotion on threat assessment should not be limited solely to effortful calculations concerning the presence of potential dangers or rewards (e.g., probability judgments), but should also be evident in more basic and rapid processes relevant to assessing challenges posed by one’s surroundings. We expected, therefore, that emotional states, through providing feedback to the mind, should influence judgments of perceptual identification, especially ones relevant to risk (cf. Niedenthal, 2007).

To examine this possibility, we made two modifications to Correll et al.’s (2002) original shooter bias paradigm. First, we held the ethnicity of targets constant (i.e., White) while still manipulating the type of objects held by targets (gun vs. neutral object). Second, we had participants simply identify the object being held by targets as opposed to having them decide whether or not to shoot the target. We made this modification in order to remove any basic link between induced emotions (e.g. anger) and direct, aggressive action-tendencies (e.g., shooting someone). That is, we wanted the primary decision to be one of identification as opposed to one of aggressive behavior.3

We predicted that an applicable emotion, anger, through signaling a sense of threat, would make participants more likely to misidentify harmless hand-held stimuli (e.g., wallet, cellphone) as guns than the converse. Therefore, we expected that angry participants would make significantly more errors claiming that neutral objects were guns than errors claiming guns were
neutral objects. Conversely, participants experiencing happiness or a neutral emotional state should not exhibit biased error rates. That is, experiencing an emotional state that is not indicative of enhanced threat should fail to influence participants’ expectancies for encountering threatening stimuli, and thus should not affect performance. Consequently, we expected that these participants would make equivalent numbers of errors identifying neutral objects as guns as vice versa.

Methods

Participants

Eighty-four undergraduates (49 females) participated in partial fulfillment of a course requirement and were randomly assigned to one of three emotion conditions: neutral, angry, happy. Some participants were removed from the analyses through the screening process described below.

Procedure

Participants were seated in front of computers in individual cubicles. They were informed that they would be completing several tasks meant to assess their cognitive abilities: a memory task, a hand-eye categorization task, and a short questionnaire. The hand-eye categorization task occurred in two blocks, with the memory measure occurring between the two. The “memory” measure, which involved recalling and describing in writing an emotionally-evocative memory actually functioned to induce the assigned emotional state. The blocks of the categorization task constituted the practice and critical trials for the primary dependent variable. Following the critical trials of the task, participants completed a manipulation check and measures collecting demographic information.

Manipulations and Measures
**Emotion induction.** Under the assumption that they were completing a memory task, participants were asked to write in detail about one of three types of events: their daily routine (neutral condition), an event that made them angry, or an event that made them happy (DeSteno et al., 2004). Participants were given seven minutes to describe this memory. Written descriptions were checked to assure that they were in accord with the directions provided and, in the anger condition, to make certain that they did not detail any events involving direct violence and/or guns, which might suggest a direct influence of accessibility on subsequent judgments. Participants who generated descriptions that did not meet these criteria were removed from the sample prior to all analyses (n=6).

To check the effectiveness of this manipulation, participants completed a questionnaire at the end of the experiment that contained a number of feeling descriptors. Participants indicated the degree to which each of the items described their feeling state using 7-point scales. Happiness was measured as the mean response to three items (Cronbach’s α = .93): happy, content, pleasant. Anger was measured as the mean response to three items (Cronbach’s α = .94): angry, annoyed, irritated.

**Threat Detection Measure.** All stimuli were obtained from Joshua Correll and are described in detail in Correll et al. (2002). The 10 target individuals (all of apparent European-American ancestry) each appeared twice holding a gun and twice holding a neutral object of similar size and color (i.e. camera, wallet, soda can, cell phone), resulting in a total of 40 targets. Background images consisted of several different urban and suburban scenes (e.g. park, train station, street corner). Sample images can be found in Appendix A. For each of the 40 trials, participants were asked to identify the object being held by the target individual. The ‘z’ and ‘/’ keys were clearly marked as the gun and object responses, respectively.
During each trial, participants were randomly shown between 1 and 4 background images (the images themselves also being chosen at random from the total collection of background images), each for a random length of time between 500ms and 1000ms. The final background image was then replaced by a target image, which consisted of the same final background image with a target individual embedded within it. From the point of view of the participant, the target individual simply appeared in the final background image following some random interval. The randomization of number and duration of background images was meant to keep the presentation of this target individual variable between trials and thus prevent participants from knowing when to expect a target individual to appear. The target image was displayed for 750ms, and participants were asked to decide whether the target individual was holding a gun or a neutral object within that same 750ms. Whenever participants did not respond within the 750ms window, they received a message to speed up their future responses. No feedback about accuracy was given. In order to encourage participants to perform their best on the threat detection measure and to weigh the different types of errors equally, they were informed that the top 20 scores (based upon the accuracy of responses) would be placed in a raffle for $100 at the end of the experiment.\(^4\)

Prior to the emotion manipulation, participants engaged in a block of 10 practice trials. The practice trials were composed of different but similar target individuals and background images than those presented in the critical trials. This block was meant to familiarize participants with the nature of the task without allowing them to become familiar with the actual stimuli. Participants who failed to respond within the 750ms window on 9 or more of the critical trials (2 standard deviations above the mean number of trials on which participants failed to respond) were excluded from all analyses (n=6). In addition, participants whose overall error rate
exceeded 40% (2 standard deviations above the mean overall error rate) were excluded from all analyses (n=5). This resulted in a final sample of 67 participants.

Results

Emotion Manipulation Check. A series of one-way ANOVAs (one for each measured emotion: happiness and anger) confirmed the effectiveness of the emotion manipulations across induction conditions ($F$’s > 44.76, $p$’s < .001). Paired comparisons revealed that happy participants experienced significantly more happiness ($M = 4.11, SD = .88$) than angry ($M = 1.72, SD = .66$) or neutral ($M=2.98, SD=.97$) participants ($t$’s > 3.95, $p$’s < .001). Similarly, angry participants experienced significantly more anger ($M = 3.63, SD = 1.08$) than happy ($M=1.43, SD=.49$) or neutral ($M=1.69, SD = .83$) participants ($t$’s > 6.76, $p$’s < .001).

Error Rates. A planned interaction contrast on error rates specifying an enhanced bias to perceive guns among angry participants confirmed the predicted moderation of error rates by emotion, $F(1, 64) = 10.91, p < .05$. Angry participants were significantly more likely to misidentify an object as a gun than vice versa, paired $t(24) = 3.02, p < .01$, whereas type of error did not significantly differ among happy or neutral participants, paired $t$’s < 1.73 (See Figure 1). No significant main effects for emotion condition or error type emerged.

Signal Detection Analysis. Signal detection theory is a well-established model of human decision making under uncertainty; the use of signal detection methods allows performance on tasks such as the object/gun judgment to be analyzed in terms of sensitivity to the task stimuli (how well can the subject discriminate objects from guns) and bias towards one response or another (whether the subject tends to respond a particular way regardless of which stimulus is presented). We subjected our data to a signal detection analysis, defining correctly identifying a gun as a hit and incorrectly identifying a neutral object as a gun as a false alarm. We first
calculated a decision criterion parameter \( c \), which can be thought of as a criterion mark before which a participant always decides to press \textit{object} and beyond which he always decides to press \textit{gun}. Note that in order to investigate bias we centered the criterion parameter at the midway point between distributions (Wickens, 2002): \( c = -z(f) - 1/2d' \). Therefore, a positive value for \( c \) indicates a bias toward responding \textit{object}, a negative value for \( c \) indicates a bias toward responding \textit{gun}, and \( c = 0 \) indicates no bias in responding (i.e. the criterion falls directly between the object and gun distributions). In accord with previous findings concerning the role of race in automatic threat detection (Correll et al., 2002), we predicted that the value of \( c \) would be significantly negative for participants in the anger condition while failing to reach significance for participants in the other conditions.

Criterion values for neutral \((c = .04, SD = .21)\) and happy \((c = -.01, SD = .22)\) participants did not differ from zero \((t's < 0.78)\), thereby demonstrating the absence of response bias. As expected, however, the criterion value for angry participants \((c = -.10, SD = .21)\) did significantly differ from zero, \( t(23) = 2.35, p < .05 \), indicating a bias toward responding \textit{gun}. A planned contrast on these idiographic scores revealed that \( c \) was significantly lower in the anger condition as compared to the other two emotion conditions, \( t(59) = 2.10, p < .05 \). Therefore, while neutral and happy participants did not show a bias in object identification, angry participants evidenced a clear bias toward identifying stimuli as guns.

In addition, although we had no specific hypotheses regarding sensitivity, examination of the sensitivity parameter \((d')\) revealed that it was significantly greater than 0 in all conditions \((t's > 12.71)\), indicating that participants in all conditions were able to distinguish between trials containing guns and trials containing neutral objects. However, sensitivity did not significantly vary among the emotion conditions.\(^{10}\)
Discussion

In signal detection analysis, it is assumed that noise (object) and signal (gun) trials vary along some judgment-relevant dimension. In the current investigation, that dimension could be thought of as how threatening a target individual appears to be. Presumably, targets holding guns should, by and large, be more threatening than targets holding neutral objects, as the gun signals a potential threat to one’s physical safety. Results suggest that anger influences the types of errors participants are willing to make when detecting potential threats without influencing their sensitivity to the distinction between threatening and nonthreatening stimuli. If anger were increasing participants’ sensitivity, we would expect that angry participants would make significantly fewer errors overall, with the underlying assumption being that anger enhances people’s ability to differentiate between threats (guns) and non-threats (neutral objects). As previously noted, however, the results suggest that this is not the case, as sensitivity was not significantly different across emotion conditions, and there was not a significant difference in overall error rates. Instead, anger appears to affect solely response bias, as the placement of angry participants’ criterion value differed across conditions.

When participants are experiencing a neutral or non-applicable emotional state (i.e. happiness), they make roughly equivalent proportions of errors claiming threatening targets are nonthreatening and vice versa. However, when participants are experiencing an emotional state that signals the presence of potentially violent or aggressive threats (i.e. anger), they make many more errors claiming non-threatening targets are actually threatening than vice versa. That is, angry participants set a much lower criterion for saying that a target is holding a gun; they require much less information before they are willing to claim a target individual is threatening. Essentially, compared to participants in other emotion conditions, angry participants are more
ready to identify as threatening even those target individuals who are inherently lacking on the judgment-relevant dimension (i.e., potential threat).

Thinking about this result from an evolutionary perspective, the influence of anger on criterion values should make great sense. Enhanced accuracy alone would not favor one’s own safety and survival in the way that a biased decision criterion does. It is more adaptive to mistakenly harm a nonthreatening (unarmed) person than to risk being harmed or even killed by a threatening person; survival-wise, it is better to be safe than sorry when one’s emotions are signaling the presence of potential dangers. Conversely, if an individual is experiencing an emotion that does not signal the presence of threats (i.e. happiness), he or she should not exhibit biased errors on a threat detection task. While Study 1 demonstrated this to be the case with an emotion of positive valence (happiness), negatively-valenced emotions that are not applicable in situations involving potential violent or aggressive threats should also fail to bias participants’ performance on the current threat detection task.

2. Background Experiment 2

In Study 2, we sought to replicate and extend our initial demonstration of an emotion-specificity bias in automatic threat detection. More specifically, we explored whether specificity would exist, as predicted, with respect to different emotions of negative valence. According to a functionalist view, emotions have specific informational and motivational, or goal-directed, components (Smith & Kirby, 2001; Smith & Lazarus, 1990; Clore et al., 2001). In line with this view of emotions is the idea that many emotion-based effects should be specific to only those emotional states that are informative concerning the situation at hand. That is, only when an environmental challenge could elicit a particular emotional state will the informational and motivational components of that emotion be applied to decisions about acting in that
environment. Moreover, such effects should diminish or even disappear when less applicable emotional states are being experienced. Research in the area of emotion has revealed the prevalence of many emotion-specific effects. For example, anger and sadness have been shown to differentially affect likelihood estimates for angering and saddening future events (DeSteno et al., 2000). Similarly, anger and disgust have been shown to modulate implicit prejudice against outgroups as a function of applicability constraints; each emotion increased bias only for groups whose stereotype suggests a threat applicable to the emotion (Dasgupta, DeSteno, Williams, & Hunsinger, 2009).

In order to demonstrate that the bias identified in Study 1 functions in accord with applicability constraints, as opposed to simply representing a broad effect of emotional valence, we predicted that the error bias exhibited by angry participants—whereby participants misidentify more nonthreatening objects as guns than vice versa—would not be exhibited by participants who are experiencing some other negative emotion. That is, we expected that participants experiencing negative emotional states that are not applicable to the gun/object judgment (e.g., sadness and disgust) would not demonstrate systematically biased error rates.

Methods

Participants

One hundred and eighty-two undergraduates (105 females) participated in partial fulfillment of a course requirement and were randomly assigned to one of four emotion conditions. Some participants were removed from the analyses through the screening process described below.

Procedure
The procedure for Study 2 was identical to that of Study 1 with the exception of the emotions induced. Here, we employed four emotion conditions: neutral, anger, disgust, and sadness. As in Study 1, participants were asked to write about a time when they experienced one of these emotions. Eleven participants (7.1%) were excluded because their written descriptions were not in accord with the directions provided or because they detailed events involving direct violence and/or guns.

*Emotion Manipulation Check.* At the end of the experiment, participants responded to a series of feeling descriptors on 7-point scales. Anger was measured as the mean response to three items (Cronbach’s α = .90): angry, annoyed, frustrated. Disgust was measured as the mean response to three items (Cronbach’s α = .83): disgusted, sick, queasy. Sadness was measured as the mean response to three items (Cronbach’s α = .93): sad, down, gloomy.

*Perception Measure.* As before, participants who did not respond within the 750ms window on 9 or more of the trials (2 standard deviations above the mean number of trials on which participants failed to respond) were excluded from all analyses (n=7), and participants whose overall error rate exceeded 39% (2 standard deviations above the mean overall error rate) were excluded from all analyses (n=6). Four additional subjects were removed due to extremely aberrant emotion scores. This resulted in a final sample of 154 participants (40 neutral, 42 angry, 37 disgusted, and 35 sad).

**Results**

*Emotion Manipulation Check.* A series of one-way ANOVAs (one for each emotion scale) confirmed the effectiveness of the emotion manipulations ($F's > 18.60, p’s < .001$). Paired comparisons revealed that angry participants experienced significantly more anger ($M = 3.65, SD = 1.13$) than neutral ($M = 1.95, SD = .89$), disgusted ($M = 2.41, SD = 1.17$), or sad ($M = 2.47, SD = 1.11$).
participants ($t's > 4.77, p's < .005$). Similarly, disgusted participants experienced significantly more disgust ($M = 3.16, SD = 1.32$) than neutral ($M = 1.45, SD = .69$), angry ($M = 2.13, SD = 1.06$), or sad ($M = 2.18, SD = .88$) participants ($t's > 3.69, p's < .005$). Finally, sad participants experienced significantly more sadness ($M = 3.75, SD = .92$) than neutral ($M = 1.57, SD = .66$), angry ($M = 2.42, SD = 1.05$), or disgusted ($M = 2.01, SD = .99$) participants ($t's > 5.85, p's < .001$).

**Error Rates.** A planned interaction contrast again confirmed the predicted pattern of bias in error rates, $F(1, 150) = 4.86, p < .05$. As illustrated in Figure 2, angry participants made significantly more errors calling a neutral object a gun than vice versa, paired $t(41) = 3.10, p < .005$, whereas participants in all other conditions (neutral, disgust, sadness) did not demonstrate a significant difference in types of errors made, (paired $t's < 1.23, ns$).

A 4(Emotion: Neutral, Angry, Disgusted, Sad) X 2(Error Type: Object v. Gun) ANOVA with error type as a repeated measures variable did reveal a significant main effect for error type suggesting that all participants made more object errors than gun errors, $F(1, 150) = 10.02, p < .005$. However, this main effect appears to be a function of the interaction, driven by the significant difference between error types in the angry condition alone.

**Signal Detection Analysis.** To further investigate the nature of this bias, the data were again subjected to a signal detection analysis. The criterion value for angry participants ($c = -.14, SD = .25$) was once again significantly less than zero, $t(41) = 3.30, p < .005$, indicating a bias toward responding gun. In addition, a planned contrast revealed that the criterion value was significantly lower in the anger condition as compared to the other three emotion conditions, $t(150) = 2.11, p < .04$. The criterion values for neutral ($c = -.05, SD = .25$), disgusted ($c = -.03, SD = .21$), and sad participants ($c = -.05, SD = .23$) did not differ significantly from zero ($t's <
1.40, p’s > .17), indicating the absence of response bias. Therefore, in accord with our hypotheses, angry participants evidenced a clear bias toward identifying stimuli as guns while participants experiencing negative emotional states that were not applicable to the threat-related judgment at hand failed to demonstrate this bias in object identification.

