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The Effects of Emotional States and Traits on Risky Decision-Making

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The Effects of Emotional States and Traits on Risky Decision-Making

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Abstract

Understanding the role of emotional states is critical for predicting the kind of decisions people will make in risky situations. Currently, there is little understanding as to how emotion influences decision-making in situations such as terrorist attacks, natural disasters, pandemics, and combat. To help address this, we used behavioral and neuroimaging methods to examine how emotion states and traits influence decisions. Specifically, this study used a wheel of fortune behavioral task and functional magnetic resonance imaging (fMRI) to examine the effects of emotional states and traits on decision-making pertaining to the degree of risk people are willing to make in specific situations. The behavioral results are reported here. The neural data requires additional time to analyze and will be reported at a future date. Biases caused by emotion states and traits were found regarding the likelihood of making risky decisions. The behavioral results will help provide a solid empirical foundation for modeling the effects of emotion on decision in risky situations.

Acknowledgments

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Nomenclature

DoD	Department of Defense
DOE	Department of Energy
fMRI	functional Magnetic Resonance Imaging
HSB	Human Subjects Board
IRB	Institutional Review Board
MIND	Mental Illness and Neuroscience Discovery
SNL	Sandia National Laboratories
UNM	The University of New Mexico

1. Introduction

Over the past 40 years, the cognitive revolution in psychology has had a profound impact in increasing our understanding of human decision making. However, until recently the impact of emotion on decision making has been mostly neglected. That is, only in the past 10-15 years, psychologists and neuroscientists have developed methods that have greatly enhanced our ability to study human emotion (Davidson, 2000; Pankseep, 1998). Part of this work has begun to examine the powerful effects that emotion can have on how humans make decisions (Damasio, 1999; Lerner & Keltner, 2001).

Emotions have evolved as action tendencies that enable humans to build resources for adaptation and survival, as well as permitting quick and effective reactions to prototypic situations (Fredrickson, 1998; LeDoux, 1998). These prototypic situations often involve threat and danger where decisions can have life or death consequences. Understanding how humans react in dangerous situations such as terrorist attacks, natural disasters, pandemics, and combat should provide the information needed to help model behaviors that will ultimately predict the effects of emotion on decision making. This is especially important for soldiers and first responders during high threat/danger situations.

Emotions have generally been categorized into positive emotions such as joy, interest, love, and enthusiasm and negative emotions such as anger, fear, anxiety, and sadness. Positive emotions appear to signal that things are going well for the organism and enable it to broaden and build its resources for facing challenges and threats (Fredrickson, 1998). Although positive emotions are reported much more frequently than negative emotions, little is known as to how they impact the willingness to take risks in potentially threatening or dangerous situations.

Negative emotions appear to enable the organism to mobilize the physiological resources to react quickly in situations that involve immediate threat or danger. There is some initial evidence to suggest that emotions such as fear, anxiety, and sadness may reduce the likelihood of making risky decisions and that anger may increase the likelihood of making risky decisions (Lerner & Keltner, 2001). Negative emotions such as fear, anxiety, and sadness are associated with threat of a loss (fear and anxiety) or a loss that has occurred (sadness).

Fear and anxiety are thought to differ in that fear has a specific object (snakes, spiders) whereas anxiety is often more general in nature. Thus, it is possible that they may reduce the likelihood of taking further risks that may result in losses. Anger is also associated with threats such as fear and anxiety but also with the preparation to fight to reduce or eliminate the threat. Anger, fear, and anxiety may be particularly critical to understand the response to dangerous situations that are strongly involved in the "fight-or-flight" stress response (Cannon, 1932). Thus, they may have particularly important implications for decision making when people are under stress.

Finally, there are two important levels at which the influence of emotion on decision making may be important to understand. The first is the general or trait level of emotion (i.e., personality) that a particular human organism experiences. There are important individual differences in how much, on average, people experience various positive and negative emotions. In fact, the two personality characteristics that have been identified

across almost all models of personality, and arguably account for the most variance, are neuroticism and extraversion (Costa & McCrae, 1992).

