AFRL-RH-WP-TR-2010-0114

Facial Expressions of Emotion and the Assessment of Performance

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July 2010
Interim Report

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NOTICE AND SIGNATURE PAGE

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
15-07-2010

2. REPORT TYPE
Interim

3. DATES COVERED *(From - To)*
January 2009 – May 2010

4. TITLE AND SUBTITLE
Facial Expressions of Emotion and the Assessment of Performance

5a. CONTRACT NUMBER
In-House

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
62202F

6. AUTHOR(S)
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5d. PROJECT NUMBER
7184

5e. TASK NUMBER
0223

5f. WORK UNIT NUMBER
71840223

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

**Henry Jackson Foundation
***InfoScitex

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
*Air Force Materiel Command
Air Force Research Laboratory
711th Human Performance Wing
Human Effectiveness Directorate
Biosciences and Performance Division
Vulnerability Analysis Branch
Wright-Patterson AFB OH 45433-7947

10. SPONSOR/MONITOR'S ACRONYM(S)
711 HPW/RHPA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
AFRL-RH-WP-TR-2010-0114

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release, distribution is unlimited.

13. SUPPLEMENTARY NOTES
88ABW cleared on 21 Sep 2010; 88ABW-2010-5132

14. ABSTRACT
The following report describes an exploratory study that investigated the ability of facial contractions to provide information regarding one's decision making capabilities under two emotional stressors. The study was a 2 (male, female) X 2 (fear, anger) design. The study utilized a comprehensive assessment method that included a baseline and post emotion elicitation testing period. Testing periods included a saliva sample (cortisol concentration), systolic and diastolic blood pressure, beats per minutes, subjective emotion, and a gambling task measuring decision making and risk-taking. The emotion elicitation methods utilized a movie clip that was pre-selected from an initial study that resulted in producing the greatest changes in subjective fear and anger related emotions. During the movie clip, electromyography (EMG) data were collected on 6 different facial muscles. The results of this study showed that temporal increases in facial contractions following anger elicitation were related to more conservative risk-taking behavior for males. The results also showed that a particular facial location (AU 9; nose cringe) was informative for more conservative risk-taking behavior following fear elicitation for females, but in combination with cardiac and endocrine increases. It is concluded from this study that efforts to replicate these findings are recommended along with extending the data collection period to also investigate individual differences in emotion regulation.

15. SUBJECT TERMS
Emotion, Facial Expressions, Risk-taking, Gender Differences

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Regina Schmidt
U	U	U	SAR	35	19b. TELEPHONE NUMBER *(include area code)* NA

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

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SUMMARY

The following report describes an exploratory study that investigated the ability of facial contractions to provide information regarding one's decision making capabilities under two emotional stressors. The study was a 2 (male, female) X 2 (fear, anger) design. The study utilized a comprehensive assessment method that included a baseline and post emotion elicitation testing period. Testing periods included a saliva sample (cortisol concentration), systolic and diastolic blood pressure, beats per minutes, subjective emotion, and a gambling task measuring decision making and risk-taking. The emotion elicitation methods utilized a movie clip that was pre-selected from an initial study that resulted in producing the greatest changes in subjective fear and anger related emotions. During the movie clip, electromyography (EMG) data was collected on 6 different facial muscles. The results of this study showed that temporal increases in facial contractions following anger elicitation were related to more conservative risk-taking behavior for males. The results also showed that a particular facial location (AU 9; nose cringe) was informative for more conservative risk-taking behavior following fear elicitation for females, but in combination with cardiac and endocrine increases. It is concluded from this study that efforts to replicate these findings are recommended along with extending the data collection period to also investigate individual differences in emotion regulation. Also recommended is the use of functional Magnetic Resonance Imaging (fMRI) to further clarify the processes of cognitive down-regulation and automatic emotion regulation.

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1.0 INTRODUCTION

The United Stated Air Force Special Operations Command (AFSOC), along with many other groups in the United States Air Force, is an elite group of versatile individuals who face critical operations on a regular basis. Operators often have to make time-sensitive decisions under conditions of extreme emotional stress, and they have only their instinct and expertise to rely upon. "The job of AFSOC operators is to quickly turn a patch of hostile terrain into a fully-functional airfield. Sometimes this means a stealthy attack by motorcycle and ATV. Other times it means cleaning out hostile forces by scouting locations for the delivery of 15,000-pound BLU-82 Daisy Cutter bombs" (Gourley, 2002). Until recently, emotional stress has been viewed as an inhibitory mechanism leading to distraction and poor performance. However, emotive components have been found to facilitate prefrontal cortical activity. In a recent fMRI study, Gray, Braver, & Raichle (2002) found that emotion modulated task-related neural activity within the lateral prefrontal cortex, which is a region of the brain that is critical for cognitive control. In addition, an adaptive stress response has been identified that utilizes the sympathetic-adrenomedullary (SAM) axis and is associated with energy mobilization, low subjective stress, and enhanced task performance (Tomaka, & Palacios-Esquivel, 1997). Thus, emotional stress is not just manifested in maladapive human behavior but in adaptive forms as well.