As before, the sensitivity parameter (d’) was significantly greater than 0 for each of the four emotion conditions (t’s > 17.08, p’s < .001), indicating that participants in all conditions were able to distinguish between trials containing guns and trials containing neutral objects. There were no significant differences in sensitivity between emotion groups.13

Discussion

As predicted, the emotion-based bias in threat detection appears to function in accord with applicability constraints. The majority of emotion theories suggest that each emotion is elicited only in response to a given set of circumstances, and thus each emotional state can uniquely motivate or prepare an individual to contend with those given circumstances in a unique, adaptive way (Smith & Kirby, 2001; Ellsworth & Scherer, 2003; Dalgleish, 2003). In accord with this view of emotions as functional, the demonstrated bias in threat detection should only result when a participant is experiencing an applicable emotional state—that is, an emotional state that could ostensibly be elicited in response to the given challenges or opportunities posed by the current environment.

When participants were experiencing emotional states that were not applicable to judgments about potential violent or aggressive threats, they failed to exhibit a systematic bias in the types of errors made throughout the threat detection task, even when the non-applicable emotion was negative in valence. Sadness, for example, should not be elicited in response to a situation involving potential violent or aggressive threats. Thus, experiencing sadness should
provide no informational value for decisions regarding how threatening different target individuals appear to be. Not surprisingly, sad participants made the same proportion of errors claiming that nonthreatening individuals were threatening as vice versa. Although disgust should signal the presence of certain types of threats in the environment, specifically threats of contamination or disease, disgust should not provide information about the likelihood of encountering the type of threat represented by a gun (i.e. threat of physical violence) even though it is a negative, high arousal state. The results from Study 2 support this view, as disgusted participants also did not exhibit biased error rates.

Conversely, anger is applicable for judgments about how threatening potentially armed target individuals appear, as anger is elicited in response to situations involving conflicts and competition where a gun could presumably be present. It appears conceivable that anger may alert an individual to the presence of certain classes of threat in the immediate environment (i.e., threats of potential aggression or violence) and by so doing, prepares an individual to act efficiently in the face of such threats. That is, by increasing vigilance for relevant dangers, anger actively helps an individual avoid harm. As such, angry people are willing to make more errors claiming nonthreatening individuals are actually threatening in order to avoid making errors where they fail to accurately identify an anger-relevant threat when it is present.

3. Background Experiment 3

Having established the existence of an emotion-based bias in threat detection, it is essential to put careful consideration toward what, if anything, one can do to diminish the impact of anger on decisions about potential threats. Although anger may typically serve an adaptive function, preparing individuals to act efficiently in the face of potential dangers, it is not difficult to envision instances in which this survival-driven bias is problematic. For instance, police
officers and soldiers, who are commonly placed in emotionally evocative situations, are expected to make rapid, accurate decisions regarding potential threats without allowing their emotions to exert any undue influence. Given that the results from Studies 1 and 2 demonstrate the biasing effect of anger at one of the most basic and automatic levels of processing (i.e. object recognition), there is reason to question whether the demonstrated bias is amenable to correction. In fact, it is not clear from the previous studies whether or not participants are even aware of the errors they are committing. Accordingly, an exploration of potential boundary conditions may prove fruitful in addressing these concerns. Therefore, Experiment 3 investigates participants’ ability to identify and correct for errors in the threat detection task when they are given the opportunity to change their initial responses.

Optimistically, there is reason to predict that angry participants will be able to recognize and fix their biased decisions. Preliminary research on how racial stereotypes impact weapon misidentifications has demonstrated that people are aware of their mistakes (Payne et al., 2005). When given the opportunity and sufficient time to respond again after making an initial, rapid identification judgment, participants were able to correct their mistakes without seeing the target image for any additional length of time. That is, they were, at least in hindsight, aware of the mistakes they made in their initial judgments of whether an object was a gun or a more neutral stimulus and were able to indicate the correct response when given the opportunity to engage in further processing. It appears that it was only the necessity of their initial response being very rapid that prevented them from always making accurate decisions.

It is certainly possible that limiting responses to a very strict time window results in uncertainty about object identification. As such, participants must rely on other strategies or other available information in order to increase their chances of making accurate decisions about
whether a stimulus is threatening or not under these conditions of uncertainty. In the case of the
study by Payne and colleagues (2005), participants primed with African American faces may
have adopted a decision strategy that incorporated their heightened expectancy of encountering
threatening objects following an African American face for their initial time-limited response,
but they were able to utilize more accurate decision strategies when the time restraint was lifted.
Because emotional states and primed concepts such as racial stereotypes are often thought to
operate through the same or similar mechanisms (Clore et al., 2001), there is reason to believe
that participants experiencing anger may also be aware of and able to correct for their errors in
the threat detection task. That is, although angry participants under time pressure appear to
employ a decision strategy based on their heightened expectancy of encountering guns, they
should opt for more accurate decision strategies that rely less heavily on likelihood estimates
when given the opportunity to respond without the strict time constraints.

Given that Studies 1 and 2 demonstrated the existence of the bias only among angry
participants, we focused our examination on those experiencing anger. Moreover, to explore the
potential limits of the bias, we used a methodology similar to Payne et al. (2005). In short, the
design follows the one used in Studies 1 and 2, with the exception that participants were offered
the opportunity to change their initial responses immediately following the normal 750ms
response window. If participants are unaware of their initial errors, we would expect that they
would have no reason to correct their responses (i.e., to say that they really saw an object when
they first indicated seeing a gun). However, we predicted that when angry participants are given
the opportunity to engage in correction, the systematic error bias for reporting guns relative to
neutral objects should disappear. That is, angry participants should be aware of their initial
mistakes, at least after having further processing time, and thus should evidence no greater errors
in categorizing objects than in categorizing guns when they are given an opportunity to respond a second time.

Methods

Participants

Twenty-seven undergraduates (17 females) participated in partial fulfillment of a course requirement. Based on the aforementioned screening procedure, participants were removed from the analyses if: descriptions written for the emotion induction did not follow instructions or contained direct mention of guns/violence (n=2), they failed to respond within the given window on the first attempt on 7 or more trials (2 standard deviations above the mean number of trials on which participants failed to respond) (n=2). In addition, an extreme outlier whose overall error rate was 60% was excluded from analyses. This resulted in a final sample of 22 participants.

Procedure

The procedure for Experiment 3 was quite similar to that of Experiments 1 and 2: participants completed a block of 10 practice trials, an emotion induction task, a block of 40 critical trials, and finally a short questionnaire consisting of the manipulation check and demographic information. However, there were two significant changes. Firstly, an adjustment to the threat detection measure (in both the practice and the critical blocks) was made in order to assess whether participants were able to identify and correct for errors when not under time pressure. After each trial, participants were given the opportunity to change their response. That is, after participants responded to the target image during the initial 750ms for which it was displayed (exactly as they had in Experiments 1 and 2), they were taken immediately to another screen that allowed them to change their answer if they believed it to be incorrect. They did not
see the image for any additional time as the new screen immediately overwrote the previous
screen with large text reading: “Please Respond Again: Was the person you just saw actually
holding a gun or some other object?” There was no time limit for this second response;
participants moved on to the next trial after making their second decision. Secondly, all
participants completed the anger emotion induction, making Experiment 3 a completely 2
(Attempt: First vs. Second) X 2 (Error Type: Object Error Rate vs. Gun Error Rate) within
subjects design.

Results

Error Rates

Replicating the findings of the previous studies, angry participants’ initial responses (i.e.,
those made within the 750ms window) evidenced more errors identifying neutral objects as guns
than vice versa, paired $t(21) = 1.76$, $p = .09$ (See Figure 3). However, when participants were
allowed to revisit their decision without time pressure, errors in both object and gun trials were
practically nonexistent; the mean overall error rate dropped to 2.4%, with 16 of the 22
participants making absolutely no errors at all. Thus, when given the opportunity to consider
their judgments more carefully, participants did not make a significantly different amount of
errors identifying objects as guns or identifying guns as objects, paired $t(21) = 1.44$, ns.

A 2(Error Type: Object Error Rate vs. Gun Error Rate) X 2(Attempt: First vs. Second)
fully repeated measures ANOVA revealed the presence of the predicted interaction between
error type and attempt, $F(1, 21) = 6.59$, $p < .02$, thereby confirming the differential impact of
anger on the first and second responses. Although anger resulted in the predicted bias in errors
when under time pressure, its impact on threat detection disappeared when this particular
constraint on responding was lifted.
Discussion

These results suggest that participants are, at least in hindsight, by and large aware of the errors they make in the threat detection task under time pressure, which supports the view that an emotion-based bias in threat detection is amenable to correction. These findings are consistent with research on how racial stereotypes result in weapon misidentifications (Payne et al., 2005; Klauer & Voss, 2008), suggesting that emotional states, like racial stereotypes, do not appear to influence weapon identification when participants are given the opportunity to respond without time constraints.

It again appears that anger leads participants to show a bias toward identifying objects as guns in the face of uncertainty. However, the results of Experiment 3 also demonstrate that angry participants are able to identify and correct for this propensity to respond “gun” when given the opportunity to respond without time pressure, even without any additional exposure to the target stimulus. That is, without time constraints, participants were able to use a more accurate decision strategy that did not depend chiefly on more heuristic strategies, like their expectancy of encountering threatening versus non-threatening objects. This suggests that the biasing influence of anger on threat detection is not unreceptive to attempts at correction, and may be able to be alleviated or even eliminated completely with minimal increases in the time necessary to reach a decision. As such, Experiment 3 opens a promising avenue of inquiry into the discovery or development of potential interventions or training strategies for those individuals who must make fairly rapid decisions about potentially threatening stimuli on a regular basis.

Nevertheless, any successful intervention would ultimately need to address the mechanism through which emotion is influencing threat detection performance, and as of yet,
this mechanism remains undiscovered. As such, an important next step is to explore potential mediating variables that may explain how the experience of anger is able to bias criterion values in the current paradigm.
PART II

BASE RATE ESTIMATES AS A MEDIATOR OF ANGER’S INFLUENCE ON THREAT DETECTION
Chapter 3

Emotion Influences Base Rate Estimates

Findings from the signal detection analyses in previous studies can help begin to disambiguate the processes underlying anger’s influence on decisions in the current threat detection task. Since no significant differences were found in participants’ sensitivity to the stimuli as a function of emotion condition, anger does not appear to enhance or detract from one’s general ability to distinguish between threatening and nonthreatening objects. That is, anger does not make it easier to correctly distinguish a gun from a neutral object or vice versa. Because sensitivity did not vary by emotion, the bias appears to be driven by changes in the criterion parameter alone: angry participants were setting a much lower criterion—they needed much less information about how threatening a target might be before they were willing to claim a gun was present. Signal detection theory specifies that three factors impact the placement of an observer’s decision criterion. In essence, observers should adjust their strategies for deciding whether a signal (i.e. a gun) is present under conditions of uncertainty in accord with actual or subjective changes in three relevant factors (Green & Swets, 1988; Lynn, Cnaani, & Papaj, 2005). Consequently, it is likely that the ability of anger to produce the bias in question stems from its influence on one of these factors.

The first factor corresponds to the distribution of the signal trials (i.e., gun trials), which may be interpreted as how much evidence a participant obtains indicating that each gun is in fact a gun and not something else. As such, changes in the signal distribution largely reflect changes in how easily identifiable each gun stimulus is (i.e. changes in the clarity or size of gun images or variation in the prototypicality of gun stimuli). However, as identical and highly prototypical
stimuli were used for participants in all conditions, it seems somewhat unlikely that anger is affecting participants’ signal distributions in the present threat detection task.

The second factor concerns the rewards or costs associated with each decision outcome (i.e. whether one type of error is more costly than the other). Although one could theorize that missing a gun might be more costly than missing a neutral object, at least in terms of threat detection, it seems that this subjective difference in relative costs should be similar across emotion conditions. (i.e. there is no reason to believe that neutral participants value not getting killed less than angry participants). Moreover, we explicitly set constraints in the previous experiments to dampen any such asymmetry in cost. That is, we instructed participants to be as accurate as possible on all trials, thereby making all errors of equal cost. Moreover, to make the costs real, participants were told, as noted above, that they would be given the opportunity to win money if they indeed had low error rates. Consequently, we believe that the third factor, which involves the probability of encountering the different stimuli in the environment, stands as the most likely candidate to be mediating anger’s influence on threat detection. As such, we chose to start our investigation of mechanism there.

1. Experiment 4

In the context of our experiment, this third factor involves the relative frequency of gun and object trials – either the difference in the actual probabilities of encountering threatening versus non-threatening objects or the difference in the subjective probabilities of doing so. If individuals expect to encounter an equal proportion of threatening and non-threatening objects, then there is no reason for them to be predisposed toward responding “gun” or “object.” Given that both types of stimuli are equally likely to appear, there is no strategic advantage to favoring one response over the other. Conversely, if individuals expect to encounter a larger proportion
of threatening versus non-threatening objects, they should adopt a lenient decision criterion that requires them to have less information, or less certainty, before deciding an object is threatening (Green & Swets, 1988; Lynn et al., 2005; Wickens, 2002). To be precise, if they expect that guns will be encountered more frequently in the stimulus set or environment, they should favor the “gun” response as this strategy will increase the probability of a correct response under conditions of uncertainty. We believe that anger causes just such a change in expectancies; that is, anger may be causing participants to expect to encounter more guns than neutral objects, which in turn causes them to adopt a more lenient decision criterion, requiring less information to claim a gun is present.

As previously mentioned, there is an abundance of prior research demonstrating that emotions exert an influence on the perceived probability that specific emotionally-congruent events will occur (e.g., DeSteno et al., 2000; Johnson & Tversky, 1983; Lerner & Keltner, 2001; Loewenstein & Lerner, 2003). These studies have demonstrated the impact of affective states on the computation of likelihood estimates, such that participants experiencing a given emotion will report a higher probability for encountering events of an emotionally-congruent tone in the future. For instance, happy participants believe they are more likely to encounter events that would make them happy, while sad participants believe they are more likely to encounter events that would make them sad (Johnson & Tversky, 1983). More specifically, DeSteno et al. (2000) have shown that this bias is not a function of valence, but rather demonstrates emotion specificity. For example, angry participants believed they were more likely to get stuck in traffic or be intentionally sold a lemon by a dishonest car salesman as compared to neutral or sad participants.
In order to investigate the role that emotion-biased expectancies might be playing in the current paradigm, we first need to establish that angry participants do in fact expect to encounter more threats than neutral participants. Experiment 4 was designed to address this issue by having participants “identify” stimuli as neutral objects or guns in the absence of any actual exposure to either stimulus. That is, we informed participants that they would be subliminally exposed to images containing either guns or wallets, and they were asked to guess which stimulus had been shown. In reality, on each trial of the shooter bias task, participants were merely shown an image of random noise (black and white dots) in the hand of the target individual which was very quickly covered with a gray circle as a mask. This was done to give participants the impression that they had indeed been shown something but that it had flashed so briefly on the screen that they were unable to consciously recognize it. We predicted that participants experiencing anger would guess that a gun was hidden behind the gray circle more frequently than would participants experiencing a neutral state. In other words, angry participants would expect to encounter more threats than would neutral participants, thereby supporting the first leg of the proposed meditational model.

**Methods**

**Participants**

Fifty undergraduates (36 females) agreed to participate in this study in partial fulfillment of a course requirement. Based on the aforementioned screening procedure, participants were removed from the analyses if the descriptions written for the emotion induction did not follow instructions or contained direct mention of guns/violence (n=3). In addition, one participant was removed from the neutral condition because s/he made no gun responses. This resulted in a final sample of 46 participants across 2 conditions: neutral (n=24) and angry (n=22).
Materials

All of the target images from previous studies were modified such that the object or gun being held by each target individual was covered completely with a small shape made up of a random assortment of black and white dots. The shape was roughly circular with irregular rounded edges; the exact same image of the same size was used for all targets. Thus the new target images were all identical to those used in previous studies except that the same ‘noise’ shape covered the hand of the individuals in each image. After saving this new set of target images, the images were modified a second time by placing a gray oval over the ‘noise’ shape in each image. Again, the exact same gray oval was used in modifying all images. These two new sets of images were used in Experiment 4 in place of the original target images for the threat detection task. Sample images can be found in Appendix B.

Procedure

The procedure for Experiment 4 was quite similar to that of the previous studies: participants completed a block of practice trials, an emotion induction task, a block of critical trials, and finally a short questionnaire consisting of the manipulation check and demographic information. However, there were two significant changes. Firstly, participants were randomly assigned to one of two emotion conditions: anger or neutral. Secondly, the threat detection task was modified in order to have participants make predictions about the relative base rates of gun and object trials in the task without ever actually exposing them to the stimuli of interest.

To accomplish this goal, the new modified sets of target images (as described above) were used in place of the original target images from previous studies. Aside from this replacement, the threat detection task was completed in exactly the same manner as it was in the first two studies. After a random number of background images each shown for a random
duration of time, each trial of the task ended with the presentation of a target image. First, the image with the target individual’s hand covered with the irregular ‘noise’ shape flashed on the screen for 50ms. This was immediately followed by the same target image (same background and individual) but with the gray oval covering his hand. The target image with the gray oval remained on the screen for another 700ms, during which time participants were required to respond. As before, this left a total of 750ms as a response window from the time of stimulus onset. The brief presentation of the random ‘noise’ shape was meant to give the participant the subjective impression that some true stimulus had indeed been flashed very rapidly before s/he was required to respond.