Most important, a central component of extraversion is the tendency to experience more positive emotion, whereas the central component of neuroticism is the tendency to experience more negative emotion. Thus, the major organizing principle for how people are different may have to do with their experience of positive and negative emotions. The implication is that any attempt to model the role of emotion or personality in human decision making will need to take into account the effects of neuroticism (trait negative affect) and extraversion (trait positive affect).

The other important way that emotion can influence decision making is in the state variation in emotion that exists in individuals across time. For example, the effects of a negative emotion such as anger on whether a soldier takes a risk in battle will be determined by the combination of that soldier's general tendency towards anger (trait anger) and the anger that is generated by the specific context of battle (state anger). Thus, modeling the effects of emotion on decision making requires that the effects of trait emotion (personality) and state emotion (context) affect the outcome of the decision.

2. The Current Study

The purpose of the study was to examine the effects of primary trait and state emotions on whether or not a person makes a risky decision. The participants were healthy men and women (13 men and 13 women; mean age = 28 years, standard deviation = 10 years). The task that was selected for examining decision making is one that has been successfully used to examine the likelihood of making risky versus safe decisions (Ernst & Paulus, 2005) in both behavioral and neuroimaging studies. We first trained the participants on how to carry out the task and then had them perform the task while they were lying in an MRI scanner. We recorded the choices that they made, their reaction times, and the neural response when they were making their choices. The choices and reaction times are reported here and their neural response will be reported in a future paper. Emotion was assessed by having the participants complete a questionnaire that assessed trait emotion, positive and negative emotions related to the participants' personality, as well as participants' positive or negative emotions related to the context of the situation. The study described below received full UNM IRB and SNL HSB approval before it began.

2.1 Decision Making Task

The decision making task that was used is called the wheel of fortune (WOF) task. Each time the subject sees a WOF, they are asked to press a button for the purpose of selecting either the left or the right side of the wheel.

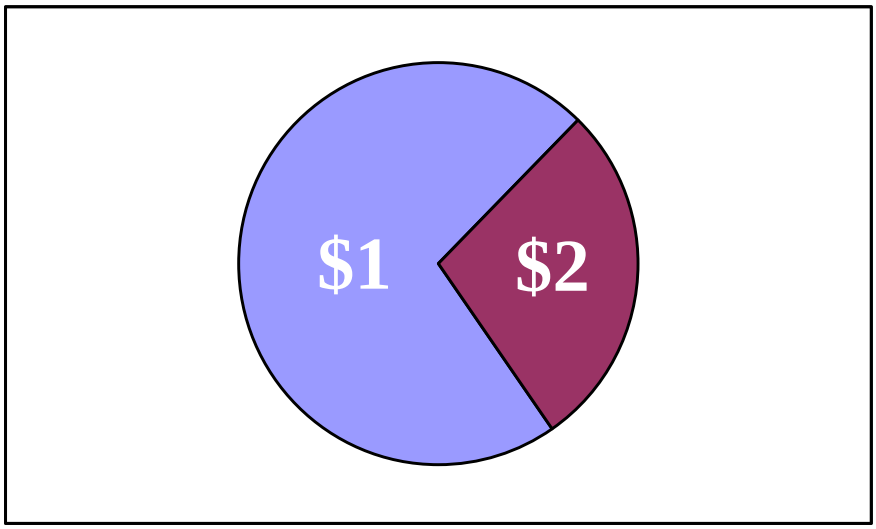


Figure 1. In the "wheel or fortune" task, participants select either the left side or the right side of the wheel. If they select the side with the greater amount of one color (here the left side), they would have a greater chance of winning the amount of money listed on that portion (here $1.00). If they select the side with the smaller amount of one color (here the right side), they would have a lesser chance of winning the amount of money listed on that portion (here $2.00).