The emotional modulation of cognitive control has recently gained attention in the area of human performance enhancement. Specifically, the differentiating physiological reactivity of anger and fear was identified (Ax, 1953) and validated in the human response to task performance (Lerner, Dahl, Hariri, & Taylor, 2007). Anger and fear, in response to tasks and events, have been explained as the fight and flight autonomic nervous system responses. These responses have also been called task-aviodance/task-approach (Schneider 2004; Schneider, 2008), and challenge appraisals/threat appraisals (Schneider 2004; Schneider, 2008). Regardless of terminology, these researchers have found that emotional reactions are correlated with physiological responses and those physiolgical changes influence cogntive abilities.

A leap further has led researchers to examine whether facial expressions can be relied upon as an indication of an individual's emotions, and therefore, serve as a window into the physiological changes that would occur as a result of emotional stimuli. If probable physiological changes can be deduced from facial expressions, then performance could also be predicted by facial expressions. Facial expressions of emotion, in response to an event, have been found to differentiate across individuals with dependence on one's appraisal of a stressful task (whether the person responds with fear or anger). Lerner, Dahl, Hariri, and Taylor (2007) found that fearful facial expressions increased neuroendocrine and cardiovascular activity, whereas angry facial expressions decreased neuroendocrine and cardiovascular activity. Those who respond with fear, also typically exhibit avoidance toward the associated task and report a sense of lack of control over their resources. Those who respond with anger often take an optimistic approach toward the task and report a sense of control over their resources (Lerner & Keltner, 2001). Generally, individuals who perceive a task as challenging perform significantly better on cognitive tasks than those who perceive the task as a threat (Schneider, 2008; Tomaka, Blascovich, Kelsey, & Leitten, 1993). Thus, it is not surprising that individuals who respond to events with fear often do not perform as well on subsequent tasks as those who respond with anger. Further, this performance differentiation has also been generalized to training performance where differences in performance, based on the subjects' emotional reactivity, remained stable throughout the training exercise (Gildea, Schneider, & Shebilske, 2006).

Previous studies, like Lerner and Keltner (2001) and Lerner, Dahl, Hariri, and Taylor (2007) that have found associations between facial expressions and the biological response to emotions, have utilized a subjective evaluation of facial expressions via human observers. One of the aims of this study was to replicate those findings with a more robust, objective measure. Therefore, Electromyography was employed, because it is regarded as a "gold standard" technique for reliably assessing facial muscle deformations. In addition, it has been found that females report greater changes in affect following emotional stimili (though subjective reports of emotion did not differ between genders). Thus it is important to control for gender differences when assessing the effects of emotion on cognition (Kring & Gordon, 1998).

The association between an individual's biological response to an event and its effect on that person's performance has been largely studied by Schneider (2008) and Tomaka, Blasovich, Kelsey & Leitten (1993). However, emotional facial expressions have not been reliably studied in the context of cognitive task performance (See Figure 1 below).

In order to formally conclude that facial expressions reveal information regarding the biological response that is efficacious for performance outcomes, the entire sequence of this *emotional modulation of cognition* needs to be carefully studied. The validation of this sequence of human behavior in response to anger or fear inducing materials would have large implications for further basic and applied research. For example, the emotional modulation of human performance could be assessed through physiological monitoring much less invasively than has been done in the past. Though the EMG technique is somewhat invasive, less developed technology exists for remote sensing and automatic recording of facial feature recognition. However, it is necessary that the facial feature recognition techniques for human performance evaluation be assessed first, and so this research began with the gold standard technique of EMG as an initial validation technique. Subsequent studies should compare state-of-the-art devices with the EMG.

The primary objective of this study was to investigate the ability of facial contractions to provide information regarding one's decision making capabilities under two emotional stressors. The two emotional stressors included fear and anger. Measurements included facial muscle activity, cardiovascular reactivity, endocrine response, subjective affect, and decision-making.