For each trial, participants were asked to identify which stimulus they believed had been presented by pressing one of two marked keys on the keyboard. Unlike previous studies, participants were asked to respond “wallet” or “gun” instead of “object” or “gun”. We felt that in the absence of any actual stimulus information, it would be easier for participants to respond that they had seen one of two specific stimuli instead of one of two classes of stimuli. Participants made this decision for each of the 40 critical trials. In addition, the 10 practice trials were also modified to be in accord with the changes described here.

Results and Discussion

An independent sample t-test confirmed the effectiveness of the emotion manipulation: angry participants experienced significantly more anger \((M= 3.80, SD=.079)\) than neutral participants \((M= 2.15, SD= 1.15)\), \(t(44) = 5.61, p < .001\). Of import, an independent samples t-test also confirmed the predicted pattern of responding such that angry participants guessed that a higher proportion of trials contained guns \((M=0.51, SD= 0.07)\) than did neutral participants \((M=.45, SD= 0.12), t(44)=2.07, p<.05\).15
These results demonstrate that angry participants expected to encounter a larger percentage of threatening objects in comparison to neutral participants. It is important to note that the base rate of expectation for the presence of wallets vs. guns in the environment by neutral participants may reflect several influences. First, it is likely that wallets are a more common occurrence than guns in daily experience. Second, the shape of the black-and-white “noise” stimulus may arguably have been more similar to the prototypical shape of a wallet than a gun. Nonetheless, the presence of anger resulted in a significant increase in guessing that the stimulus behind the gray mask was a gun, thereby reflecting an elevated expectancy for the occurrence of guns in the environment. Consequently, it is the subjective relative as opposed to absolute level of frequencies that is central here.

These results not only contribute to the already substantial body of research demonstrating that emotions influence people’s expectancies of encountering certain classes of events or objects, but also extend its reach by demonstrating that such emotion-based effects can occur even at time pressures favoring intuitive, as opposed to explicitly calculated, judgments. However, while it was important to demonstrate that differences in predicted base rates could be captured by decisions under time pressure on a trial by trial basis, this particular procedure leaves the results open to an alternative interpretation. Namely, one could conceive of this procedure as a signal detection task in which all trials are noise trials and signals are never presented. In this sense, every “gun” response would be considered a false alarm. Thus, instead of measuring participants’ perceived likelihood that each trial contained a threat, these results may be interpreted as simply another measure of response bias. That is, Experiment 4 may just be another demonstration of how angry participants favor the “gun” response over the “wallet”
response. In order to rule out this alternative interpretation, Experiment 5 attempts to replicate the findings from Experiment 4 without requiring participants to make a response for each trial.

2. Experiment 5

In order to ascertain whether anger increases the proportion of trials a participant predicts will contain a gun or simply leads participants to favor the “gun” response on a trial by trial basis, Experiment 5 will involve participants making one overall estimate for the proportion of trials that contained guns at the end of the task. That is, participants will not indicate whether they believe they saw a wallet or a gun for each trial, but will only be asked to provide a single estimate of the base rate for guns in the task. As in Experiment 4, participants will be told that they will be shown images of guns and wallets subliminally. They will then be asked to predict how many of each stimulus was shown subliminally throughout the task. In so doing, I also hope to expand on previous findings in the literature on emotion and likelihood estimates which has typically focused on hypothetical future events. That is, the current paradigm will allow me to assess whether emotion’s ability to influence likelihood estimates extends to estimates for experiences that are more immediate both temporally and experientially.

In addition, Experiment 5 will attempt to replicate more directly those previous findings concerning emotion’s impact on likelihood estimates for various hypothetical future events. As previously mentioned, past research has repeatedly shown that experiencing different emotional states can influence people’s likelihood estimates for emotionally-congruent future events (DeSteno et al., 2000; DeSteno et al., 2004). As such, I expect to replicate previous findings demonstrating the emotion-specificity of anger’s impact on likelihood estimates. That is, I hypothesize that angry participants will predict that anger-relevant future events are more likely to occur than will neutral participants, but that participants will not differ in their estimates for
the likelihood of future happy or sad events. Importantly, I also hope to determine whether likelihood estimates for future events related to potential violence or aggression (particularly ones that involve guns) are influenced by the experience of anger. If, as I have claimed throughout this research, situations involving the potential for violence or aggression are relevant to the emotional experience of anger, then results should show that angry participants predict such events are also more likely than do neutral participants.

Methods

Participants

Sixty-three undergraduates (35 females) agreed to participate in this study in partial fulfillment of a course requirement. Based on the aforementioned screening procedure, participants were removed from the analyses if the descriptions written for the emotion induction did not follow instructions or contained direct mention of guns/violence (n=4). In addition, 6 participants were removed from analyses because their predictions for the number of gun and wallet trials were aberrant (e.g., they did not add up to 40). This resulted in a final sample of 53 participants across 2 conditions: neutral (n=26) and angry (n=27).

Materials

In addition to the manipulation check and demographic information questionnaire from previous studies, participants in the current experiment completed a questionnaire meant to assess how likely they believed various events or situations were to occur (See Appendix C). This questionnaire was based on one originally developed by DeSteno et al. (2000) and includes several of the same items. The events in the questionnaire varied in emotional overtone and included three events thought to be associated with each of the following emotional states: sadness (e.g., “lose a loved one to disease”), happiness (e.g., “win the lottery”), and anger (e.g.,
“get stuck in traffic”). In addition, three events related to violence and aggression were included (e.g., “witness a violent crime”). Participants were asked to indicate how many people in Boston, MA, they believed would experience each event within the coming year. Participant responses for each item were transformed into z scores prior to analysis.

Procedure

The procedure for Experiment 5 was nearly identical to that of Experiment 4: participants completed a block of practice trials, an emotion induction task, a block of critical trials, and finally a questionnaire consisting of the manipulation check and demographic information. Importantly, participants in this experiment were also asked to complete the likelihood estimates questionnaire prior to the manipulation check and demographic information questionnaire. As in previous experiments, the emotion induction consisted of an autobiographical recall task. In this experiment, participants were randomly assigned to recall and write either about an event in their past that made them angry (anger condition) or about their typical day (neutral condition).

The modified threat detection task utilized in Experiment 4 was used in this experiment as well for both the practice and critical trials. However, one important additional modification was made: participants were no longer required to respond for each trial of the task. Instead, participants were asked to simply observe the trials of the threat detection task as they were displayed on the computer screen. Participants were told before the beginning of the task that the men pictured would be holding a wallet in some trials of the task and would be holding a gun in other trials of the task. The goal was to observe all of the trials while keeping in mind that we would ask them questions after the task to assess whether they were able to subliminally pick up information about how many trials contained each kind of object. Following the critical trials of the threat detection task, participants were asked to indicate how many of the 40 trials they
believed contained guns and how many of the 40 trials they believed contained wallets. It was made clear that the two numbers would need to add to 40 exactly.

Results

An independent sample t-test again confirmed the effectiveness of the emotion manipulation: angry participants experienced significantly more anger ($M= 3.81$, $SD=.95$) than neutral participants ($M= 1.61$, $SD= .64$), $t(51) = 9.87$, $p < .001$. Of import, an independent samples t-test also confirmed the predicted pattern of responding such that angry participants guessed that a higher proportion of trials contained guns ($M=0.50$, $SD= 0.13$) than did neutral participants ($M=.41$, $SD= 0.17$), $t(51)=2.15$, $p<.05$.

Likelihood Estimates Questionnaire. Due to a computer malfunction, likelihood estimate data for 4 participants was not recorded and so the analysis for this questionnaire was conducted on the remaining 49 participants. As expected, an independent samples t-test confirmed that participants in the angry condition believed that they were more likely to encounter violent or aggressive events in the future ($M= .24$, $SD= 1.02$) than were participants in the neutral condition ($M= -.35$, $SD= .30$), $t(47) = 2.72$, $p < .05$. Also as expected, anger did not influence predictions for future events associated with sadness or happiness, $ts< 1.34$. Finally and unexpectedly, participants in the anger condition did not predict that angering events were significantly more likely than participants in the neutral condition, $t(47)= 1.44$, $p=.15$. However, the means for the anger items were in the predicted direction ($M_A= .09$, $M_N= -.23$). Moreover, combining the violence and anger items into a single index for all anger-relevant events in the questionnaire yielded the predicted pattern with angry participants reporting that they were significantly more likely to encounter anger-relevant events ($M= .17$, $SD= .85$) than neutral participants ($M= -.29$, $SD= .43$), $t(47)= 2.37$, $p < .05$. 
Discussion

Results clearly demonstrate that anger increases participants’ base rate estimates for the number of gun trials in the threat detection task. As in Experiment 4, it is important to mention that the relative difference in base rate estimates between emotion conditions is of primary concern here as absolute values for base rates may have been subject to many influences. Importantly, as seen in Figure 4, the relative difference in the proportion of trials predicted by angry and neutral participants to contain guns was very stable across the methodological differences in Experiments 4 and 5.

Moreover, results from the likelihood estimate questionnaire were largely consistent with previous research demonstrating emotion’s influence on predictions for the likelihood of future events. That is, angry participants did not predict future happy or sad events were significantly more likely than did neutral participants, presumably because such events are not relevant to the emotional experience of anger. However, there was a marginally significant trend such that angry participants did predict that future angering events were more likely compared to neutral participants. Importantly, the results clearly showed that the experience of anger influenced estimates for future events involving violence or aggression, including events that involved guns; angry participants believed such events were more likely than did neutral participants. This finding suggests that, as previously claimed, situations involving guns and the potential for violence or aggression are indeed anger-relevant.

Taken together, Experiments 4 and 5 provide strong evidence to suggest that such emotion-biased expectancies may underlie participants’ performance on the threat detection task. More than mere replications of previous findings on emotion and biased expectancies for future events, these studies demonstrate that experiencing a given emotion can influence base rate
estimates for events that are much more immediate both in terms of temporal distance as well as experiential distance. That is, the ability of emotional states to influence likelihood estimates does not appear limited to events that may or may not take place at some distant point in time, but extends to events that are actually and currently taking place.

Nevertheless, in Experiments 4 and 5 participants were merely led to believe that they were being exposed to guns and wallets subliminally and thus involved participants making identification judgments in the absence of actual stimulus exposure. As such, these experiments fail to address whether an emotion’s impact on likelihood estimates can account for the biased responding reported in our earlier experiments where actual images of neutral objects and guns were being shown that were demonstrably distinguishable. As such, additional evidence is necessary to successfully address whether these biased expectancies actually play a causal role in mediating anger’s impact on threat detection.
Chapter 4

Base Rate Estimates Mediate Impact of Anger on Threat Detection

1. Experiment 6

In order to examine the viability of the demonstrated anger-induced increase in expectancies as a mediator for the previously identified bias in threat detection, we decided to use an experiment-based strategy suggested by MacKinnon (2008). This methodology involves decoupling the mediator from the independent variable through direct control or manipulation of the mediator. As such, it allows causal inferences that typical meditational analyses based on covariance structure modeling do not allow. In the current experiment, we accomplished this goal by directly manipulating participants’ expectancies for the frequencies of guns, thus preventing individuals from forming or utilizing their own subjective, emotion-induced expectancies about the proportion of threatening versus non-threatening stimuli they would encounter in our version of the shooter-bias task.

Using a blocking strategy, we attempted to prevent angry participants from forming heightened expectancies of encountering threatening objects in two ways. We explicitly told them that half of the trials they would encounter contained guns and half of the trials contained neutral objects. We also modified the practice blocks to emphasize this distribution; participants completed more practice trials containing an equal frequency of gun and object trials compared to in previous studies. Because emotion biases in expectancies only occur when uncertainty about the quantities to be estimated exists (cf. Schwarz & Clore, 2007), this technique was expected to block the ability of anger to enhance expectancies for encountering guns, and thereby stop angry participants from adopting a decision strategy based on such biased
expectancies. Thus, if expectancies mediate anger’s influence, angry participants told to expect an equal number of guns and objects should not evidence a lower criterion for deciding a gun is present. That is, angry participants should appear similar to neutral participants in terms of decision criterion.

In a separate condition, we attempted not to block the mediator, but to enhance it where it normally was not enhanced. Specifically, we sought to raise the expectancies among neutral participants to determine if they would subsequently match the pattern of biased responding exhibited by angry participants. To accomplish this goal, we explicitly told some participants that 67% of the trials would contain guns and 33% would contain neutral objects. In addition, we modified the practice trials accordingly. The result, we expected, would be that these neutral participants would adopt a decision strategy that favored the “gun” response to account for these differential expectancies. That is, they would exhibit a significantly lower criterion that matched that of angry participants.

If differential expectancies about the likelihood of encountering threatening versus non-threatening objects are indeed playing a mediational role, then the manipulation of participants’ expectancies should eliminate any main or interactive effect of induced-emotion, leaving only a main effect for expectancies. That is, emotional states should evidence no causal efficacy to shape bias outside of direct manipulation of expectancies. On the other hand, if differential expectancies are not playing a mediating role, then the difference in the decision criterion between emotion conditions should remain intact when participants’ expectancies are manipulated, although there should be, in addition, a main effect for manipulated expectancies (cf. Lynn et al., 2005, Wickens, 2002). If, as we hypothesize, we are able both to block the effect of anger on threat detection as well as create an effect that matches that of anger by
manipulating participants’ expectancies, then we will have built a strong case for the mediating role of expectancies in the impact of anger on threat detection.

Methods

Participants

One hundred and forty-two undergraduates (109 females) participated in partial fulfillment of a course requirement. Based on the aforementioned screening procedure, participants have been removed from the analyses if the descriptions written for the emotion induction did not follow instructions or contained direct mention of guns/violence (n=3). As in previous studies, participants who failed to respond within the given time window on 11 or more of the trials (2 standard deviations above the mean number of trials on which participants failed to respond) were removed from all analyses (n=8), as were participants whose overall error rate exceeded 38% (2 standard deviations above the mean overall error rate) (n=3). This resulted in a final sample of 128 participants across 4 conditions: neutral/even-split (n=30), anger/even-split (n=29), neutral/high-frequency gun (n=34), and anger/high-frequency gun (n=35).

Procedure

The procedure for Experiment 6 was quite similar to that of the original background experiments: participants completed a block of practice trials, an emotion induction task, a block of critical trials, and finally a short questionnaire consisting of the manipulation check and demographic information. However, there were three significant changes. Firstly, participants were randomly assigned to one of two emotion conditions: anger or neutral. Secondly, the proportion of gun and object trials were manipulated between subjects, and participants in the anger and neutral conditions were randomly assigned to a high-frequency gun condition or an even-split condition. In the high-frequency gun condition, participants were explicitly informed
that two-thirds (~67%) of all trials would contain guns and one-third (~33%) of the trials would contain neutral objects. In the even-split condition, participants were explicitly informed that half (50%) of all trials would contain guns and half (50%) would contain neutral objects. The proportion of gun and object trials in both the training and critical blocks were, in fact, manipulated to be consistent with these instructions. Finally, the number of overall trials was increased in order to ensure that participants perceived the aforementioned base rates: the participants all completed a block of 24 practice trials and a block of 60 critical trials. The practice trials consisted of similar but different stimuli than the critical block, and both blocks were consistent with the expressed proportion of gun and object trials (e.g. two-thirds of the trials in the practice block and the critical block were guns for participants in the high-frequency gun condition). Therefore, Experiment 6 is a 2(Emotion: Neutral vs. Anger) by 2(Expectancy: High-frequency Gun vs. Even-Split) between subjects design.

Results

Emotion Manipulation Check

As expected, the emotion manipulations were again successful. Participants who wrote about an angering event ($M=3.77$, $SD=0.88$) reported experiencing significantly more anger than did participants who wrote about their daily routine ($M=1.91$, $SD=0.93$), $t(126) = 11.63$, $p<.001$.

Response Bias

The analysis of differences in errors by stimulus type in Experiment 6 is complicated by the fact that participants across conditions were not all exposed to equal numbers of object and gun trials. This fact results in differential opportunities to make object and gun errors and confounds the interpretation and comparison of error rate differences. Instead, biased responding
can be analyzed by comparing the signal detection parameters $c$ and $d'$ across conditions, as the calculation of these parameters takes into account the varying number of gun and neutral object trials.

In the even-split condition, where we prevented participants from having a subjectively inflated estimate of gun trials, we were successful in blocking the bias among angry participants. As predicted, angry participants’ criterion values did not significantly different from 0, indicating an absence of the usual response bias, $t(28) = 1.82$, $ns$. Moreover, $c$ did not significantly differ between neutral and angry participants in the even-split condition, $t(57) = 0.69$, $ns$ (see Figure 5).