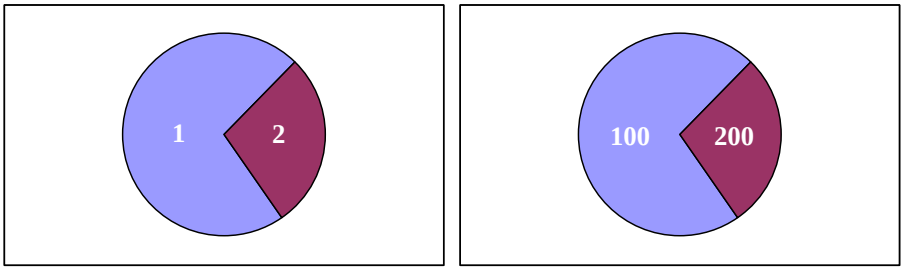
There are two things to consider when they make this choice. The first is the value of the number on each side of the wheel and the second is the size of the colored area on each side of the wheel. The number represents how much money they can win if they select that side of the wheel. The size of the colored area represents the chance they have of winning that much money. Each wheel is set up so that there was a safe choice (larger than 50% chance of winning the smaller amount of money) or a risky choice (smaller than 50% of winning the larger amount of money).

The types of wheels presented varied in two primary ways, which can be seen in Figure 2. First, they varied in the amount or magnitude of winnings that were available. There were wheels with either a high or a low magnitude of reward (50% were high and 50% were low magnitude). For the low magnitude wheels, there was the number '1' on the large portion of the wheel and the number '2' on the small portion of the wheel. For the high magnitude wheels, there was the number '100' on the large portion of the wheel and the number '200' on the small portion of the wheel. The number represented how much the subjects would win in cents if they picked the side of the wheel that the computer "picked" as well. The magnitude of winnings was varied so that we could determine whether how much was at stake actually influenced the effects of emotion on whether or not the person made the risky decision.

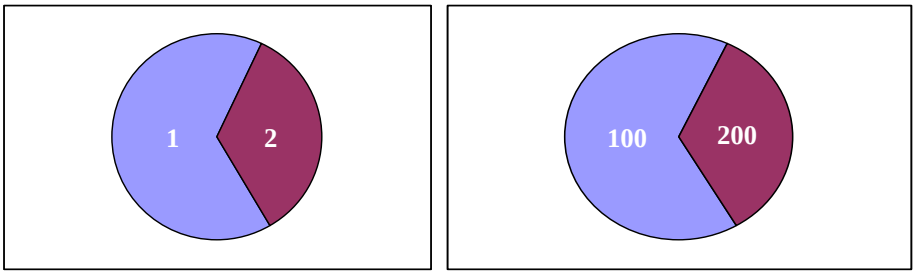
Second, the portions representing the chances of winning if participants made the safe or the risky choice were varied. These portions were varied so that there were three variations that were presented an equal number of times. There were "risky biased" wheels where the odds were in favor of their making a risky choice (155 degrees for the risky choice and 205 degrees for the safe choice). There were "safe biased" wheels where the odds were in favor of making a safe choice (105 degrees for the risky choice and 255 degrees for the safe choice). Last, there were "balanced" wheels where there was no perceived advantage to making a risky versus a safe choice (130 degrees for the risky choice and 230 degrees for the safe choice). The "balanced" wheels were 130 and 230 degrees rather than 120 and 240 degrees (which would mathematically balance the expected values of making each choice) because pilot testing determined that people have a "safe choice" bias.

The purpose of the "risky biased" wheels was to determine whether certain negative emotions (i.e., anxiety and fear) would prevent people from making the best choice even if it was risky. The purpose of the "safe biased" wheels was to determine whether certain emotions (e.g., anger) would prevent people from making the best choice even if it was safe. The purpose of the "balanced" wheels was to determine what choice an emotion influenced people to make if there was no obvious advantage to making either choice.

Wheels Biased to Safe Selection (260/100 - 16 trials each for 32 total)



"Balanced" Wheels (230/130 - 16 trials each for 32 total)



Wheels Biased to Risky Selection (205-155 - 16 trials each for 32 total)