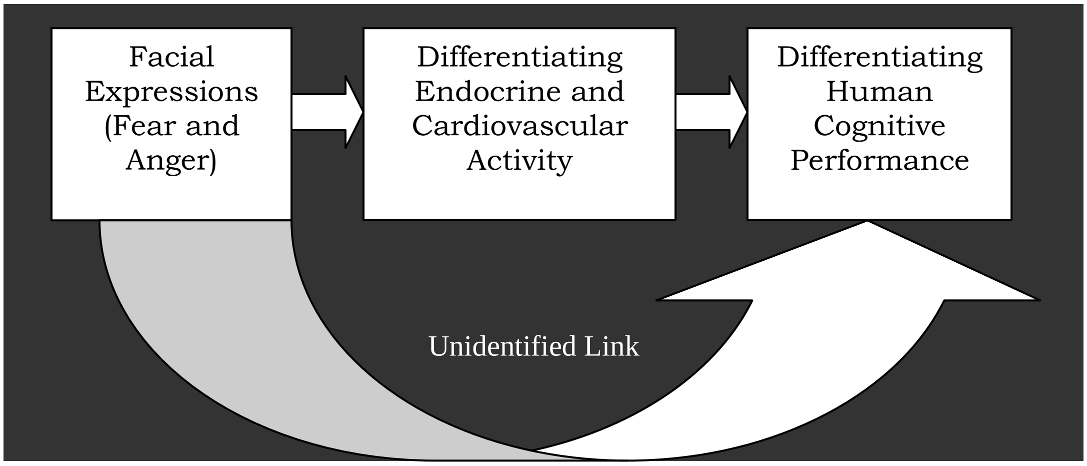

Figure 1. Generating the Link between Facial Expressions of Emotion and Human Cognitive Performance

2.0 METHOD, ASSUMPTION AND PROCEDURES

2.1 Equipment and Materials

2.1.1 Anger and Fear

Anger and fear were induced using movie clips presented on a 40-inch wide screen CPU monitor. A pilot study took place first in order to identify scenes that most elicit fear and anger. Scenes from Law and Order: SVU, The Punisher, The Patriot, Bastard out of Carolina, and Schindler's List were evaluated for anger. Scenes from The Shining, Joy Ride, Strangers, and Panic Room were evaluated for fear. In order to identify the scene that evoked the strongest emotion, twenty pilot subjects watched all of the scenes from one condition (10 subjects per condition) and provided a pre and post subjective rating for each scene. Each scene was viewed on a different day to control for the possibility of desensitization. Schindler's List and The Shining were successfully used in previous studies to elicit anger and fear (Gross & Levenson, 1995; Nasoz, Listetti, Alvarez, & Finkelstein, 2003). The movie clips that were selected include Strangers (28 minute clip with the last 11 minutes including EMG recording) for the fear condition and Bastard out of Carolina (5 minute clip with entire clip including EMG recording) for the anger condition. The results for this pilot study are presented in the results section.

2.1.2 Facial Expressions

Electromyography (EMG) was used at the sites specific to the facial patterns for "fear" and "anger" to extract facial muscle activity; these sites were specified in the Facial Action Coding System of Ekman and Friesen (1978) as "action units". Data were collected with the BioCapture System from Cleveland Medical Devices, Inc. (Cleveland, OH). Kohler and colleagues (2004) performed a detailed study investigating the action units that are unique and the characteristic of both fear and anger. The action units specified by these researchers were targeted for the present study and shown in Figure 2, include AU 2 (Frontalis, pars lateralis), AU 9 (levator palpebrae superioris), AU 7 (Orbicularis oculi), AU 16 (Depressor Labii inferioris), AU 23 (orbicularis oris), and AU 26 (Masseter). Each facial location was cleaned with a noninvasive conductive gel. Individual sensors were then placed on each facial location with an ambulatory grounding device attached to the participant's chair. The computer unit was located on a computer just 3 feet from the participants. Data collection began at the start of each movie clip and continued at a sampling rate of 57.6 Khz until the movie clip was over.