In the high-frequency gun condition, we were successful in producing a response bias in neutral participants that matched that of angry participants. The criterion value for neutral participants in the high-frequency gun condition was significantly lower than 0, $t(33) = 8.35$, $p < .001$), indicating a bias toward responding “gun.” Moreover, $c$ did not significantly differ between neutral and angry participants in the high-frequency gun condition, $t(67) = 1.06$, $ns$ (see Figure 5).

Subjecting these data to a 2(Emotion: Neutral vs. Anger) by 2(Expectancy: High-frequency Gun vs. Even-Split) ANOVA with $c$ as the dependent variable confirmed the predicted pattern of results. There was a significant main effect for expectancy, such that participants in the high-frequency gun conditions ($c = -.26$, $SD = 0.31$) had a significantly lower criterion value than participants in the even-split conditions ($c = 0.05$, $SD=0.34$), $F(1, 124) = 69.43$, $p < .001$. Also as expected, there was no main effect for emotion and no interaction between emotion and expectancy $F’s <1.5$, $ns$. Taken together, the results from Experiment 6 strongly support the proposed mediating role of expectancies in anger’s influence on threat detection.
Finally, as before, the sensitivity parameter \( (d') \) was significantly greater than 0 for each of the four conditions \( (t's > 17.73, p's < .001) \), indicating that participants in all conditions were able to distinguish between trials containing guns and trials containing neutral objects.\(^{17}\) There were no significant differences in sensitivity between groups, \( F < 1 \).

Discussion

Results from Experiment 6 support the predicted mediating role of participants’ expectancies in anger’s influence on threat detection. When participants were prohibited from developing and utilizing their own subjective expectations about the probability of encountering threatening versus nonthreatening objects, differences in the decision criterion between emotion conditions disappeared. Angry participants who were told to expect the same number of gun and neutral object trials failed to set criterions that significantly differed from the zero mark. That is, angry participants who were blocked from forming a heightened expectancy of encountering threatening objects behaved more like the neutral participants than the angry participants from previous studies: they no longer demonstrated a bias toward responding “gun.” Conversely, neutral participants who were led to expect more trials to contain guns than objects demonstrated a significantly lower criterion to decide stimuli were threatening. That is, like the angry participants in previous studies, they needed less information before they were willing to respond “gun.”

Put differently, both neutral and angry participants set similar decision criterion within each expectancy condition, suggesting that this criterion placement was influenced primarily by the expected proportions of gun and object trials. Thus, as shown in Experiments 4 and 5, it appears angry participants in previous studies indeed held heightened expectancies of encountering threatening objects; otherwise the manipulation of expectancies in Experiment 6
would not have eliminated the main effect of emotion in this way. In essence, it appears that anger sets the priors for the threats the mind expects to encounter, and readies the body to cope with those potential dangers by increasing vigilance for relevant threats.

These findings are consistent in process with previous work on threat detection and racial stereotypes by Correll and colleagues (Correll, Park, Judd, & Wittenbrink, 2007), suggesting that emotional states may serve a similar informational, or prediction-based, function with respect to identifying stimuli. By manipulating the covariance of race and guns in a preliminary set of trials, Correll et al. demonstrated the mediating role of this covariance, or expectancy, information in participants’ propensities to shoot African American targets and not shoot White targets. That is, participants exposed to a larger number of trials containing stereotype consistent information (armed African Americans and unarmed Whites) exhibited a more pronounced bias in a subsequent task than did participants initially exposed to a larger number of trials containing stereotype inconsistent information (unarmed African Americans and armed Whites).

The three parameters previously discussed as influences on the placement of an individual’s criterion are thought to be independent of one another (Green & Swets, 1988, Lynn et al., 2005). As such, we believe the lack of emotion main effect in Experiment 6 indicates that it is unlikely that differences across emotion conditions in the other parameters are contributing to the demonstrated response bias found among angry participants. Put differently, it appears that neither relative differences in the subjective costs associated with the different types of identification errors nor differences in the variance of the signal distribution are causing or playing a significant role in the observed differences in biased responding found between emotion conditions. If one of the other two parameters were indeed contributing significant additional influence in producing the demonstrated bias, we should have found that angry
participants still set a significantly lower criterion than did neutral participants in both expectancy conditions in Experiment 6. Although consistent with our assumed model, these claims have yet to be tested directly. Thus, Experiments 7A and 7B are designed to more directly address whether one of these remaining parameters can potentially mediate emotion’s influence on threat detection in the current paradigm.
PART III
DECREASED SIGNAL VARIANCE DOES NOT
MEDIATE ANGER’S INFLUENCE ON THREAT
DETECTION
Chapter 5

ROCs and Variance Estimates

To this point, we have utilized a signal detection model that assumes the signal and noise distributions have equal variance, and we have assumed that these variances are not affected by the experience of anger. Justifying these assumptions is critical not only to validate the interpretation of signal detection parameters that we have made to this point, but also to rule out potential alternative causes of the observed error rate differences among neutral and angry participants. We will address each of these points separately.

First, however, it is important to understand what the theoretical signal and noise distributions are referring to in the current threat detection task. In signal detection theory, it is assumed that all of the trials vary along some evaluative dimension. In the current experiment, that dimension can be conceptualized as how threatening each target stimulus is. How much evidence of threat is obtained by a participant will vary on a trial by trial basis for both signal and noise trials, though participants should obtain more evidence to suggest the presence of a threat on signal trials (gun trials) on average than on noise trials (neutral object trials). The distributions are theoretical frequency distributions for the amount of evidence obtained on any given trial that a threat is present. Variance in the amount of information obtained may be the result of properties of the stimuli, like the prototypicality of stimuli or the complexity of the stimuli; simple, easily identifiable stimuli will result in relatively smaller variances than complex or hard to identify stimuli. However, variance in the amount of information obtained also results from more internal sources, such as distraction, blinking, or fatigue.
The calculation of signal detection parameters relies on the assumption that the signal and noise trials fall into separate but overlapping distributions—the overlap being caused by internal or external variance in the amount of information obtained across trials. To this point, we have used an equal variance Gaussian model to calculate all of our signal detection parameters. That is, we have assumed that the signal and noise distributions have roughly equal variance. However, this assumption has yet to be tested directly, and if the signal and noise distribution do not in reality have equal variance then our interpretation of what these parameter estimates mean in terms of underlying decision making processes is flawed.

For instance, in the equal variance model the value $1/2d'$ falls halfway between the mean of the signal and noise distribution, and in the equal variance model this point also corresponds to where the probability density functions for the two distributions cross (See Figure 6). As such, the formula we have used to calculate criterion values ($c = -z(f) - 1/2d'$) is considered a gauge of response bias in the equal variance model. In essence, $c$ describes a participant’s decision criterion ($-z(f)$) in relation to this halfway point. If the decision criterion falls directly on $1/2d'$, then the value of $c$ will be 0. Because the distributions have equal variance and overlap at this point, a criterion at $1/2d'$ indicates that an equal proportion of misses and false alarms were made. This is why $c=0$ is considered to indicate a lack of response bias in the equal variance model. Alternatively, as the criterion moves to the right of $1/2d'$, the value of $c$ becomes more positive, and the proportion of misses becomes more and more large in comparison to the proportion of false alarms. Moreover, if the criterion is to the right of $1/2d'$, then there are instances to the left of the criterion (between the criterion and $1/2d'$) where the probability density function for the signal distribution is greater than the probability density function for the noise distribution. Because this falls to the left of the criterion placement, this means there are
times when a participant actually has more evidence to suggest that a signal is present than to suggest that a signal is not present, but still claims that a signal is not present. For these reasons, significantly positive values of $c$ are interpreted as indicating a “conservative” response bias whereby participants need a great deal of confirming information before they are willing to claim a gun is present. Conversely, as a person’s criterion moves to the left of $1/2d'$, the value of $c$ becomes more negative, and the proportion of false alarms becomes more and more large in comparison to the proportion of misses. In such a case, there are instances to the right of the criterion (between the criterion and $1/2d'$) where the probability density function for the noise distribution is greater than the probability density function for the signal distribution. Because this falls to the right of the criterion placement, this means there are instances where a participant has more evidence to suggest that a signal is not present than to suggest that a signal is present, and yet still claims that a signal is present. For these reasons, significantly negative values of $c$ are interpreted as indicating a “risky” response bias whereby participants need relatively little confirming information before they are willing to claim a gun is present.

These interpretations hinge on the fact that the two distributions have equal variance. If the signal and noise distribution do not have equal variance then the value $1/2d'$ calculated by assuming the distributions have equal variance corresponds only to the halfway point between the two distribution means; it does not correspond to the point where the probability density functions overlap and it does not necessarily divide the errors equally into misses and false alarms. Therefore, the comparison between a participant’s criterion and this point would be meaningless in terms of making statements about response bias.

Past studies on threat detection provide reasons to be concerned about unequal variance in the current threat detection paradigm. Namely, studies have repeatedly shown a distinct
advantage for threat-relevant stimuli in visual search tasks. For example, individuals are more efficient at finding an angry face among a crowd of distractor faces than they are at finding a happy or nonthreatening face (Krysko & Rutherford, 2009; Pinkham, Griffin, Baron, Sasson, & Gur, 2010; Ohman, Lundqvist, & Esteves, 2001; Horstmann & Bauland, 2006; Schmidt-Daffy, 2011). Moreover, research has demonstrated that this advantage in the detection of threat-relevant stimuli extends beyond objects like angry faces and snakes which the biological system may have been tuned to detect over evolutionary history. That is, researchers have found that individuals are more efficient at detecting even modern threats like guns, knives and syringes (Blanchette, 2006; Brosch & Sharma, 2005), and that the threat advantage for stimuli like snakes is not greater than the threat advantage for stimuli like guns (Fox, Griggs, & Mouchlianitis, 2007).

What this may mean for the current threat detection task is that participants may be orienting to the gun stimuli more rapidly than to the neutral object stimuli. If true, participants would have more time within the response window to observe and process information about object identity before having to make a response on gun trials than on neutral object trials. In theory, this difference could mean that participants gain greater and more uniform information about object identity on gun trials than on neutral object trials, and thus the variance of the noise (neutral object) distribution would be greater than the variance of the signal (gun) distribution.

This situation, where the variance of the signal distribution is smaller than the variance of the noise distribution, is depicted in Figure 7. As shown in the figure, this type of unequal variance would result in the value $1/2d'$ (as calculated assuming equal variance, where $1/2d'$ equals half the distance between the distribution means) falling to the left of the point where the signal and noise probability density functions cross as well as to the left of the point where the
proportions of misses and false alarms are equal. This would mean that values for $c$ that were not significantly different from 0 (e.g., those calculated for neutral participants in previous studies) may have actually corresponded to a condition where participants were exhibiting a risky bias, needing less information before being willing to claim a gun was present. Similarly, this would mean that values for $c$ that were significantly negative (e.g., those calculated for angry participants in previous studies) may have actually underestimated the magnitude of the risky response bias. To put it differently, it is possible that in previous studies neutral participants were also exhibiting a significant bias toward claiming that stimuli in the threat detection task were guns and that angry participants were actually exhibiting a more pronounced response bias than we had claimed. Only by investigating the shape of the underlying signal and noise distributions can we be certain of which interpretation is correct.

The second assumption warranting investigation is that the relative difference in the variance of the two distributions (or lack thereof) is not affected by our emotion manipulation. The concern here is that if differences in the variance of the signal and noise distributions do exist for angry participants but not for neutral participants, then this difference alone could account for the low criterion value observed among angry participants in our previous work. In essence, the lower criterion value among angry participants would reflect differences from neutral participants in the shapes of the underlying distributions and not differences from neutral participants in terms of actual decision strategies as we have claimed (See Figure 8). That is, if the distributions do not in actuality have equal variance when one is experiencing anger, it could merely appear that angry participants have a response bias relative to neutral participants because the signal detection parameters being calculated are based on a model that is inappropriate for the angry participants. This possibility has not been investigated directly despite our
contention—based on previous research findings and the use of highly prototypical stimuli in the threat detection task—that this parameter does not contribute to angry participant’s bias toward identifying neutral objects as guns. Thus, it is important to further test the accuracy of our assumed model by investigating the potential influence of one’s emotional state on the relative variance of the signal and noise distributions in the current threat detection task.

In order to obtain the lower criterion value observed among angry participants through emotion-caused shifts in the relative variance of the underlying distributions alone (i.e., not due to a shift in criterion placement), angry participants would need to have less variance in their signal (gun) distributions compared to their noise (neutral object) distributions (See Figure 8). This shift would result if angry participants, compared to neutral participants, were for some reason able to obtain more uniform information about object identity when a gun was presented than when a neutral object was presented. Indeed, past research offers a possible suggestion as to why individuals experiencing anger (in comparison to individuals in a more neutral emotional state) may not be able to obtain information about object identity as uniformly on trials where the target is holding a neutral object compared to trials where the target is holding a gun. As discussed above, people seem to exhibit an advantage for threat-related stimuli in visual search tasks. Interestingly, research has also demonstrated that emotional experiences may affect this threat detection advantage. That is, researchers have demonstrated that higher levels of state anxiety were associated with more rapid responses to probes that followed threatening versus neutral words, indicating increased attention to the threat-related words (Mogg, Bradley, Bono, & Painter, 1997). Similarly, anxiety has been shown to increase attentional biases toward photos of threat-relevant objects. Rinck, Reinecke, Ellwart, Heuer, and Becker (2005) demonstrated an attentional bias toward spiders that was much stronger among individuals who were afraid of
spiders than individuals who were not. This prior research suggests that, compared to neutral participants, angry participants in the current threat detection task may more readily direct their attention to the guns than to the neutral objects.

Another potential cause of unequal variance among angry but not neutral participants could stem from angry participants using their expectancy of encountering threats to guide which features of stimulus objects are sought out or attended to most. If, as we believe, anger is signaling the presence of potential threats in the immediate environment, angry participants expecting guns may attend more to features that are consistent with threat-related stimuli (e.g., the L shape of a gun). Indeed, past research has suggested that threat detection may be based, in part, on context-free visual cues like simple geometric shapes (Larson, Aronoff, Sarinopoulos, & Zhu, 2008). Because all of the guns would contain such features but only some of the neutral objects would contain such features (e.g., an open wallet may form a similar L shape) this would increase the variance of the neutral object trials relative to the signal trials. That is, there would be some noise trials where angry participants attended to features of the object that were consistent with the threat-related stimuli and thus had unusually heightened information to indicate a threat was present; the variance of the noise distribution would increase to include such trials. Conversely, all of the signal (gun) trials would contain these features and so any influence of anger on which features were being attended to would likely not impact signal variance (if anything, it would potentially decrease signal variance). Put differently, anger may highlight features of ambiguous stimuli that appear relevant to or consistent with the emotion being experienced (i.e., may make them appear more “gun-like”). If this is true, angry participants would experience greater variance in the distribution of the neutral object trials compared to the distribution of the gun trials.
If anger can cause this kind of asymmetry in the distributions, then it is likely that anger’s influence on the size and shape of the distributions may be a contributing cause of the demonstrated anger-induced bias in threat detection. Experiments 7A and 7B are designed to test this possibility by measuring anger’s impact on the relative variance of the signal and noise distributions directly. In so doing, these experiments will also help us to assess the validity of our original assumption that the signal and noise distributions have equal variance for all participants in the current threat detection task.

1. Experiment 7A

One way to investigate whether differences in variance exist is to calculate a Receiver Operating Characteristic (ROC) for a number of individuals experiencing each emotion of interest. An ROC is a plot that shows the covariation of hit and false alarm rates across two or more criterion settings for the same stimulus conditions. It allows an estimation of the relative variance in the internal noise and signal distributions. Here, ROC measurement entails having participants complete the task several times while the criterion level is being experimentally manipulated, and sensitivity is being held constant. By investigating how the proportion of false alarm errors and hits change as the criterion moves, one can make confident assumptions about the relative shapes of the underlying signal and noise distributions.

To accomplish this, each participant in Experiment 7A completed two versions of the threat detection task. The only difference between the two versions of the threat detection task was the relative base rates of signal and noise trials, a difference which is known to influence individuals’ criterion placements (Wickens, 2002). One version contained a relatively greater number of signal trials which decreases one’s criterion value; the other version contained a relatively greater number of noise trials which increases one’s criterion value (Wickens, 2002;
Green & Swets, 1988). In order to investigate whether the equal variance assumption holds across different emotion conditions for the current paradigm, participants were again split into two emotion conditions (anger and neutral) for this study. Based on previous findings (cf. Experiment 6), we predicted that the relative variance of the signal and noise distributions would be the same for participants in both the angry and neutral conditions, indicating that this parameter is not a viable mediating cause of anger’s influence on threat detection. Moreover, although one can use past research on the advantage of threat-relevant stimuli in visual search to build support for the claim that the signal (gun) distribution may have lesser variance than the noise (neutral object) distribution in the current threat detection task, we predicted that our original assumption about the underlying shape of the distributions was correct. That is, we predicted that the signal and noise distributions would have equal variance for all participants.