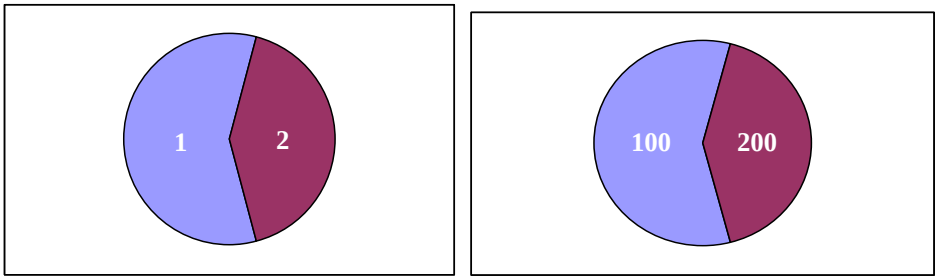


Figure 2. Different portions and magnitudes used for the wheel of fortune task

Each of the six types of wheel (2 magnitudes x 3 portions) were presented 16 times, half with the risky choice on the left and half with the risky choice on the right. These trials were divided up into four blocks in which subjects made selections for 24 wheels each (total of 96 wheels/choices). Subjects were given a break between each block and were told the total they had earned. Figure 3 shows the timing for each trial. First, the WOF was presented for 4 seconds, during which the subject had to make a choice. Second, there was a 2, 4, or 6 second interval that is necessary for analyzing the neuroimaging data. Third, there was a 2 second feedback screen that told the subject whether they won anything (e.g., either "you won 100 cents" or "you won 0 cents"). Fourth, there was another 2, 4, or 6 second interval before the beginning of the next trial.

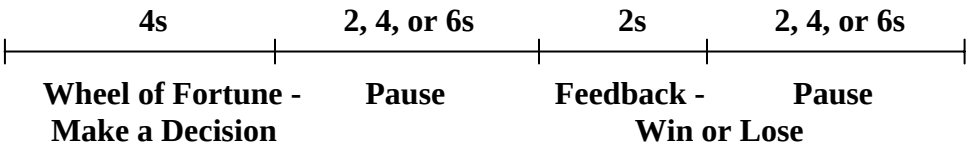


Figure 3. Wheel of fortune trials

2.2 Measures of Emotion

Our measures of state emotion included the positive and negative affect schedule (Watson, Clark, & Tellegen, 1988). We used the positive affect scale as the measure of state positive emotion and the negative affect scale as the measure of state negative emotion. We used two items from the negative affect scale as an indicators of state anger (i.e., hostile, irritated) and two items from the negative affect scale as indicators of state fear (i.e., scared, afraid).

Our measures of trait emotion included the positive emotion, negative emotion, anger, and anxiety/fear subscales of the NEO-PI-R personality inventory (Costa & McCrae, 1992). We used the anger, anxiety/fear, and depression scales of the neuroticism scale as a measure of trait negative emotion.

3. Findings

3.1 Selection of Risky Vs. Safe Choices

Table 1 shows the percentage of times that the subjects selected the safe versus risky selection and the mean reaction times for each choice. There was no significant difference in how long people took to make risky versus safe decisions. There was no significant difference in how long people took to make decisions when presented with the high versus the low magnitude wheels. Finally, the balanced wheel selections took longer than the risky biased and safe biased wheel selections ($t(1661) = -3.693$, $p < .001$ and $t(1662) = -3.739$, $p < .001$, respectively). There was no significant difference between the time it took to make choices on the risky biases versus the safe biased wheels. The extra time taken for the balanced wheels selections is consistent with the idea that more difficult tasks take more thought. Finally, men appeared to take less time making decisions and make more risky selections although the number of participants was too small to detect significant differences. However, if the number of trials (n = 2496) rather than the number of participants (n = 26) was considered the sample size, then the differences between men and women were significant.

3.2 Association of Emotional States and Traits with Risky Decisions

Table 2 shows the correlation between the measures of state and trait emotion and risky decisions when participants were faced with the balanced wheels (32 trials per subject) and all wheels including balanced, risky biased, and safe biased wheels (96 trials per subject). With regard to state emotions, positive emotion was related to less risky selections and negative emotion, anger, and fear were related to more risky choices on the balanced wheels. When all wheels were considered together, positive emotion was related to less risky selections and anger was marginally related to more risky selections. With regard to trait emotions, negative emotion, anger, and fear were related to more risky choices on the balanced wheels and all wheels combined while positive emotion was related to neither.