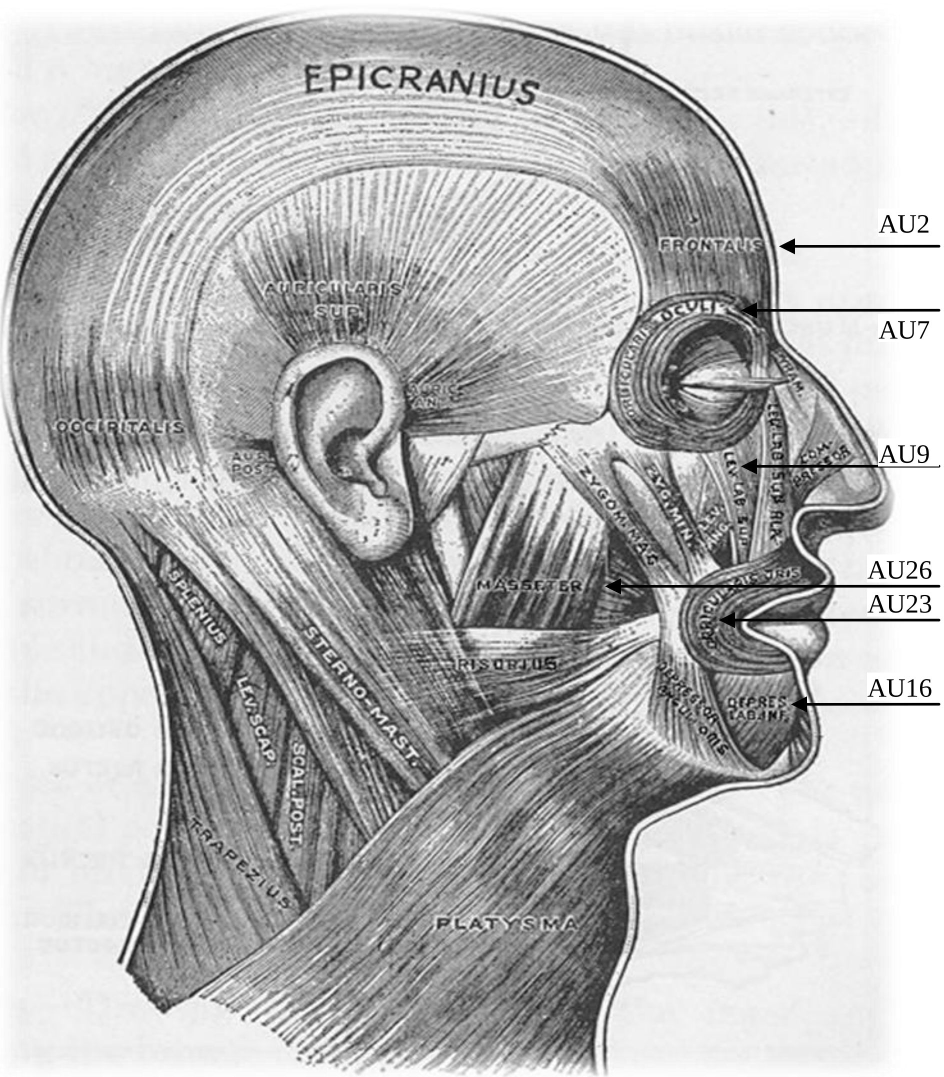

Figure 2. Facial Muscle Diagram

2.1.3 Cardiovascular Reactivity

In the original methods for the study, there were plans to collect heart rate inter-beat intervals and arterial pulse rate; however, due to a limited number of leads, only heart rate inter-beat intervals were collected. This was accomplished using a cloth snap electrode on the sternum, and interbeat interval was recorded before and during emotion elicitation and task performance. Systolic and diastolic blood pressure, and beats per minute were collected before (serving as a baseline) and post emotion elicitation using a blood pressure cuff that was placed on the subject's non-dominant arm. Participants wore the blood pressure cuff for the duration of the data collection session.

2.1.4 The Endocrine Response

Salivary samples were collected in order to determine participant's cortisol concentration levels before and after the emotional stress manipulation (emotion elicitation). Unstimulated saliva was collected using a standard technique (Navazesh, 1993). Subjects refrained from eating, drinking, using chewing gum or mints, etc. the morning prior to the sampling. Samples were obtained by requesting subjects to swallow first, tilt their head forward, and expectorate all saliva into 50-mL sterile plastic centrifuge tubes. All samples were frozen immediately and stored at -20C until the cortisol assay was performed by the Applied Biotechnology branch of AFRL (RHPB). All saliva samples were transported to RHPB without personal identifiers from the participants (only subject numbers were assigned to each assay). The Cortisol Immunoassay Kit from R&D Systems was performed by RHPB. The assay kit is designed to measure Cortisol in various biological fluids including saliva. Saliva samples were thawed on ice. The samples were diluted 5 fold. The assay was performed accordingly to the manufacturer's instructions. Microplate reader was used to measure absorbance at 450nm, with the correction wavelength set at 540 nm or 570 nm. All measurements were done in replicates. If readings were out of range of the calibration curve, samples were subjected to further dilutions before the assay. The whole assay, including standard curve, was repeated for those samples.