Methods

Participants

Forty-seven participants (14 males and 33 females) were randomly assigned to one of 2 emotion induction conditions (Anger v. Neutral). Across emotion conditions, 9 participants were removed because their performances yielded nonsensical signal detection parameters, indicating a disregard for or misunderstanding of the task instructions. Thus the final sample consisted of 38 participants: 20 participants in the anger induction condition and 18 participants in the neutral induction condition.

Procedure

The procedure was fairly similar to that used in previous studies; participants completed a block of practice trials of the threat detection task, an emotion induction, a block of critical trials of the threat detection task, and finally a brief questionnaire that served as a manipulation
check and gathered demographic information. Compared to previous experiments, however, the
critical block was significantly longer and was broken into two sections of equal length. Half of
the 120 trials were designed to force a risky (low) criterion while the other 60 trials were
designed to force a conservative (high) criterion. The instructions for the risky criterion trials
informed participants that 67% of the trials contained guns, while only 33% of the trials
contained neutral objects. Participants are known to adjust their criterion to account for this
difference in the frequency of gun and neutral object trials (see Experiment 6, Green & Swets,
1988; Wickens, 2002); they set a low criterion that reflects their preference for the “gun”
response under these conditions. Conversely, the instructions for the conservative criterion trials
informed participants that 67% of the trials contained neutral objects, while only 33% of the
trials contained guns. Under this set of circumstances, participants are known to adjust their
criterion to reflect a preference for the “object” response. The frequency of gun and neutral
object trials in the two critical blocks was manipulated to be consistent with the instructions
provided, and the order of these two critical blocks was randomized across participants. Thus,
Experiment 7A was a 2 (Emotion: Neutral vs. Anger) X 2 (Criterion Level: Low vs. High)
design, where criterion level was a within subjects variable.

Additionally, a second emotion induction took place between the two blocks of the
critical trials in order to reinstate the emotional state and ensure that any influence of the
experienced emotion did not dissipate due to the extended length of the task. In the second
emotion induction task, participants were asked to continue writing for 4 minutes about the
emotional memory they had originally recalled in the first emotion induction task.

Results

*Emotion Manipulation Check*
As expected, the emotion manipulations were again successful. Participants who wrote about an angering event ($M = 3.03$, $SD = 0.80$) reported experiencing significantly more anger than did participants who wrote about their daily routine ($M = 2.28$, $SD = 1.02$), $t(36) = 2.55$, $p < .02$.

Signal Detection Parameters

Data were again analyzed using signal detection techniques. Measures of sensitivity ($d'$) as well as measures of criterion ($c$) were calculated for each participant for each set of base rates. Consistent with previous findings, participants’ sensitivity was significantly greater than zero in the neutral condition in both the high gun base rate critical block ($M=1.70$, $SD=.70$) and the low gun base rate critical block ($M=2.16$, $SD=.83$), $t > 10.28$, $p < .001$. Similarly, participants’ sensitivity was significantly greater than zero in the angry condition in both the high gun base rate critical block ($M=1.97$, $SD=.76$) and the low gun base rate critical block ($M=1.99$, $SD=.82$), $t > 10.85$, $p < .001$. Moreover, sensitivity did not significantly differ between neutral and angry participants in either the high gun base rate critical block or the low gun base rate critical block of the threat detection task, $t < 1.11$.

The pattern of criterion values was also consistent with that found in previous studies. The average criterion value was significantly greater than zero for the low gun base rate critical block of the threat detection task for both neutral ($M=.14$, $SD=.28$) and angry ($M=.17$, $SD=.21$) participants, $t > 2.03$, $p < .06$. Thus, all participants demonstrated a bias toward responding “object” in the critical block where there were more neutral objects than guns in the threat detection task. Similarly, the average criterion value was significantly less than zero for the high gun base rate critical block of the threat detection task for both neutral ($M=-.29$, $SD=.42$) and angry ($M=-.25$, $SD=.26$) participants, $t > 2.92$, $p < .01$. Thus, all participants demonstrated a bias.
toward responding “gun” in the critical block where there were more guns than neutral objects in the threat detection task. Also consistent with previous findings (Experiment 6), criterion values did not significantly differ across emotion conditions in either critical block of the threat detection task, $t_{S}<1$.

**Receiver Operating Characteristic**

The standardized value of the proportion of false alarms ($z(\text{fa})$) was graphed against the standardized value of the proportion of hits ($z(\text{h})$) for each participant. Participants’ performances on the two critical blocks of the threat detection task were treated separately to generate two points on a graph: $(z(\text{fa}_1), z(\text{h}_1))$ and $(z(\text{fa}_2), z(\text{h}_2))$. That is, each participant’s graph consisted of two points: one point calculated based on that participant’s performance on the low gun base rate critical block and one point calculated based on that participant’s performance on the high gun base rate critical block. Connecting these two points generated a straight line, or Receiver Operating Characteristic (ROC), whose slope was calculated for each participant. The slope of that line ($\text{slope} = \Delta z(\text{h})/\Delta z(\text{fa})$) estimates the relative amount of internal variance in the noise and signal distributions on the threat dimension. If the slope of the ROC line is 1, then the variance of the signal and noise distributions is equal. That is, if a participant’s false alarm rate and hit rate are changing at the same rate as his or her criterion changes, then the variance of the two distributions must be equal. However, if the slope of the ROC line is significantly different than 1, this indicates that the hit rate and false alarm rate are not changing at the same rate as criterion placement shifts. Thus, calculating an ROC slope that significantly differs from 1 would suggest that the variances of the two distributions are not equal.

As expected, the average slope of the ROC lines did not significantly differ from 1 in the neutral condition ($M=.73, SD=1.89$) or in the anger condition ($M=.70, SD=1.52$), $t_{S}<1$. Put
differently, the variance of the signal and noise distributions did not significantly differ from one another within either emotion condition. Moreover, the average slope of the ROC lines did not significantly differ between the neutral and the angry conditions, \( t_1 < 1 \). Thus, the relative variance of the signal and noise distributions also did not significantly differ between emotion conditions.

*Other Estimates of Signal Variance*

Aside from directly comparing the average ROC slope to 1, calculating an ROC line for each individual participant makes other methods of assessing signal variance possible. Namely, we can calculate measures of sensitivity by measuring the distance between points of interest on the ROC line and the origin in Gaussian coordinates. By using this method we can calculate measures of sensitivity that do not rely on the assumption that the signal and noise distributions have equal variance (their relative variance will be captured by the slope of the ROC line directly). By comparing these more assumption-free estimates of sensitivity to those calculated using the equal-variance model, we can again assess whether our data suggest that the equal variance assumption is well-founded.

The ROC line has the equation: 

\[
z(h) = a + b*z(fa),
\]

where \( b \) represents the slope and \( a \) represents the y-intercept (the vertical distance from the origin in Gaussian coordinates to the ROC line). When the equal variance model holds, \( a = d' \) and \( b = 1 \). We have already shown above that the slope \( b \) does not significantly differ from 1 for either of our emotion conditions. Similarly, we can calculate the value of \( a \) for each participant and ensure that it does not significantly differ on average from our measures of sensitivity, \( d' \), for each participant. A series of paired samples t-tests revealed that \( a \) did not significantly differ from \( d' \) for neutral participants in the low gun base rate condition or in the high gun base rate condition, \( t_{1.24} < 1.24 \).
Similarly, a did not significantly differ from $d'$ for angry participants in the low gun base rate condition or in the high gun base rate condition, $t_{s} < 1$. See Figure 9.

In addition, one can calculate $de$, which is a measure of sensitivity that captures the distance from the origin in Gaussian coordinates to the point on the ROC line that corresponds to a condition with equal error rates. The point $e$ is where the ROC slope intersects the minor diagonal: $z(h) = -z(fa)$. This minor diagonal is of interest because it corresponds to the conditions in which the different error rates are equal (i.e., the condition where the proportion of false alarms is equal to the proportion of misses). The distance $ze$ from the point $e$ to the origin is given by the equation: $ze = a/(1+b)$. Note that if the equal variance model holds, $a = d'$ and $b = 1$, and the equation can be rewritten as $ze = d'/2$. The measure $de$ refers to the value $ze$ multiplied by 2 ($de = 2a/(1+b)$). As seen in the above equations, $de$ should be equivalent to $d'$ as long as the equal variance model holds. Therefore, we calculated $de$ for each participant in order to assess whether these values differ on average from the measures of $d'$ we calculated for each participant. A series of paired samples t-tests revealed that $de$ did not significantly differ from $d'$ for neutral participants in the low gun base rate condition or in the high gun base rate condition, $t_{s} < 1.34$. Similarly, $de$ did not significantly differ from $d'$ for angry participants in the low gun base rate condition or in the high gun base rate condition, $t_{s} < 1$. See Figure 9.

Discussion

The results support our original assumption that the noise and signal distributions in the current threat detection task have equal variance. Recall that if the average slope of the lines in a given condition is 1, then the variance of the signal and noise distributions are equal for that condition. Because our results indicate that participants in both the neutral and anger conditions had slopes that did not significantly differ in value from 1 or from each other, it appears that the
distributions have equal variance and, perhaps more importantly, that the relative variance is not influenced by emotion induction condition. As such, a difference in the relative variance of the signal and noise distributions is not a viable mediator of anger’s biasing influence on threat detection.

Moreover, although the average slopes calculated for each emotion condition did not significantly differ from 1, the individual slopes were rarely if ever calculated to be exactly 1. The slope means (.73 and .70) indicate that the slopes tended to be slightly, but not significantly, less than 1. This trend is important to address as an ROC slope less than 1 indicates that the variance of the signal distribution is greater than the variance of the noise distribution. Although there was no clear reason—either theoretically or based on previous research—to believe the signal variance might be greater than the noise variance in the current threat detection task, such a finding could be problematic for our interpretation of signal detection parameters in previous studies. Namely, an ROC that was truly less than would indicate that any response bias found in previous studies may have been overestimated. This could potentially call into question whether angry participants had ever actually demonstrated a response bias at all. Thus, although the ROC slopes in our study did not significantly differ from 1, the trend for the ROC slopes to be less than 1 warrants further investigation. Of note, the error variance in this experiment was unusually high which casts some doubt on the stability of the average slope values found here. In order to address this issue and make stronger claims about whether the ROC slopes are equal to or less than 1, we decided to run Experiment 7A a second time with some minor alterations.

2. Experiment 7B

In Experiment 7B, we hope to provide a direct replication of the findings from Experiment 7A. However, we made some minor modifications to the methods in an attempt to
help reduce the some of the error variance associated with the ROC slopes. While ROC slope estimates are typically associated with somewhat heightened error variance—due to the fact that they are calculated based on several other parameter estimates that have their own, independent error variance—the amount of error variance in Experiment 7A was still above and beyond what one would hope. One major source of error variance in the current experiments is lack of motivation. In order to get stable signal detection parameter estimates, participants need to be motivated to perform well on the task and to read all of the instructions carefully. As such, for Experiment 7B we decided to recruit participants from Northeastern University and the surrounding community and to offer $10 for participation in the experiment. By recruiting people who had to be interested in participating and willing to commit to come in to the lab, we hope to reduce some of the noise that may have been associated with unmotivated psychology students completing the experiment as a compulsory part of their class participation credits. In addition, participants in Experiment 7B were told that the top 10 scores on the threat detection task (as opposed to the top 20) would be placed in a raffle for $100 at the end of the study. The goal was, as before, to motivate participants to want to perform well on the task without making it seem as though their performance had to be absolutely perfect in order to win the money. We hoped that dropping the number of people involved in the lottery would make this incentive more appealing.

Despite these modest changes to the methods, we predict that we will replicate the results from Experiment 7A. We hypothesize that participants will have ROC lines with slopes that do not significantly differ from 1, and we also hypothesize that the average slope of the ROC lines will not differ between angry and neutral participants.

Methods

Participants
Seventy-one participants (47 females) were randomly assigned to one of 2 emotion induction conditions (Anger v. Neutral). Across emotion conditions, 10 participants were removed because their performances yielded nonsensical signal detection parameters, indicating a disregard for or misunderstanding of the task instructions. Thus the final sample consisted of 61 participants: 29 participants in the anger induction condition and 32 participants in the neutral induction condition. Participants were recruited from Northeastern University or the surrounding Boston area and were paid $10 for their participation in the experiment.

Procedure

The procedure was nearly identical to that of Experiment 7A: participants completed a block of practice trials, an emotion induction, a block of critical trials of the threat detection task, a second emotion induction, a second block of critical trials of the threat detection task, and finally a brief questionnaire that served as a manipulation check and gathered demographic information. As before, one of the blocks of critical trials contained more guns than neutral objects (67% guns) while the other block of critical trials contained more neutral objects than guns (67% neutral objects). Participants completed both blocks of the threat detection task in a random order. Thus, Experiment 7B was a 2 (Emotion: Neutral vs. Anger) X 2 (Criterion Level: Low vs. High) design, where criterion level was a within subjects variable.

In the hopes of increasing motivation to perform well on the threat detection task and thus reduce variance in the signal detection parameter estimates, participants were told that the top 10 scores (as opposed to the top 20 scores in previous studies) would be placed in a raffle for $100 at the end of the study. Scores, they were told, would be calculated using both speed and accuracy. In reality, the winner of the lottery was chosen at random from all participants.

Results
Emotion Manipulation Check

Unexpectedly, the emotion manipulation was not successful. We believe this may be due to running the study near the end of the semester when participants, who were generally students, were frustrated and stressed about finals and finishing up the semester’s work. As such, 4 additional participants were removed from the anger condition who had reported little to no experience of anger, and 6 additional participants were removed from the neutral condition who had reported extremely heightened experiences of anger (i.e., 4 or higher on a 5-point scale). With these participants removed, the emotion manipulation was unsurprisingly successful.

Participants who wrote about an angering event \((M = 2.44, SD = 1.04)\) reported experiencing significantly more anger than did participants who wrote about their daily routine \((M = 1.88, SD = .86)\), \(t(49) = 2.07, p = .05\). All further analyses were conducted on this final set of 51 participants. However, none of the results (aside from the manipulation check) were significantly affected by the exclusion of these 10 participants. Analyses conducted with these participants included can be found in Appendix D.

Signal Detection Parameters

Data were again analyzed using signal detection techniques. Measures of sensitivity \((d')\) as well as measures of criterion \((c)\) were calculated for each participant for each set of base rates. Consistent with previous findings, participants’ sensitivity was significantly greater than zero in the neutral condition in both the high gun base rate critical block \((M=2.05, SD=.77)\) and the low gun base rate critical block \((M=2.20, SD=.79)\), \(t_s>13.63, ps<.001\). Similarly, participants’ sensitivity was significantly greater than zero in the angry condition in both the high gun base rate critical block \((M=2.29, SD=.85)\) and the low gun base rate critical block \((M=2.33, SD=.81), ts>13.51, ps<.001\). Moreover, sensitivity did not significantly differ between neutral and angry
participants in either the high gun base rate critical block or the low gun base rate critical block of the threat detection task, \( ts < 1.07 \).

The pattern of criterion values was also consistent with that found in previous studies. The average criterion value was significantly greater than 0 for the low gun base rate critical block of the threat detection task for both neutral (\( M=.30, SD=.24 \)) and angry (\( M=.33, SD=.23 \)) participants, \( ts > 6.29, ps < .001 \). Thus, all participants demonstrated a bias toward responding “object” in the critical block where there were more neutral objects than guns in the threat detection task. Similarly, the average criterion value was significantly less than 0 for the high gun base rate critical block of the threat detection task for both neutral (\( M=-.27, SD=.23 \)) and angry (\( M=-.31, SD=.24 \)) participants, \( ts > 6.01, ps < .001 \). Thus, all participants demonstrated a bias toward responding “gun” in the critical block where there were more guns than neutral objects in the threat detection task. Also consistent with previous findings (Experiment 6), criterion values did not significantly differ across emotion conditions in either critical block of the threat detection task, \( ts < 1 \).

**Receiver Operating Characteristic**

As in Experiment 7A, the standardized value of the proportion of false alarms (\( z(fa) \)) was graphed against the standardized value of the proportion of hits (\( z(h) \)) for each participant. Participants’ performances on the two critical blocks of the threat detection task were treated separately to generate two points on a graph: \( (z(fa_1), z(h_1)) \) and \( (z(fa_2), z(h_2)) \). Connecting these two points generated a straight line, or Receiver Operating Characteristic (ROC), whose slope was calculated for each participant (slope = \( \Delta z(h)/\Delta z(fa) \)).

As expected, the average slope of the ROC lines did not significantly differ from 1 in the neutral condition (\( M=.94, SD=1.04 \)) or in the anger condition (\( M=1.05, SD=1.12 \)), \( ts < 1 \). Put
differently, the variance of the signal and noise distributions did not significantly differ from one another in either emotion condition. Moreover, the average slope of the ROC lines did not significantly differ between the neutral and the angry conditions, $t<1$. Thus, the relative variance of the signal and noise distributions also did not significantly differ between emotion conditions.