Table 1. Descriptive statistics for selections and reaction times

	Risky Choice		Safe Choice	
	%	RT	%	RT
All	51.2	1536	49.8	1462
Gender				
Men	55.2	1387	44.8	1398
Women	47.3	1684	52.7	1526
Magnitude				
High Magnitude	53.3	1529	46.7	1511
Low Magnitude	49.1	1543	50.9	1414
Portion				
Risky Wheel	85.7	1390	14.3	1519
Safe Wheel	15.6	1597	84.4	1372
Balanced Wheel	52.3	1582	47.7	1515

Note. RT = reaction time in milliseconds.

Table 2. Correlations between emotional states and traits and risky decisions.

	Balanced Wheels	All Wheels
State Emotion Measures		
Positive Emotion	-.427*	-.463*
Negative Emotion	.458*	.319
Anger	.390*	.374+
Fear	.435*	.279
Trait Emotion Measures		
Positive Emotion	-.242	-.244
Negative Emotion	.594**	.469*
Anger	.579**	.521**
Fear	.473*	.391*

Note. **p < .01, *p < .05, +p < .10.

3.3 Relative Importance of Emotional States and Traits with Risky Decisions

Table 3 shows the results of multiple regression analyses depicting the related value of the anger, fear, and positive emotional states and traits in predicting risky decisions. Negative emotion was not included because the anger and fear measures are included in the negative emotion measures and we wanted to examine the differential effect of anger and fear. Although the small sample size reduced many of the effects to non-significance, there was a trend for state fear to predict more risky decisions on the balanced wheels and state positive emotion to predict less risky decisions on all wheels. In addition, trait anger was related to more risky decisions on the balanced wheels and there was a trend towards trait anger predicting more risky decisions on all wheels.

Table 3. Regression Beta Weights for Emotional States and Traits Predicting Risky Decisions.

	Balanced Wheels	All Wheels
State Emotion Measures		
Positive Emotion	-.296	-.361+
Anger	.149	.138
Fear	.355+	.192
Full State Model		
R^2	.339	.272
F	3.76*	2.73+
Trait Emotion Measures		
Positive Emotion	-.011	-.033
Anger	.455*	.413+
Fear	.284	.220
Full Trait Model		
R^2	.400	.309
F	3.76*	3.28*

Note. $^{**}p < .01$, $^{*}p < .05$, $^{+}p < .10$.

More important, when the overall modeling including all three types of emotion were considered together, the state emotions accounted for 33.9% of the variance in balanced wheel selections and 27.2% of the variance in all wheel selections. Finally, the trait emotions accounted for 40.0% of the variances in the balanced wheel selections and 30.9% of the variance when all wheels were considered together. Thus, emotion appears to have a stronger effect when only the balanced wheels were considered, implying that emotion may be important if cost-benefit ratios are balanced and nearly equal.

Finally, to determine the relative effects of state and trait emotions, we conducted hierarchical multiple regressions predicting risky decision on the balanced wheels and all wheels considered together. We entered the trait emotions on the first step and the state emotions on the second step based on the idea that stable individual differences are prior to and influence state emotions. When predicting selections for the balanced wheels, we found that trait emotions accounted for 40.0% of the variances and state emotions added an additional 5.9%. When predicting selections for all wheels, we found that trait emotions accounted for 30.9% of the variance and that state emotions accounted for an additional 6.5%. Thus, when added together, trait and state emotions accounted for 45.9% of the variance in making risky decisions for the balanced wheels and 37.4% of the variance when wheels were added together.