2.1.5 Affect

Subjective affect was measured via the *Visual Analog Scale* (VAS) (Penetar et al., 1993). The VAS requires that participants indicate the points on different lines that correspond to how he/she feels along the specified affect continuum at the time the test is taken. Rather than marking the line as a response, participants were asked to verbally respond to each adjective on a scale from 0-100. Verbal responses were recorded so that they could later be digitized and analyzed by the BLISS system (Lieberman & Blumstein, 1988) or another voice stress analytic technique. Example metrics include conventional sound spectrograms, Fourier analysis of the speech spectrum, "formant frequency" patterns that distinguish among vowels and consonants, fundamental frequency (FO) contour of an utterance, and "jitter," a measure of period-by-period variation in FO. The adjectives included in the VAS are as follows: Frustrated, Afraid, Irritable, Angry, Hostile, Tense, Nervous, and Disgusted. The VAS was administered prior to (baseline) and post emotion elicitation.

2.1.6 Cognitive Control (Decision Making)

Cambridge Gambling Task (CGT): The Cambridge Gambling Task is part of the CANTABeclipse Battery and was developed to assess decision-making and risk-taking behavior outside a learning context. The participant was presented with a row of ten boxes across the top of the screen, some of which were red and some were blue (see Figure 3). At the bottom of the screen, there were rectangles containing the words 'Red' and 'Blue'. The subjects were required to guess whether a yellow token was hidden in a red box or a blue box. In the gambling stages, subjects started with a number of points, displayed on the screen. When the task began, the participants had to decide what proportion of their points (5%, 25%, 50%, 75% or 95%) they were willing to bet on their decision. The number of points that they could choose to bet was displayed, in either an increasing or decreasing fashion, in a second box on the screen. After a bet was chosen, a stakes box displayed the current amount of the bet on the screen. The performance metrics recorded for this task included deliberation time, quality of decision making, overall proportion bet, delay aversion, risk adjustment, and risk taking. These metrics are defined below.

Deliberation Time: The average time it takes for the participant to select a choice, on which to bet.

Proportion Bet: Average proportion of points that a participants chooses to risk on each gamble trial.

Quality of Decision Making: The proportion of trials on which the participant chooses to gamble on the more likely outcome.

Delay Aversion: The tendency to bet larger amounts when large amounts are presented first.

Risk Adjustment: The degree to which the participant places larger bets when the odds are more in the participant's favor.

Risk Taking: Average proportion of points that a participant chooses to risk when the most likely option is selected.

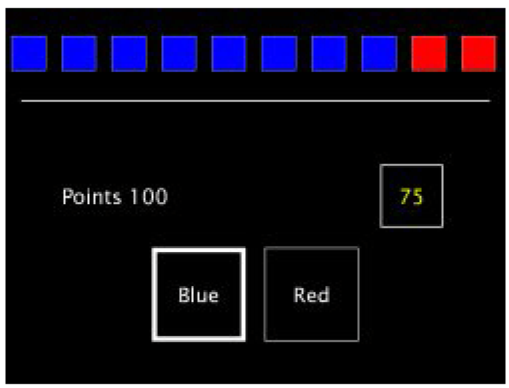

Figure 3. CANTABeclipse Cambridge Gambling Task

2.2 Subjects

Twenty participants (7 Female, 13 Male) were recruited as pilot subjects in order to identify a movie clip that elicited fear and one that elicited anger. The results of this study determined the emotional stimuli that were implemented for the final study. Fifty-two participants were screened and 51 enrolled (30 Males; 21 females) for the experimental study. One participant was rejected by the medical monitor because s/he had too many previous medical conditions and was taking too many medications. In addition, technical difficulties occurred during the data collection for the last female participant, making her data unusable. The study was completed with 30 males and 20 females with a mean age of 31.88 years. Because previous research has shown that females exhibit greater emotional expressiveness (Kring & Gordon, 1998), an attempt was made to recruit an equal number of males and females and to place an equal number in each condition. Each participant was screened by the medical monitor for any stress-related illnesses such as hypertension and generalized anxiety disorder, as well as for any cardiovascular diseases.

All subjects were required to have normal or corrected to normal vision. Each participant completed an informed consent form. Participants were openly recruited via word of mouth or email, and for emails, the investigators of the study attached a “study brief” to active duty Wright Patterson Air Force Base personnel. Each participant was asked to comply with a list of requirements prior to the experimental data collection. Salivary amylase samples are very sensitive to certain substances and circadian effects. Thus, participants were required to fast on the testing day (no food or drink consumption the morning of testing). They were informed that they could take sips of water if needed, such as if prescription medication must be taken. Subjects were asked to refrain from taking any medication that was not prescription until the end of experimentation. In addition, participants were asked to wear a wrist activity monitor the night before testing so that the researchers could ensure that the participant had at least 6 hours of rest. Participants were offered snacks following experimentation. Each data collection took place at 8:15am and did not exceed two hours. Participants were blind as to which condition they were assigned until the emotion elicitation occurred.