**Other Estimates of Signal Variance**

As in experiment 7A, we were again able in Experiment 7B to calculate other estimates of sensitivity that do not rely on the assuming the equal-variance model to be true. Thus, whether these new measures of sensitivity are consistent with those calculated based on the equal-variance model ($d'$) can provide additional evidence about the appropriateness of the equal-variance model for the current threat detection task. First, we calculated the y-intercept ($a$) of the ROC line for each participant. As described in the results section of Experiment 7A, when the equal variance model holds, $a$ is equivalent to $d'$. A series of paired samples t-tests revealed that $a$ did not significantly differ from $d'$ for neutral participants in the low gun base rate condition or in the high gun base rate condition, $ts<1$. Similarly, $a$ did not significantly differ from $d'$ for angry participants in the low gun base rate condition or in the high gun base rate condition, $ts<1$. See Figure 10.

We also calculated the measure $de$, which derives from the point $e$ where the ROC slope intersects the minor diagonal: $z(h) = -z(fa)$. As explained in the results section of Experiment 7A, $de$ ($de = 2a/(1+b)$) should be equivalent to $d'$ as long as the equal variance model holds. A series of paired samples t-tests revealed that $de$ did not significantly differ from $d'$ for neutral participants in the low gun base rate condition or in the high gun base rate condition, $ts<1.35$. Similarly, $de$ did not significantly differ from $d'$ for angry participants in the low gun base rate condition or in the high gun base rate condition, $ts<1.33$. See Figure 10.
Discussion

As predicted, the results of Experiment 7B replicate the findings from Experiment 7A. Once again, the average slope of the ROC lines did not significantly differ from 1 for participants in both the neutral and anger conditions. Thus, we have demonstrated further evidence to suggest that emotion-based differences in the relative variance of the signal and noise distributions are not causally contributing to anger’s influence on threat detection. To this point, both Experiment 7A and Experiment 7B also replicate the findings from Experiment 6 where base rate expectancies were manipulated. Although Experiment 6 had a between-subjects design and Experiments 7A and 7B had within-subjects designs, all three experiments demonstrated that providing explicit information to participants concerning the number of gun and neutral object trials could eliminate the main effect of emotion condition on response bias. As stated in the discussion of Experiment 6, this suggests that when we block participants’ ability to utilize their own subjective estimates for the number of gun trials in the threat detection task, we also block anger’s ability to produce a response bias. Similarly, by elevating participants’ expectancies to encounter guns in the task we can successfully produce a response bias that did not otherwise exist among neutral participants.

Experiment 7B was also somewhat successful in its attempt to reduce the error variance associated with the calculated ROC slopes. Not only was error variance reduced in this experiment, but the average ROC slopes for the neutral and angry conditions were much closer to 1 (.94 and 1.05, respectively). Taken together with the results from Experiment 7A, we have built up strong evidence to suggest that the equal variance model is indeed acceptable for calculating signal detection parameters in the current paradigm. Thus, it appears that any attentional advantage for threat-relevant stimuli in visual search (Blanchette, 2006; Brosch &
Sharma, 2005; Fox et al., 2007; Ohman et al., 2001; Krysko & Rutherford, 2009) is not affecting signal variance in the current threat detection task. There are several reasons why this well-demonstrated effect may not be influencing performance on the current task. For instance, the 750ms stimulus display in the current studies may be relatively long compared to the time course of such effects, making any small changes in how quickly participants can attend to the stimuli inconsequential for how much information they are able to obtain about object identity in the allotted time.

These results support our continued utilization of an equal variance signal detection model, and they rule out an important alternative interpretation of the results of our previous studies. For an elaboration on this point and some new analyses on the data from Background Experiments 1 and 2 assuming unequal variance in the distributions, please see Appendix E. Perhaps more importantly, taken together with the results of Experiment 6 and Experiment 7A, we have now made a strong case for excluding this parameter as a viable mediating variable. That is, if emotion condition has no impact on the relative differences in the variance of the signal and noise distributions, then any such differences cannot possibly account for anger’s impact on threat detection. Thus, we have gained more evidence to support our contention that it is the expected frequency of gun trials that is causally responsible for anger’s influence on threat detection performance.
PART IV

GENERAL DISCUSSION
Chapter 6

General Discussion

Taken together, these studies represent a concerted effort to understand the processes underlying how one’s emotional state can influence the identification or detection of potential threats. Building off of 3 background studies that establish an anger-induced response bias toward identifying unambiguous stimuli as “guns” as opposed to “neutral objects” under time pressure, 5 new studies investigating how the experience of anger may create this bias constituted the primary efforts of this dissertation. Studies 4, 5, and 6 revealed that the bias appears to be driven by changes in participants’ subjective, emotion-induced expectancies of encountering certain classes of stimuli in their environments. In essence, it appears that anger leads participants to form heightened expectancies of encountering violence-related threats. Finally, studies 7A and 7B provided evidence that one’s emotional state does not seem to impact the variance of the signal distribution and so suggests that this parameter is not a viable mediator of anger’s impact on threat detection.

While the current research has focused on the emotion anger and the threat of physical harm or aggression, we believe that these findings are really a specific example of a more general phenomenon concerning all emotions and their influence on decisions about emotionally-relevant threats or opportunities. That is, the specific effect demonstrated here should be thought of as an example of how emotions in general will influence object identification. We theorize that the emotions which failed to demonstrate an effect on performance in the shooter bias paradigm (e.g., happiness, sadness, disgust) were simply not utilized as a source of information in the task because they were judged as inapplicable or irrelevant by participants to the gun/ no-gun decision. Conversely, there are other instances in
which we would expect these emotions to influence decision-making but where we would expect anger to fail to produce any bias.

Indeed, previous research has explored how the influence of external sources of information is constrained by whether or not those sources of information are perceived to be applicable to the current judgment or task. There is substantial evidence that activated information deemed to be irrelevant or inapplicable will not be utilized in categorizing or assigning value to a given ambiguous behavior, event, or object (cf., Higgins, 1996). Here, applicability refers to the overlap between features of some activated information or knowledge and the attended features of a stimulus. Higgins, Rholes, and Jones (1977), for instance, demonstrated that participants would utilize primed constructs to understand ambiguous behaviors only when those constructs could actually be used to characterize the behavior and not when the primed constructs were unrelated to any potential cause or correlate of the ambiguous behavior. In terms of the current work, this past research suggests that even though an emotion manipulation may activate stored information and associations, that activated content will only be utilized to inform decisions if it is readily perceived as applicable to the stimuli at hand.

For instance, if we had shown participants images of food products that were either fine to eat or that were spoiled and would likely cause illness, we would expect the experience of disgust to bias participants toward identifying all food products as likely to cause illness while we would expect no effect of anger on performance. Similarly, if we had shown participants neutral objects and rewarding objects (e.g., money, ice cream) we would expect a positive emotion like happiness to bias individuals toward identifying objects as potential opportunities or rewards; negative emotions would not be expected to affect decision making under such conditions. In sum, we theorize that an emotional state will influence rapid object recognition to
the extent that the emotional state is deemed applicable to the judgment at hand, and it will bias judgments by making emotion-relevant outcomes seems more likely.

**Anger’s Influence on Threat Detection as an Emergent Phenomenon**

In the current research, we believe that both affective and cognitive components of anger are being activated and that neither alone is causing the bias in threat detection performance seen among angry participants. While Background Experiments 1 and 2 clearly demonstrate that affective valence alone cannot account for the effects, it is less clear that the demonstrated bias in threat detection could not result from heightened arousal alone or from semantic priming alone, and so we will address these two possibilities here.

**Affective Arousal.** There is always a concern in research involving the manipulation of emotional states that the demonstrated effects are caused by affective arousal alone and not necessarily the experience of a specific emotional state. In order to combat this alternative explanation, the current research investigated the effects of several distinct emotional conditions aside from anger on threat detection performance in the current paradigm. Of import, Background Experiment 2 included a condition in which participants were induced to experience disgust, an emotion typically considered to be high in arousal like anger, and this emotion manipulation failed to produce a bias in threat detection performance. We took this null result as evidence that affective arousal alone could not explain the effects of anger on decision making in the current threat detection task.

Moreover, it would be difficult to make a case for arousal influencing performance on the threat detection task in the manner demonstrated. That is, it seems more likely that if arousal were driving performance differences in the threat detection task, then more aroused participants would perform better or worse overall compared to less aroused participants. However, in all 8
experiments discussed here, sensitivity estimates did not differ across emotion conditions, indicating that emotion manipulations had no effect on overall accuracy in the threat detection task. It is less clear how affective arousal alone could influence criterion estimates; that is, how affective arousal could cause participants to favor the gun response over the neutral object response.

Conceptual Knowledge. In 2002, Innes-Ker and Niedenthal investigated how activation of the conceptual knowledge of an emotional state alone differs from activation of that knowledge as part of an emotional experience (i.e., in conjunction with an affective experience). They demonstrated that a sentence unscramble task that contained either happy, sad, or neutral emotion words failed to produce any significant changes in self-reported emotional state although it did influence performance on a subsequent lexical decision task, indicating that the sentence unscramble task successfully primed semantic knowledge related to the emotion words. In a separate study, participants either completed the sentence unscrambling task or watched films meant to induce happy, sad, or neutral emotional states. All participants then read a written account of a fictional character’s typical morning that was designed to be emotionally ambiguous. Participants in the film induction conditions self-reported differences in their emotional state during the experiment, and also judged the character in the passage as displaying emotions that were congruent with their emotion induction condition (e.g., participants in the sad condition rated the character as seeming more sad). The sentence unscramble task, on the other hand, failed to produce any differences in self-reported emotion or judgments of the fictional character’s emotional state.

Taken together, these studies (Innes-Ker & Niedenthal, 2002) suggest the semantic knowledge associated with a given emotional state can be primed independently of any
experience of that emotional state, but that the activation of conceptual knowledge alone has effects on behavior distinguishable from emotion induction procedures. Overall, the findings in the current investigation are more consistent with the pattern of results following a full emotion induction than the pattern of results following a semantic priming task. For example, the studies demonstrated that priming semantic knowledge of an emotion category is not sufficient to produce differences in self-reported experiences of emotional states. However, in all 8 experiments in the current investigation, participants in the different emotion conditions did indeed self-report differential experiences of emotion. These results are incongruent with any claims that the autobiographical recall task used in the present investigation merely primes semantic knowledge of an emotion category. Moreover, Innes-Ker and Niedenthal (2002) also demonstrated that activating conceptual knowledge about an emotion category was not sufficient to elicit emotion-congruent judgments in subsequent tasks. Again, this finding seems to suggest that semantic priming alone could not account for the findings in the present investigation of anger’s impact on threat detection, as experiments repeatedly demonstrated emotion-congruent decision making on experimental tasks following the emotion induction.

Given the implausibility that activation of affective arousal, affective valence, or conceptual knowledge alone could explain all of the findings demonstrated across the 8 experiments in the current investigation, we believe that the autobiographical recall task successfully induces ‘full blown’ emotional states that contain both affective and conceptual components. More importantly, we believe that anger’s ability to influence subsequent threat detection performance is an emergent property of the emotion anger that could not be explained by the independent contributions of its component parts.

Future Studies
The current studies hold important consequences not only for future avenues of inquiry, but also for practical application. For instance, given that individuals systematically vary with respect to the intensity, specificity, and awareness of emotional states (Barrett & Salovey, 2002) as well as sensitivity to threat and rewards (Higgins, 2000), such dispositional factors might moderate the influence of emotion on threat detection. Ideally, knowledge of such situational and dispositional constraints on the ability of emotion to bias threat detection might be of high value in the development of interventions or training programs meant to sharpen decision-making among those for whom such rapid decisions hold high consequence (e.g., police officers, military analysts).

*Individual Differences Related to Emotion and Threat Detection*

It seems logical that if shifting mood states can affect threat-relevant object recognition, then the perceiver’s more stable dispositional traits may also play a role in biasing such judgments. For example, Petzel and Michaels (1973) found that individual differences in level of hostility affected rapid judgments about how violent different scenes were perceived to be. Participants were shown two images simultaneously through a stereoscope for half a second; one image was always violent and the second image was always nonviolent. Participants with high scores on the Buss-Durkee Inventory of Hostility evaluated the images as significantly more violent overall than participants with lower scores. Hostility, of course, is but one of the more stable dispositional traits that might influence threat detection performance.

*Big Five.* The Big Five model for understanding and classifying personality traits is one of the most widely accepted models in personality theory research (McCrae & John, 1992). Arguably the broadest and most pervasive of the Big Five traits are extraversion and neuroticism (Costa & McCrae, 1980). Extraversion involves sociability, social participation, an involvement
with other people, and activity. Neuroticism involves anxiety, worry, a proneness to guilt, and psychosomatic concerns. In a study on subjective well-being, Costa and McCrae (1980) demonstrated that neuroticism was more strongly correlated with the negative affect scale (NAS) than either the positive affect scale (PAS) or the affect balance scale (ABS), and that extraversion was more strongly correlated with the PAS than either the NAS or the ABS. The authors claim that, “Extraversion, together with its component traits of sociability, tempo, and vigor, predisposes individuals toward positive affect, whereas neuroticism (and hence general emotionality, impulsivity, fear, and anger) predisposes individuals toward negative affect” (p.673). Thus, there is reason to believe that these traits are related to more general biases in object recognition. That is, individuals high in neuroticism (with their proclivity for negative affective states) may be biased toward identifying neutral objects as threatening while individuals high in extraversion (with their proclivity for positive affective states) may be biased toward identifying neutral objects as rewarding or advantageous.

Negative Emotionality. Also, research on negative emotionality or negative affectivity has demonstrated that individuals differ in the frequency and intensity of the negative emotions that they experience (Barret & Salvoy, 2002), and that these individual differences in negative affectivity can moderate the effects of negative emotions on subsequent judgments. For example, Eaton and Bradley (2008) demonstrated that negative affectivity was positively correlated with how stressful participants perceived a hypothetical scenario to be. In another experiment, Tipples (2008) demonstrated that higher scores on a measure of negative emotionality (self-reported negative emotional arousal) were correlated with greater overestimations for the duration of faces with angry expressions and, to a lesser degree, fearful expressions. On the other hand,
negative emotionality scores in the experiment were not correlated with time perception for happy or neutral faces.

In terms of the threat detection task used in the current research, it is possible that negative affectivity measures would correlate with the magnitude of the demonstrated decision bias. That is, participants who score high on measures of negative affectivity or negative emotionality, who tend to experience a greater quantity and intensity of negative emotions, may be more inclined in general to identify neutral objects as threatening ones. It is also possible that negative affectivity would interact with the emotion manipulation such that individuals high in negative affectivity would be more influenced by manipulated negative emotional states than individuals low in negative affectivity and thus would demonstrate a more pronounced bias toward evaluating objects as threatening as opposed to non-threatening especially within the anger induction conditions.

*Regulatory Style.* Individual differences in the ways in which people think about and pursue their goals may also contribute to threat-relevant object recognition. Regulatory focus theory differentiates between two self-regulatory states: prevention focus and promotion focus (Higgins, 1997; 2000; 2005). Prevention focus concerns vigilance, safety, security, and avoiding negative outcomes. People in a prevention focus tend to think about their goals in terms of duties and obligations. They tend to focus on goals that feel they have to accomplish; so they view the goal in terms of losses and non-losses. Prevention focused individuals strive to avoid negative outcomes (losses) by any means they can. On the other hand, promotion focus concerns eagerness, risk-taking, and obtaining positive outcomes. People in a promotion focus tend to think about their goals in terms of hopes and aspirations. They tend to focus on goals that they would ideally like to accomplish, and they view the goal in terms of gains and non-gains.
Promotion focused individuals strive to reach a hopeful goal (gain) by any means they can (Higgins, 1997).²²

Research has shown that promotion focus is typically related to a more risky bias on decision making tasks and prevention focus is related to a more conservative bias (Crowe & Higgins, 1997). However, these studies all required participants to make decisions about neutral stimuli (e.g., word or non-word). Scholer, Stroessner, and Higgins (2007) showed that, when faced with negative input, individuals in a prevention focus were willing to incur false alarms to ensure that negative stimuli were correctly identified—a tactic typically associated with the risky bias of promotion-focused individuals. The authors demonstrated that a risky bias in response to negativity does in fact best fit the prevention focus’s typically vigilant strategy, with its concerns about prevention and safety. Because an individual in a prevention focus is particularly sensitive to the presence or absence of negative outcomes, they should be especially focused on any negativity in the environment. Therefore, when faced with negative input, prevention focused individuals should shift away from their typical tactic of being conservative and avoiding false alarms in order to ensure that negative stimuli are detected. This would be in keeping with prevention focus’s central concern of maintaining safety and security by making sure nothing goes wrong (still a vigilant strategy). Similarly, it follows that participants in a prevention focus should adopt a risky bias to serve their usual vigilant strategy in the current threat detection task. That is, prevention-focused individuals should be especially sensitive to negative stimuli and safety concerns, and should be willing to incur false alarms in order to correctly identify any trials containing guns.