4. Implications for Model Development and Applications

4.1 Building a Model of the Effects of Emotional States and Traits with Risky Decisions

Figure 4 presents a model of the effects of emotion states and traits that is consistent with and supported by this study. First, despite earlier findings that anger may increase risk taking while fear may decrease risk taking, we found that both trait and state anger and fear appear to be related to increased risk taking. Thus, it may make the most sense to consider negative emotion as a whole – including both fear and anger because of their similar effects. Second, trait positive and negative emotion is related to increased vulnerability to experience positive and negative emotions, respectively, in specific situations and contexts. Indeed, our data strongly supports this in that trait positive emotion is strongly related to state positive emotion ($r = .475$, $p < .05$) and trait negative emotion is even more strongly related to state negative emotion ($r = .645$, $p < .01$). Next, while trait emotion may have indirect effects on risky decision making through state emotion, it also may have direct effects as suggested by our finding that trait anger was strongly related to risky decision making while state anger was not. Most important, the valence of the relationships in the model is indicated by plus and minus signs. Generally, positive emotion is negatively correlated with negative emotion, although much less so with state emotions. Evidence suggests that people can experience varying degrees of positive and negative emotion at the same time in many circumstances (Zautra, 2003). Finally, negative emotion in both trait and state form appears to increase the likelihood of making a risky decision (all things being equal) while positive emotion appears to decrease the likelihood of making a risky decision.

Why might this be so? The association between negative emotions and the greater likelihood of making a risky decision is consistent with the idea that negative emotions may signal a problem or deficit for the organism and a change may need to be made (LeDoux, 1996). The threat of harm or loss that occurs with the emotions of anger and fear may influence cognitive processes in the direction of taking risks to avoid or escape the danger and/or reestablish a homeostatic state. The association between positive emotions and the reduced likelihood and making a safe decision is consistent with the idea that positive emotions help to preserve and conserve when the organism is doing well or is in a homeostatic state (Fredrickson, 1998).

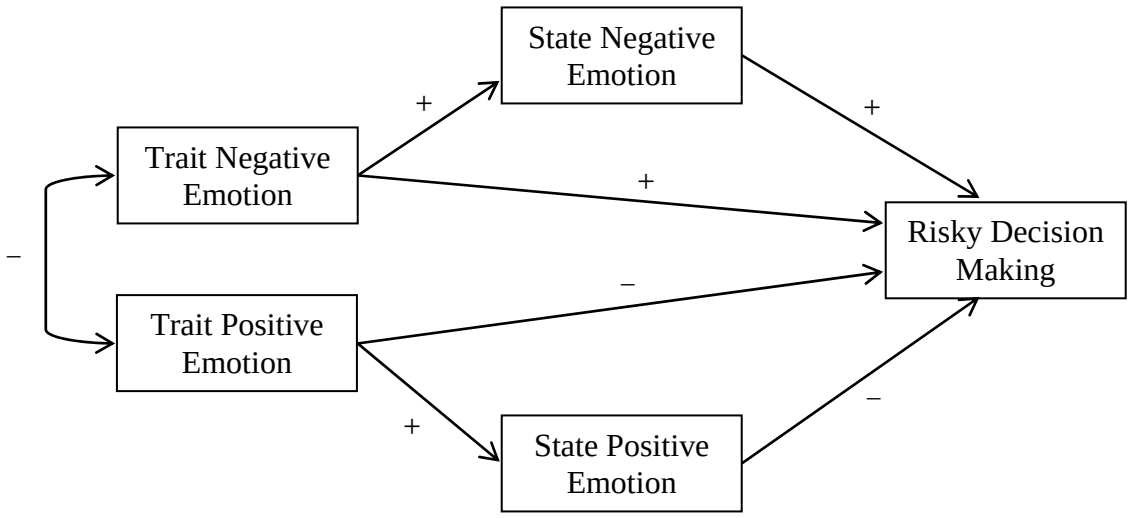


Figure 4. Overall model of the effects of emotional traits and states on risky decision-making.

4.2 Applications of the Model for Making Decisions in Times of Stress

The model of the differential effects of positive and negative emotional traits and states on decision carries potentially important implications for making decisions in times of stress. The hierarchical regression showed that emotional states and traits accounted for 37% of the variance in whether subjects made a risky decision in all situations and 46% of the variance in whether they made risky decision in the most difficult situations that closely balanced cost and benefit. Thus, emotion may play a critical role in what people do in times of stress, when negative emotions that increase risk may be strong and positive emotions that decrease risk may be weak.