Additionally, training was required for the present study. All participants were asked to come to the lab to pick up the actiwatch and receive instructions for testing the day before their data collection session. During this training, the Cambridge Gambling Task was introduced, and each participant performed a short version of the task for familiarization.

2.3 Description of experiment, data collection, and analysis

The testing session began at 8:15am by taking baseline performance including the gambling task, a 2-minute EMG/ECG resting period, systolic and diastolic blood pressure, beats per minutes, and a salivary amylase sample, as well as a subjective measure of affect. Each participant then viewed a segment from either Bastard out of Carolina (anger condition; 5 minutes) or Strangers (fear condition; 28 minutes). During the movie segment, EMG data was continuously being recorded (only the last 11 minutes of the fear clip, when the clip was most intense). After the clip, a salivary amylase sample was drawn, and arterial blood pressure, including beats per minute, was taken. Then, subjective assessments of affect were taken again. Finally, the Cambridge Gambling Task was performed, concluding experimentation. Each participant was then debriefed on the nature of the experiment. Participants were seated in a 12 X 12 room at the beginning of experimentation and remained in the same chair throughout the experiment. During the movie clip, participants were seated facing the wide-screen CPU monitor, approximately 3 feet away. The lights were turned off and no additional sounds were in the room.

The mean signal (amplitude) for each action unit or facial location for each participant was computed along with 1 standard deviation from the mean signal. This measure was the baseline measure. The facial contraction EMG data were used to calculate the proportion of time that muscle contracted greater than 1 SD above or below the mean signal for the baseline. Paired-sample t-tests were computed between baseline/post emotion elicitation metrics (subjective affect, blood pressure, beats per minutes (ECG data was not analyzed due to the lack of resources available to compute nonlinear analyses on cardiac behavior), cortisol concentration, and risk-taking metrics). A one-way analysis of variance test was performed in order to assess differences between the fear and anger conditions. In addition, a two-way analysis of variance was performed to test for the main effects and interactions of gender and condition. Correlations were computed to explore relationships between all metrics. Finally, predictive models, via MAX R^2 regression procedures, were run with all predictive variables on each dependent measure (risk-taking metrics) in order to identify the best combination of metrics to predict changes in risk-taking behavior.

3.0 RESULTS AND DISCUSSION

3.1 Emotion elicitation selection pilot study

Twenty subjects (13 males; 7 females) were enrolled for the pilot portion of the study. In order to determine if each video clip significantly increased associated subjective emotions, a paired samples t-test was performed on the baseline ratings and the post emotion elicitation rating.

Table 1 shows the difference scores on the subjective affect ratings from baseline to post emotion elicitation (higher numbers indicate a greater change in subjective ratings) for each movie in the fear condition. The segment from the movie "Strangers" was the only movie clip to significantly change the emotions: afraid [$t(9) = -2.327$, $p = .045$], tense [$t(9) = -3.830$, $p = .004$] and nervous [$t(9) = -3.294$, $p = .009$]. Thus, Strangers was selected as the method of fear elicitation for the full scale experiment.

Table 1. Differences in subjective ratings for pre-movie clip to post-movie clip for the fear condition

	Afraid	*Tense*	*Nervous*
Joy Ride	7.95	12.10	10.52
The Shining	11.75	19.10	12.95
Panic Room	7.65	14.15	11.80
Strangers	*16.95	*33.4	*26.05

* < .05

Table 2 shows the difference scores on ratings from baseline to post emotion elicitation (higher numbers indicate a greater change in subjective ratings) for each movie in the anger condition. While every movie clip significantly increased more than one emotion associated with anger, the segment from the movie "Bastard out of Carolina" produced the greatest subjective change. Specifically, participants reported that they were significantly more frustrated [$t(9) = -3.507$, $p = .007$], irritable [$t(9) = -3.330$, $p = .009$], angry [$t(9) = -9.330$, $p = .000$], hostile [$t(9) = -8.638$, $p = .000$], tense [$t(9) = -3.707$, $p = .005$], and disgusted [$t(9) = -7.551$, $p = .000$] as a function of the emotion elicitation.

Table 2. Differences in subjective ratings for pre-movie clip to post-movie clip for the anger condition

	Frustrated	*Irritable*	*Angry*	*Hostile*	*Tense*	*Disgusted*
The Patriot	12.75	3.90	23.80	**19.50	*24.25	*29.55
The Punisher	23.55	13.00	**30.95	*12.95	*24.4	*25.30
Schindler's List	11.95	*6.10	**34.55	*25.35	*23.75	**44.00
Law and Order	*24.55	*16.80	**47.25	**31.15	15.15	**60.80
Bastard out of Carolina	**35.40	**31.00	**69.50	**58.10	**41.15	**71.00

** p < .01
* p < .05

3.2 Full-scale experimental study

Fifty-two subjects were screened and 51 enrolled (30 males; 21 females) in the experimental study. The medical monitor could not approve one individual's participation, due to medical reasons, and another participant's data was unusable because of technical difficulties (the DVD for the movie clip was damaged). The study was completed with 30 males and 20 females.