**Contextual Influences on Anger-induced Threat Detection Biases**
Perceptual Distortion Studies. In addition to studying the relationship between more stable individual differences and anger’s effect on threat detection, future research should also seek to investigate how contextual features of the task may contribute to or alter the demonstrated bias. For instance, future research should also seek to investigate the role of perceptual distortion in producing biased threat detection with stimuli that are more ambiguous and less prototypical. While the results of Studies 4-7B suggest that only differences in the expectancy of encountering threats is driving anger’s impact on threat detection, it is possible that perceptual distortion may have additional biasing influence on threat detection performance when there is some perceptual ambiguity inherent in the target stimuli. It is not difficult to envision instances in which visibility might impact one’s ability to make accurate object identifications: police officers pursuing a suspect at night or in a fog; soldiers in moving helicopters at a great distance from their targets or trying to see through sand or dirt in the air during a conflict. In such instances, it is possible that angry individuals would be more willing to identify neutral objects as guns because, in addition to anticipating encountering more guns, they might also perceive neutral objects as actually looking more like guns. An exploration of when and if perceptual distortion might occur is an important next step to understanding emotion’s impact on threat detection.

Subjective Costs and Benefits Studies. Another parameter that is known to influence placement of a decision criterion but has remained unexplored in the current research involves the relative costs and rewards of the various errors and correct responses, respectively. Although past research has suggested that this parameter is not a causal mechanism for anger’s influence on threat detection (Baumann & DeSteno, 2010), this research explicitly placed constraints on participants’ ability to form and utilize their own subjective costs and rewards for the various
responses. In these past studies, participants were told that the individuals with the top 20 scores on the threat detection task would be placed in a raffle for $100. Participants were told that scores would be based on their overall accuracy. This instruction served two purposes: it motivated participants to try their best throughout the task and it dampened or eliminated any potential subjective differences in the relative costs or rewards of the different responses. That is, since overall accuracy was emphasized, all errors were assumedly of equal cost.

If, as we have claimed, emotions provide an evaluative gauge for one’s surroundings and recruit one’s resources for appropriate action (Barrett et al., 2007; Clore et al., 2001; Ellsworth & Scherer, 2003; Schwarz & Clore, 2007), then it is possible that the experience of a particular emotion may subjectively increase the expected value of behaviors or decisions that are relevant to the emotion being experienced. That is, emotions may lead individuals to prefer a particular decision or action by making the negative outcome of such a decision seem the least costly and/or the positive outcome of such a decision seem the most rewarding.

Indeed, there have been several studies that suggest incidental emotions may guide decision making by influencing the relative costs and rewards of various outcomes (Fessler, 2001). For instance, compared to individuals in a neutral emotional state, individuals experiencing happiness view losses as being more unappealing (Isen, Nygren, & Ashby, 1988). Moreover, Raghunathan and Pham (1999) demonstrated that different emotions of the same valence can have divergent effects on how participants assess costs and benefits when making risky decisions. The authors found that experiencing sadness leads individuals to choose high-risk/high-reward options over low-risk/low-reward options. They argue that sadness primes a goal of reward replacement whereby the high-reward is especially appealing and counters the higher riskiness of this alternative. Conversely, the authors demonstrated that anxious individuals
seem biased toward low-risk/low-reward options in decision making, presumably because anxiety primes a goal of uncertainty reduction whereby the low-reward is made less unappealing because of the higher certainty of the outcome.

If participants are allowed to form and utilize their own subjective values for the relative costs and rewards of the various responses, it is possible that angry participants will subjectively skew the relative costs of their decisions such that it is less costly to respond as if a threat is present, as this is the response of particular relevance for one experiencing anger. As such, they would be more willing to make errors where non-threats are mistakenly identified as threats than vice versa. Future studies exploring emotion’s influence on how participants set the subjective costs and rewards of various decisions will help to identify if and when such subjective values may contribute to an emotion-based bias in threat detection performance.

*Comparing Applicable Emotions.* Finally, while the current research demonstrates a lack of response bias in the shooter bias paradigm among several distinct non-applicable emotional states, it does not suggest how biases in threat detection may differ among different applicable emotional states. Of particular interest is the experience of fear. Although fear differs from anger on many relevant dimensions of appraisal (Lerner & Keltner, 2001), we would expect fear to produce a response bias similar to that demonstrated by participants experiencing anger in the current threat detection task. That is, while anger is associated with appraisals of high certainty and control and fear is associated with appraisals of low certainty and control, we hypothesize that the heightened expectation of threats having to do with violence that occurs in both emotional states would mediate their influence on automatic threat detection. In any aggressive conflict, the expectations for violence and harm are elevated. The experience of fear should thus motivate or prepare individuals to cope in the face of potential violent or aggressive threats by
heightening their expectancy of encountering such threats—predisposing them to identify stimuli in their environment as dangerous.

Indeed, although Lerner and Keltner (2001) demonstrated that fear and anger have opposing effects on risk perception, their findings show that the nature of the effect depends on the ambiguity of the risks being assessed with respect to appraisals of certainty and control. As the sudden appearance of a dangerous individual wielding a gun is very unambiguous on these appraisal dimensions (i.e., it is a risk that is very uncertain and very uncontrollable) it is unlikely that responses will differ between emotions due to differences in how the dimensions of certainty and control are appraised. Accordingly, the influence of emotion here is more likely to be driven by its informational value with respect to expectancies for the presence or absence of specific threats in one’s environs (cf. DeSteno et al., 2000). Moreover, it has already been demonstrated that emotions associated with opposing appraisals of certainty and control (happiness-high, sadness-low) both fail to produce biased threat detection within this paradigm. While research on the effect of fear would likely necessitate methodologies for emotion induction that differ from those used in the current investigation (e.g., threat of shock), it would contribute to a growing body of literature detailing when and how the different underlying dimensions of an emotion contribute to decision making and behavior more generally.

*Intervention Strategies*

The identification of an emotion-induced bias in threat detection may lead to a call for intervention or training programs for individuals like police officers or soldiers who must make rapid, high consequence threat detection decisions on a regular basis. Such training or intervention programs would need to address not only the processes through which an emotion-based bias is operating, but also the circumstances that allow for anger to bias threat detection in
the first place. For instance, the bias should only emerge when people lack the motivation or ability to make accurate decisions regarding potential threats. In the current investigation (cf. Wegener & Petty, 1995), it is fair to assume that participants were motivated to be accurate in the threat detection task, as they were told that the top 20 scores would be placed in a raffle for $100 at the conclusion of the experiment. However, participants lacked the ability to make accurate decisions regarding the identity of stimuli due to the strict time constraints of the task. Following this logic, the inverse situation where an individual has the ability but lacks the motivation to be accurate should also result in biased assessments of threat, and such circumstances may be more frequent in everyday life than those that necessitate very rapid action and thus limit ability.

However, the combination of high motivation/low ability exemplified in the current set of studies does duplicate the conditions involved in some very important real-world situations, such as the police engagement that ended in the tragic deaths of Mr. Diallo or incidences of friendly fire among members of our armed forces who, constantly facing potential threats, must regularly determine whether another individual is an ally or enemy. It is safe to assume that the individuals who are forced to make such rapid assessments of threat are highly motivated to be accurate in their judgments.

In such instances, training people to be aware of their emotions as well as the potential influence of those emotions on assessments of threat may represent one possibility for enhancing accuracy. For example, Gasper and Clore (2000) demonstrated that current mood influenced participant’s judgments of risk if they said that they do not typically attend to their feelings, but it failed to affect the risk judgments of participants who claimed that they do typically attend to their feelings. This suggests that more stable differences in how frequently people attend to
emotional information can moderate the influence of emotion on judgments of risk. Accordingly, programs designed to improve the accuracy of individuals who must make rapid decisions (e.g. police officers) might find the most success eliminating emotion-based biases by training individuals to be aware of their emotions and the sources of those emotions. Although research on the viability of such training would be necessary, continual strategic thought highlighting the potential impact of emotion on expectancies might prove to be useful in limiting bias in relevant situations.

Conclusion

Emotional states constitute a central factor involved in tracking the salient costs, opportunities, and risks posed by individuals’ surroundings. Through providing feedback to the mind, emotional states appear to guide threat detection at even the most basic and automatic level. Simply put, feeling that something is likely to be in one’s environment (i.e., experiencing the phenomenological feedback that would signal the presence of a specific object or threat) increases the odds that one will claim it is there, even when it is not actually present. As such, anger emerges as an evolutionarily adaptive emotion, despite the negative behavioral consequences frequently attributed to its experience. It appears that anger actively promotes survival and the avoidance of harm by helping individuals to identify and efficiently cope with potential threats amidst ever changing environs. However, like all emotions, when the anger experienced is not directly relevant to the judgment at hand, the usefulness of its influence on judgment can become tenuous.
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Though I have chosen to use the term environment or environmental conditions in my discussion of these emotion theories, I mean this term to include a very wide range of things and processes both external and internal to the individual (e.g., physical objects, social situations, internal sensations like digestive processes).

It is important to note that although the pleasantness dimensions refers in part to hedonic valence, its meaning here is still largely cognitive as opposed to affective. That is, pleasantness evaluations are driven by properties of the external stimuli and not by the momentary internal state of the individual.

Given the results of Unkelbach, Forgas, and Denson (2008), it is very unlikely that negative emotions produce an effect on the shooter bias paradigm by increasing a general tendency to “shoot.” Indeed, their work shows an enhancement of “shooting” certain types of targets when feeling happiness, an emotion known to decrease aggressive responses. As such, the effects of emotion appear to influence object identification in this paradigm, and not generalized aggressive behavior.

The $100 was actually paid out to the winner of a random drawing from all participants in the study, and a separate drawing took place for each study.

Because the meaning of a response outside the given 750ms window is unclear, we chose to remove participants who repeatedly failed to respond in a timely manner so as to limit the influence of such instances in the analyses. We also screened for high overall error rates in order to eliminate participants for whom the task seemed unduly difficult, as the distribution of their errors was likely not the product of any experimental manipulation. In this and all other
studies in the paper, the exclusion of participants due to high time-out rates or overall error rates did not affect the overall pattern of results.

6Trials where participants exceeded the 750ms response window were not included in error rate calculations. Error rates reflect the number of object (or gun) errors divided by the total number of valid trials. Object errors refer to errors on object trials, where participants wrongly claimed a neutral object was a gun. Gun errors refer to errors on gun trials, where participants wrongly claimed a gun was a neutral object.

7The contrast was doubly-centered with weights of ±2’s for angry participant error rates and ±1’s for the remaining cells. The contrast residual was not significant. Residuals for all other contrasts presented in the paper are also non-significant unless otherwise noted.

8False alarm rates (f) were calculated by dividing the number of errors on object trials by the total number of valid object trials for each participant. Hit rates (h) were calculated by dividing the number of correct classifications on gun trials by the total number of valid gun trials for each participant. Sensitivity values (d’) were calculated for each participant from the following formula: 

\[ d’ = z(h) - z(f). \]

9Because some participants possessed a false alarm rate of 0 or a hit rate of 1 (and these extreme values result in infinite z-scores), we utilized a procedure recommended by Wickens (2002) and 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 and gun trials, respectively. This procedure was used throughout all studies discussed herein, and in none of the studies did the exclusion of such participants affect the overall pattern of results.

10Mean sensitivity values for each of the emotion conditions in Study 1: neutral (\(d’ = 2.61, SD = 0.53\)), anger (\(d’ = 2.19, SD = 0.73\)), happiness (\(d’ = 2.15, SD = 0.76\)).
We trimmed the distributions due to the presence of four individuals (disbursed across conditions) whose emotion scores were highly deviant from the norms for their conditions (> 2 SD’s from the group mean and skewed to one tail). These individuals’ scores most likely reflected pre-existing highly intensified or flattened emotional states stemming from idiosyncratic factors. Their removal did not alter the general pattern of the findings.

The contrast was doubly-centered with weights of ± 3’s for angry participant error rates and opposite sign ± 1’s for the remaining cells. The contrast residual was not significant.

Mean sensitivity values for each of the emotion conditions in Study 2: neutral ($d' = 2.04, SD = 0.72$), anger ($d' = 2.07, SD = 0.73$), disgust ($d' = 2.13, SD = 0.59$), sadness ($d' = 2.02, SD = 0.70$).

It should be noted that in the original study by Payne et al. (2005), the initial stimulus exposure was much briefer than used here (100ms). Their study was designed to explore whether participants’ errors were actual perceptual errors (i.e. they believed they actually saw a gun following an African American face) or were the result of executive failure under time pressure. However, the present Background Experiment 3 is not attempting to make any such distinction regarding potential underlying mechanisms. In using a methodology similar to Payne et al.’s, we are simply exploring potential boundary conditions on the demonstrated bias—namely, can participants identify the errors they’ve made if given the chance to correct their responses. The longer presentation times also reflect the need to process images of greater complexity; Payne et al.’s stimuli consisted of single simple objects.

As in previous studies, trials on which the participants failed to respond within the 750ms window were removed from all analyses. Thus, the proportion of trials that a participant
predicted to contain guns was calculated as the total number of gun responses divided by the total number of valid trials.

For the critical block, participants in the even-split expectancy condition first responded to the 40 original stimuli as described in Studies 1 and 2 in a randomized order, and then they responded to 20 of the stimuli (selected to be 10 gun trials and 10 neutral object trials) a second time in a random order. Therefore, the critical block consisted of a total of 30 trials with guns and 30 trials with neutral objects for the even-split expectancy condition. Participants in the high-frequency gun condition first responded to 30 of the 40 original stimuli as described in Studies 1 and 2 (i.e. all 20 stimuli containing guns and 10 of the stimuli containing objects) in a random order, and then they responded to the same 30 stimuli a second time, again in a random order. Therefore, the critical block consisted of a total of 40 trials with guns and 20 trials with neutral objects for the high-frequency gun condition.

Mean sensitivity values for each of the four conditions in Experiment 6: neutral/even-split ($d' = 2.29$, $SD = 0.71$), anger/even-split ($d' = 2.38$, $SD = 0.63$), neutral/high-frequency gun ($d' = 2.38$, $SD = 0.75$) and anger/high-frequency gun ($d' = 2.23$, $SD = 0.70$).

If the variance of the signal distribution were larger than the variance of the noise distribution, then the value $1/2d'$ (as calculated based on the equal variance model – so the point halfway between the two distribution means) would fall to the right of the point where the signal and noise probability density functions cross as well as to the right of the point where the proportions of misses and false alarms are equal. If this were the case, it would mean that in previous studies neutral participants were likely exhibiting a bias toward claiming that stimuli in the threat detection task were neutral objects and that the bias among angry participants was at
least overestimated and may not have even existed. However, given the previous research on threat detection there is no clear reason to predict the variances to be unequal in this direction.

\[^{19}\text{For calculating an ROC, the covariation of hit rates and false alarm rates needs to be measured within-subjects, so the between-subjects design of Experiment 6 did not allow for estimates of ROCs.}\]

\[^{20}\text{For all participants the practice trials contained half gun targets and half neutral object targets. The instructions did not provide explicit information about the proportion of trials containing guns or neutral objects for these practice trials.}\]

\[^{21}\text{Two additional participants were removed from the analyses of the additional sensitivity parameter estimates (a and de) because the calculation of their parameter estimates yielded nonsensical values (e.g., values greater than 100 when the average was around 2). Because the calculations for a and de utilize each participant’s ROC slope value (b) multiple times, having a large value for b can drastically inflate the values calculated for these new sensitivity parameter estimates for a participant. These two participants were included in all other data analyses for this experiment.}\]

\[^{22}\text{The regulatory styles can be thought of as enduring individual differences as well as more fleeting situational states. Research has shown that people generally adopt one regulatory focus state and tend to think about their life and their goals predominately in accord with that regulatory focus. However, certain situations can induce a temporary prevention or promotion focus in a person who normally views his or her goals in terms of the other (Higgins, 1997). For example, a person who is generally promotion-focused might be failing a class and need to get at least a B on the final exam to pass. This minimal goal can serve to induce a prevention focus in this usually promotion-focused individual, causing him or her to concentrate on making sure}\]

119
nothing goes wrong with this one particular goal and thus act in a vigilant, prevention-focused manner.

23 Background Experiments 1-3 as well as Experiments 4 and 6 were previously published in a manuscript for the *Journal of Personality and Social Psychology* (Baumann & DeSteno, 2010). Chapters 1, 2, 3, 4 and 6 were taken in whole or in part from the manuscript.
Figure 1

*Error rate as a function of stimulus type and emotional state in Background Experiment 1. Error bars equal ± 1 standard error.*
Error rate as a function of stimulus type and emotional state in Background Experiment 2. Error bars equal ± 1 standard error.
Figure 3

Error rate as a function of stimulus type and attempt in Background Experiment 3. Error bars equal ± 1 standard error.
Figure 4

Predicted proportion of gun trials as a function of emotion condition in Experiments 4 and 5. Error bars equal ± 1 standard error.
Figure 5

Criterion value as a function of expectancy and emotional state in Experiment 6. Error bars equal ± 1 standard error.