The implication is that the presentation of negative emotions involved in the stress response (anger/fight and fear/flight) and the absence of positive emotions may create an unwelcome bias towards risky decisions. This is not to say that risky decisions are not sometimes necessary. The critical point is that we found this bias when there was a nearly equal likelihood and value in making a risky versus safe choice. While it could be argued that our "balanced" wheel was biased towards a riskier choice because the proportions were 130/230 instead of 120/240, it was clear that people "perceive" both options as being equally rewarding. The presence of negative emotion and the absence of positive emotion appear to increase the likelihood of making the risky choice—which may be beneficial, but could also be dangerous.

It appears that the emotions associated with the stress response (anger and fear) bias one towards taking risks in situations where decisions are difficult and the cost and benefits appear to be balanced. The implications of this for first responders and soldiers, for example, are potentially very significant. Individuals who are higher in trait negative affect and lower in trait positive affect may be more likely to take risks (whether or not

they are called for) and may need to be made aware of this potential bias and receive training to compensate for it. It may be that the emotional habituation that can reduce the stress response through training may reduce this bias, but it is impossible to really know unless we begin to measure changes in these biases across time in trainees, seasoned soldiers, and first responders.

The implications regarding state emotion may be important for training and service, regardless of one's emotional traits or personality. In short, the very emotions of anger and fear involved in the stress response may bias one to take a risk. This willingness to take a risk may be adaptive and necessary for survival in many cases. However, there may be times when it is better to hold back rather than to fire or to wait first before one rushes to cross a minefield to save an injured soldier. One key training technique may involve increasing awareness of these emotions so that the awareness of these emotions can be considered as another factor in making a difficult decision. There are an increasing number of techniques that are and can be taught to increase mindful awareness of one's emotions and possibly even their effects on desire making processes (Kabat-Zinn, 1992; Salovey, Rothman, Detweiler, & Steward, 2000).

Another key training technique may be to learn to utilize the physiological resources that emotions may be available when thought or quick action is required (Gross, 2002). Negative emotions, in particular, have evolved to increase the chances of survival in threatening situations. Having a greater understanding of how emotions predispose one to action will enable soldiers and first responders to improve their decision making performance and optimize their responses to risky situations. To know that anger may make risk taking more likely does not mean that a risk is not called for. It may be that those who are higher in trait anger or trait fear may be better suited to special operations or other duties in which high risk behavior may be frequently required and necessary for completing successful missions. At the same time, knowing how these emotions may influence decisions could also help these risk takers to optimize their decisions on how and when to react.

5. Conclusions and Future Directions

The psychological and modeling literature has only began to examine the effects of emotions on decision making in dangerous situations, such as combat, terrorist attacks, natural disasters, and epidemics. This project was an initial step in quantifying the influence of emotional states and traits on whether or not a risk is taken in these types of situations. The evidence from this study suggests that emotions may indeed have a strong effect on making risky decisions.

Yet there are many steps that still need to be taken in order to develop and confirm a full model of the effects of emotion on decision making. While this study used a well-validated experimental paradigm on a balanced sample of healthy men and women, the obvious next steps are to study judgments that are more closely related to the decisions made in these critical situations by the people who are most likely to make them. Consequently, our objective for the near future involves identifying the kinds of decisions that are made by first responders during disaster events, as well as soldiers during combat situations. By studying individuals in these types of roles, a model could be specified that describes how emotional traits and states ultimately impact their decisions.

The evolution of a model that can most precisely predict behavior in these situations will require closer and closer approximations to actual human functioning as well as the contexts in which individuals must make life or death decisions. Both a structured debriefing of those who have actually had to make such decisions and computer modeling could be a critical link in increasing external validity to a behaviorally accurate model. While it may never be possible to be certain that one is making the perfect decision, a realistic goal and fruit of such a model could be to reduce loss of life and human suffering, while increasing human effectiveness in dangerous environments.

An additional outcome of this research could be the better understanding of group decision making processes within governments, gangs, and terrorist groups. Anger and fear are a central part what is often experienced in the context of critical events such as terrorist attacks and traditional warfare. Understanding how these emotional responses affect governments as well as terrorist groups may provide a better focus for understanding, predicting, and explaining their behaviors.

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2	MS0899	Technical Library	4536
1	MS0123	D. Chavez, LDRD Office	1011