Percent changes from baseline to post emotion elicitation were taken for those experimental measures that had all baseline values above 0, while actual changes from baseline to post emotion elicitation were taken for those measures with at least one baseline value ≤ 0. In addition, the temporal duration of muscle contractions occuring during the clip, as compared to 1 standard deviation above or below the 2 minute resting baseline, was recorded for the 6 identified sites. These changes and the temporal duration of muscle contraction were used as dependent variables in a 2-way analysis of variance. Factors were gender (female, male) and condition (anger, fear). Results from these analyses are shown in Table 3.

Table 3. Results from analysis of variance along with main effect means for change from pre to post

Measure	Change Type	Condition Main Effect			Gender*Condition
		Anger	Fear	*p*	*p*
Systolic Blood Pressure	percent	0.7	4.1*	0.113	0.436
Diastolic Blood Pressure	percent	3.1	7.4*	0.168	0.151
Heart Rate	percent	1.5	-3.1	0.172	0.043
Cortisol Concentration	percent	62.2*	65.3*	0.928	0.593
(Subjective) Frustrated	actual	20.9*	8.5	0.145	0.764
(Subjective) Afraid	actual	10.4	9.7	0.930	0.347
(Subjective) Irritable	actual	20.2*	0.7	0.027	0.476
(Subjective) Angry	actual	37.7*	9.1	0.003	0.247
(Subjective) Hostile	actual	28.5*	8.1*	0.020	0.370
(Subjective) Tense	actual	31.7*	13.8*	0.047	0.611
(Subjective) Nervous	actual	8.2	0.3	0.370	0.426
(Subjective) Disgusted	actual	55.8*	10.0*	0.000	0.768
Delay Aversion	actual	-0.01	0.04	0.268	0.004
Deliberation Time	percent	-17.2*	-23.6*	0.165	0.548
Overall Proportion Bet	percent	3.0	3.5	0.926	0.235
Quality of Decision Making	percent	0.6	-0.4	0.740	0.090
Risk Adjustment	actual	0.17	0.13	0.842	0.963
Risk Taking	percent	3.8	3.9	0.991	0.050
AU2 - % time outside 1 std baseline signal	None	39.5	38.5	0.758	0.687
AU7 - % time outside 1 std baseline signal	None	35.1	28.0	0.003	0.121
AU16 - % time outside 1 std baseline signal	None	38.5	32.7	0.000	0.498
AU9 - % time outside 1 std baseline signal	None	33.1	35.2	0.000	0.933
AU23 - % time outside 1 std baseline signal	None	35.5	27.3	0.002	0.255
AU26 - % time outside 1 std baseline signal	None	35.6	28.4	0.008	0.099

[Significant effects ($p \leq 0.05$) have p-value cells shaded. For measures other than the contractions, * indicates a significant change from pre to post ($p \leq 0.05$) using two-tailed tests with error pooled across gender for a particular condition.]

Anger was found to be significantly related to increased cortisol concentration [$t(24) = 2.402$, $p = .024$], as well as faster deliberation times during a risk taking task [$t(24) = -6.170$, $p = .000$]. Participants also reported that they were significantly more frustrated [$t(24) = 2.962$, $p = .007$], irritable [$t(24) = 2.873$, $p = .008$], angry [$t(24) = 5.145$, $p = .000$], hostile [$t(24) = 3.839$, $p = .001$], tense [$t(24) = 4.776$, $p = .000$], and disgusted[$t(24) = 7.794$, $p = .000$]. Fear was found to be significantly related to increased systolic [$t(22) = 2.588$, $p = .017$] and diastolic blood pressure [$t(22) = 3.747$, $p = .001$], cortisol concentration [$t(20) = 3.177$, $p = .005$], as well as faster deliberation times [$t(22) = -6.443$, $p = .000$]. Participants also reported that they were significantly more hostile [$t(22) = 2.472$, $p = .022$], tense [$t(22) = 2.458$, $p = .022$], and disgusted [$t(22) = 2.660$, $p = .014$]. Significant differences between anger and fear were found for subjective irritability [$F(1,46) = 5.20$, $p = .027$], anger [$F(1,46) = 9.76$, $p = .003$], hostility

[F(1,46) = 5.86, p = .020], tension [F(1,46) = 4.17, p = .047], and disgust [F(1,46) = 30.11, p = .000] with the anger condition producing higher affect.