Criterion value as a function of expectancy and emotional state in Experiment 6. Error bars equal ± 1 standard error.
Figure 6

Equal Variance Gaussian Model with the point $1/2d'$ (or half the distance between the means of the two distributions) marked with a purple line. A criterion less than $1/2d'$ ($c < 0$) is also shown in green. The area between these two points (Area A) designates the trials where the information acquired was more consistent with a noise trial than a signal trial (the probability density function for the noise trials is higher than the probability density function for the signal trials), and yet the participant still responded that a signal was present. Therefore, this criterion ($c < 0$) indicates a risky bias whereby the participant is willing to incur false alarms in order to ensure more hits.
Unequal variance Gaussian model where the variance of the noise distribution is greater than the variance of the signal distribution. The vertical green line marks the point $1/2d'$ (as it would be calculated from the equal variance model – so half the distance between the distribution means). As seen in the figure, when the signal variance is smaller than the noise variance the point halfway between the means of the two distributions falls to the left of where the signal and noise density functions cross as well as to the left of the point where the proportions of misses and false alarms are equal. If experienced anger is impacting the relative variance of the neutral object trials and the gun trials in our threat detection task, we would expect to find the distributions’ variances to be unequal in this direction.
Panel A depicts the equal variance Gaussian model with an unbiased criterion (c=0) marked. This is similar to criterion placement of neutral participants in previous studies. Panel B depicts the equal variance Gaussian model with a risky criterion (c<0) marked; this is the situation we have described for angry participants in previous studies whereby the signal and noise distributions remain the same for angry and neutral participants but angry participants shift the placement of their criterion to the left (Panels A and B). Panel C depicts the alternative explanation for the demonstrated bias among angry participants whereby criterion placement is identical for neutral and angry participants (Panels A and C), but the relative variance of the signal and noise distributions is skewed for angry participants (Panel C).
Figure 9

Comparison of different sensitivity parameter estimates by emotion condition from Experiment 7A. Error bars equal ± 1 standard error.
Figure 10

Comparison of different sensitivity parameter estimates by emotion condition from Experiment 7B. Error bars equal ±1 standard error.
Appendix A

Sample Stimuli from Shooter Bias Task
Appendix B

Sample Stimuli from Experiments 4 and 5
Appendix C

Likelihood Estimates Questionnaire

**Sad Events**

In a given year, how many of the 574,000 people in Boston will lose a loved one?

In a given year, how many of the 574,000 people in Boston will contract a serious illness?

In a given year, how many of the 574,000 people in Boston will have a serious relationship come to an end?

**Anger Events**

In a given year, how many of the 574,000 people in Boston will get stuck in traffic for more than one hour?

In a given year, how many of the 574,000 people in Boston will get into a physical altercation in a bar?

In a given year, how many of the 574,000 people in Boston will be cheated by a con man or lose money in a scam?

**Happy Events**

In a given year, how many of the 574,000 people in Boston will win a scratch off lottery ticket for more than 50?

In a given year, how many of the 574,000 people in Boston will receive an undeserved A on a paper or exam?

In a given year, how many of the 574,000 people in Boston will attend a Red Sox playoff game?

**Violence/Weapon Events**

In a given year, how many of the 574,000 people in Boston will witness a crime involving the use of a weapon?

In a given year, how many of the 574,000 people in Boston will carry a concealed weapon?

In a given year, how many of the 574,000 people in Boston will be robbed at gun point?
Appendix D

Experiment 7B Results with Additional Participants Included

*Emotion Manipulation Check*

Unexpectedly, the emotion manipulation was not successful. Participants who wrote about an angering event ($M = 2.24, SD = 1.26$) did not reported experiencing significantly more anger than did participants who wrote about their daily routine ($M = 2.34, SD = 1.09$), $t < 1$.

*Signal Detection Parameters*

Data were again analyzed using signal detection techniques. Measures of sensitivity ($d'$) as well as measures of criterion ($c$) were calculated for each participant for each set of base rates. Consistent with previous findings, participants’ sensitivity was significantly greater than zero in the neutral condition in both the high gun base rate critical block ($M = 2.06, SD = .75$) and the low gun base rate critical block ($M = 2.21, SD = .74$), $t > 7.72, ps < .001$. Similarly, participants’ sensitivity was significantly greater than zero in the angry condition in both the high gun base rate critical block ($M = 2.28, SD = .84$) and the low gun base rate critical block ($M = 2.31, SD = .81$), $t > 8.20, ps < .001$. Moreover, sensitivity did not significantly differ between neutral and angry participants in either the high gun base rate critical block or the low gun base rate critical block of the threat detection task, $t < 1.26$.

The pattern of criterion values was also consistent with that found in previous studies. The average criterion value was significantly greater than 0 for the low gun base rate critical block of the threat detection task for both neutral ($M = .31, SD = .25$) and angry ($M = .33, SD = .23$) participants, $t > 15.45, ps < .001$. Thus, all participants demonstrated a bias toward responding “object” in the critical block where there were more neutral objects than guns in the threat detection task. Similarly, the average criterion value was significantly less than 0 for the high
gun base rate critical block of the threat detection task for both neutral (M=−.28, SD=.25) and angry (M=−.29, SD=.23) participants, ts>28.59, ps<.001. Thus, all participants demonstrated a bias toward responding “gun” in the critical block where there were more guns than neutral objects in the threat detection task. Also consistent with previous findings (Experiment 6), criterion values did not significantly differ across emotion conditions in either critical block of the threat detection task, ts<1.

Receiver Operating Characteristic

As in Experiment 7A, the standardized value of the proportion of false alarms (z/fa)) was graphed against the standardized value of the proportion of hits (z/h)) for each participant. Participants’ performances on the two critical blocks of the threat detection task were treated separately to generate two points on a graph: (z(fa1), z(h1)) and (z(fa2), z(h2)). Connecting these two points generated a straight line, or Receiver Operating Characteristic (ROC), whose slope was calculated for each participant (slope = Δz(h)/Δz(fa)).

As expected, the average slope of the ROC lines did not significantly differ from 1 in the neutral condition (M=.94, SD=1.00) or in the anger condition (M=1.07, SD=1.05), ts<1. Put differently, the variance of the signal and noise distributions did not significantly differ from one another in either emotion condition. Moreover, the average slope of the ROC lines did not significantly differ between the neutral and the angry conditions, ts<1. Thus, the relative variance of the signal and noise distributions also did not significantly differ between emotion conditions.

Other Estimates of Signal Variance

The ROC line has the equation: z(h) = a + b*z(fa), where a represents the y-intercept and b represents the slope. When the equal variance model holds, a=d′ and b=1. We have already shown above that the slope b does not significantly differ from 1 for either of our emotion
conditions. Similarly, we can calculate the value of $a$ for each participant and ensure that it does not significantly differ on average from our measures of sensitivity, $d'$, for each participant. A series of paired samples t-tests revealed that $a$ did not significantly differ from $d'$ for neutral participants in the low gun base rate condition or in the high gun base rate condition, $t_{s}<1$. Similarly, $a$ did not significantly differ from $d'$ for angry participants in the low gun base rate condition or in the high gun base rate condition, $t_{s}<1$. See Figure D1.

We also calculated the measure $de$, which derives from the point $e$ where the ROC slope intersects the minor diagonal: $z(h) = -z(fa)$. As explained in the results section of Experiment 7A, $de$ ($de = 2a/(1+b)$) should be equivalent to $d'$ as long as the equal variance model holds. A series of paired samples t-tests revealed that $de$ did not significantly differ from $d'$ for neutral participants in the low gun base rate condition or in the high gun base rate condition, $t_{s}<1.28$. Similarly, $de$ did not significantly differ from $d'$ for angry participants in the low gun base rate condition or in the high gun base rate condition, $t_{s}<1.34$. See Figure D1.

![Figure D1. Comparison of Different Measures of Sensitivity by Emotion Condition in Experiment 7B (With no participants excluded for emotion manipulation check). Error bars represent ±1 standard error.](image-url)
Appendix E

Background Experiments 1 and 2 Using an Unequal Variance Model

I conducted some additional analyses on the data from first two background experiments to see how our interpretation of the data would change if the variance of the signal and noise distributions were not in actuality equal. Namely, I wanted to know how sensitive our interpretation was to changes in the relative variance of the distributions. To do so, I chose a range of signal variance values based on the observed ROC slopes in our final experiments. Because the second ROC study (Experiment 7B) produced less noisy and thus more reliable measures of the ROC slope than did Experiment 7A, I decided to utilize the upper and lower 95% confidence intervals (1.26 and .74, respectively) around the observed overall mean of the ROC slopes from Experiment 7B. By reanalyzing the data from Background Experiments 1 and 2 assuming that the ROC slope value was .74 and then assuming that the ROC slope value was 1.26, I will be able to make more confident claims about how shifts in the relative variance of the distribution (in a reasonably likely range) may affect our interpretation of the original signal detection results.

Because, as highlighted in Chapter 5, the value $c$ does not make sense as a measure of bias in signal detection models that do not have equal variance distributions, I decided to utilize the bias measure $log b$ because it would allow direct comparisons of bias across models with different relative variances. Like $c$, when $log b$ is equal to zero the participant is not exhibiting a response bias, when $log b$ is less than zero the participant is exhibiting a risky response bias (needing less information before being willing to say a gun is present), and when $log b$ is greater than zero the participant is exhibiting a conservative response bias (needing more information before being willing to say a gun is present). $Log b$ is a likelihood ratio, comparing the heights of
the signal and noise density functions at the criterion. Its value is given by the formula: \( \log b = \frac{1}{2}[z(f)^2 - \left(\frac{z(f) - u_s}{v_s}\right)^2] - \log v_s \), where \( v_s \) represents the variance of the signal distribution and \( u_s \) represents the mean of the signal distribution (cf. Wickens, 2002). The variance of the signal distribution can be calculated as 1 over the value of the ROC slope in Gaussian coordinates and \( u_s \) is equivalent to \( d' \) as calculated when assuming equal variance (\( d'=z(h) - z(f) \)).

I focus only on measures of response bias and not on measures of sensitivity in these new analyses because there is no way of calculating new sensitivity values for each participant. Using the original data from the background experiments, I do not have enough information from the individual participants to calculate other measures of sensitivity (e.g., \( de, da, a \)).

**Equal Variance Interpretation**

I first calculated \( \log b \) for each participant in Background Experiments 1 and 2 assuming that \( v_s = 1 \) for all participants, and using each participant’s idiosyncratic values for \( z(f) \) and \( d' \).

**Background Experiment 1.** As would be anticipated, a planned contrast revealed that participants in the angry condition (\( M=-.20, SD=.48 \)) had significantly lower values of \( \log b \) than participants in the neutral (\( M=.16, SD=.51 \)) and happy (\( M=.10, SD=.42 \)) conditions, \( t(64)=2.78, p<.05 \). Moreover, a series of one-sample t-tests comparing the value of \( \log b \) to zero revealed that angry participants had a significantly negative value (\( t(24)=2.06, p=.05 \)), while neutral and happy participants’ values of \( \log b \) did not significantly differ from zero, \( ts<1.46 \).

**Background Experiment 2.** A planned contrast comparing the average value of \( \log b \) among angry participants to the average values among neutral, sad, and disgusted participants was only marginally significant, \( t(150)=1.45, p=.15 \). Thus, angry participants had a marginally lower average value of \( \log b \) (\( M=-.21, SD=.54 \)) than participants in the neutral (\( M=-.12, SD=.54 \)), sad (\( M=-.06, SD=.50 \)), and disgust (\( M=-.05, SD=.45 \)) conditions. However, a series of one-
sample t-tests comparing the average values of $\log b$ to zero revealed that angry participants had a significantly negative value ($t(41)=2.53, p<.05$), while the average value of $\log b$ among neutral, sad, and disgusted participants’ did not significantly differ from zero, $t_{s}<1.38$.

**Discussion.** Not surprisingly, the transition from $c$ to $\log b$ as a measure of bias made little to no difference on our interpretation of the data from Background Experiments 1 and 2. Given only small differences in $d'$ across conditions, both measures should order conditions in the same way, making the choice between measures in the current investigation largely inconsequential as long as the signal and noise distributions do indeed have equal variance (Wickens, 2002). Thus, analysis with $\log b$ assuming equal variance revealed in both background experiments that angry participants exhibited a significantly risky bias while participants in all other emotion conditions did not exhibit a bias.

**Lower 95% Confidence Limit for ROC Slope**

Next, I calculated $\log b$ for each participant in Background Experiments 1 and 2 assuming that the ROC slope was equal to .74 (the lower limit of the 95% confidence interval surrounding the average ROC slope in Experiment 7B). As such, I assumed $\nu_s = 1/.74$ for all participants and used participants’ idiosyncratic values for $z(f)$ and $d'$ to calculate $\log b$ for each participant.

**Background Experiment 1.** A series of one-sample t-tests comparing the value of $\log b$ to zero revealed that neutral participants ($M=.23, SD=.42$) had a significant positive bias ($t(20)=2.49, p<.05$), while happy participants’ values of $\log b$ ($M=.08, SD=.39$) did not significantly differ from zero ($t<1$), and angry participants had a marginally negative bias ($t(24)=1.71, p=.10$). A planned contrast again revealed that participants in the angry condition
had significantly lower values of log b than participants in the neutral and happy conditions, \( t(64)=2.85, p<.05 \).

**Background Experiment 2.** A planned contrast comparing the average value of log b among angry participants to the average values among neutral, sad, and disgusted participants failed to reach significance, \( t(150)=1.15, p=.25 \). However, angry participants still had a lower (though not significantly so) average value of log b (\( M=-.17, SD=.46 \)) than participants in the neutral (\( M=-.11, SD=.44 \)), sad (\( M=-0.08, SD=.46 \)), and disgust (\( M=-.05, SD=.37 \)) conditions. However, a series of one-sample t-tests comparing the average values of log b to zero revealed that angry participants had a significantly negative bias (\( t(41)=2.41, p<.05 \)), while the average value of log b among neutral, sad, and disgusted participants’ did not significantly differ from zero, \( ts<1.63 \).

**Discussion.** Taken together, it appears that assuming that the lower 95% confidence limit for the ROC slope was the true ROC slope made little impact on the interpretation of results from the original background experiments. The general pattern with angry participants exhibiting a significantly risky bias compared to participants in all other emotion conditions remained intact in both experiments. However, it is important to note that the planned contrast testing this relationship failed to reach significance in Background Experiment 2. This non-significant finding should not be over-interpreted though, as the pattern of results comparing the average bias in each of the emotion conditions to zero in Background Experiment 2 was directly in line with our original interpretation.

**Upper 95% Confidence Limit for ROC Slope**

Finally, I calculated log b for each participant in Background Experiments 1 and 2 assuming that the ROC slope was equal to 1.26 (the upper limit of the 95% confidence interval
surrounding the average ROC slope in Experiment 7B). As such, I assumed $v_s = 1/1.26$ for all participants and used participants’ idiosyncratic values for $z(f)$ and $d’$ to calculate $\log b$ for each participant.

**Background Experiment 1.** As would be anticipated, a planned contrast revealed that participants in the angry condition ($M=-.43, SD=.64$) had significantly lower values of $\log b$ than participants in the neutral ($M=-.09, SD=.67$) and happy ($M=-.02, SD=.57$) conditions, $t(64)=2.38$, $p<.05$. Moreover, a series of one-sample t-tests comparing the value of $\log b$ to zero revealed that angry participants had a significantly negative bias ($t(24)=3.375, p<.05$), while neutral and happy participants’ values of $\log b$ did not significantly differ from zero, $ts<1$.

**Background Experiment 2.** A planned contrast comparing the average value of $\log b$ among angry participants to the average values among neutral, sad, and disgusted participants was only marginally significant, $t(150)=1.56$, $p=.12$. Thus, angry participants had a marginally lower average value of $\log b$ ($M=-.42, SD=.70$) than participants in the neutral ($M=-.28, SD=.75$), sad ($M=-.20, SD=.62$), and disgust ($M=-.20, SD=.62$) conditions. A series of one-sample t-tests comparing the average values of $\log b$ to zero revealed that the average value in all conditions was significantly or marginally significantly negative, $ts>1.82, ps<.07$.

**Discussion.** Taken together, it appears that assuming that the upper 95% confidence limit for the ROC slope was the true ROC slope also made little impact on the interpretation of results from the original background experiments. The general pattern with angry participants exhibiting a significantly risky bias compared to participants in all other emotion conditions remained intact in both experiments. A notable inconsistency with our original interpretation of results, however, is that in Background Experiment 2 all of the emotion conditions exhibited a significantly risky
bias. Nevertheless, angry participants were still marginally more biased compared to participants in the other emotion conditions in the experiment (neutral, sad, disgust).

Conclusions

Results from these additional analyses reveal that our original interpretation of the signal detection parameters in Background Experiments 1 and 2 are relatively stable across a wide range of possible signal variances. By focusing our analyses on the upper and lower 95% confidence limits of the ROC slopes calculated in Experiment 7B, we can be confident that we captured signal variance values at the extremes of what our data would suggest. Even at these extremes it appears that angry participants exhibit a significantly risky bias on the threat detection task, and one that is more risky in comparison to participants in other emotion conditions.