Facial EMG revealed significantly greater contractions for action units AU 7 [F(1,46) = 9.68, p = .003], AU 16 [F(1,46) = 19.54, p = .000], AU 23 [F(1,46) = 10.51, p = .002], and AU 26 [F(1,46) = 7.69, p = .008] under the anger condition; whereas AU 9 [F(1,46) = 19.91, p = .000] revealed a greater amount of contraction under the fear condition.

Gender differences were found for the overall proportion bet [F(1,46) = 5.14, p = .028] and risk taking index [F(1,46) = 6.18, p = .017] with females betting more and taking greater risk following emotion elicitation as compared to males. An interaction between gender and condition was found for heart rate [F(1,46) = 4.35, p = .043] with males experiencing greater changes in heart rate as compared to females under the anger condition only. An interaction was also found between gender and condition for delay aversion [F(1,46) = 9.43, p = .004], for the fear condition, with males exhibiting the inability to inhibit large bets when the large bet is presented first. Finally, an interaction between gender and condition was found for risk taking [F(1,46) = 4.04, p = .050] with females exhibiting greater risk taking behavior as compared to males under the fear condition only.

Figures 4-6 contain mean changes from baseline to post emotion elicitation for each condition. Listed p-values are from main effect test of condition (Ho: anger change = fear change), the symbol "*"indicates a significant change from baseline ($p \leq 0.05$) using two-tailed t-tests with error pooled across gender. Figures 7-10 contain mean changes from baseline to post emotion elicitation for each combination of gender and condition for all metrics. Spearman partial (controlling for gender) correlations were computed.

To determine partial correlations, an equal slopes analysis of covariance was performed using gender as a categorical independent variable, rank of one of the measures as a continuous independent variable, and rank of the other measure as the dependent variable. The test of Ho: slope = 0 is the same as a test for Ho: partial correlation = 0. To determine whether the linear relationship of the measures was different for the genders, an unequal slopes analysis of covariance was performed. The test of interaction between gender and the measure chosen as the independent variable is a test of whether the linear relationship varies significantly between the genders. These relationships are presented in Appendix A and will not be discussed in detail in this report.

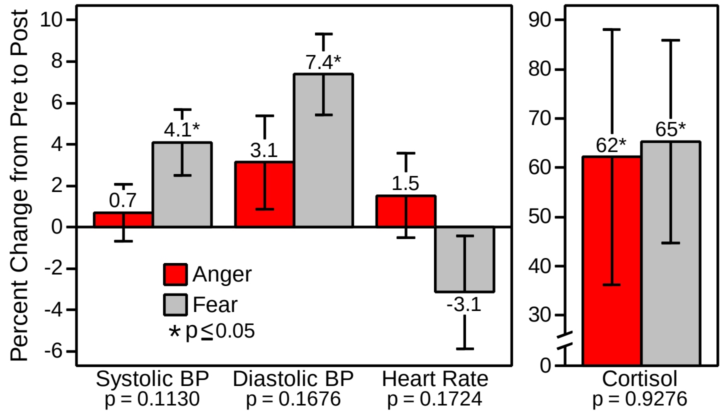

Figure 4. Cardiac and Endocrine Data

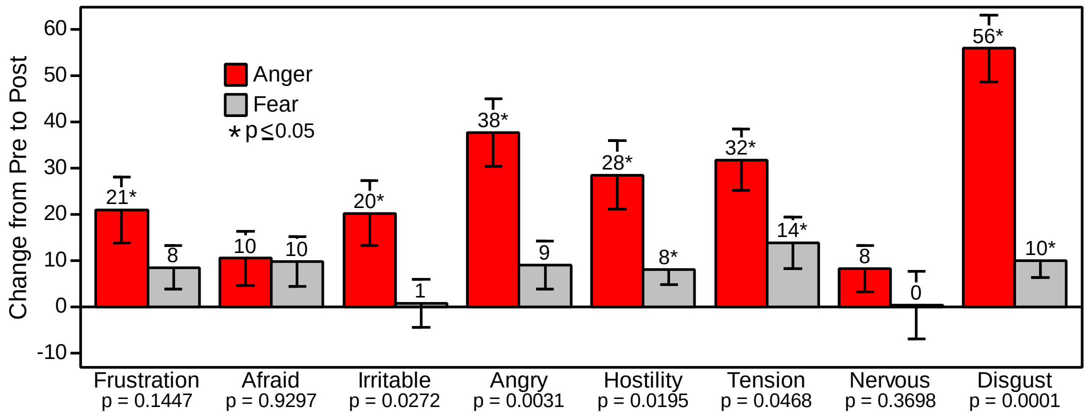

Figure 5. Subjective Affect

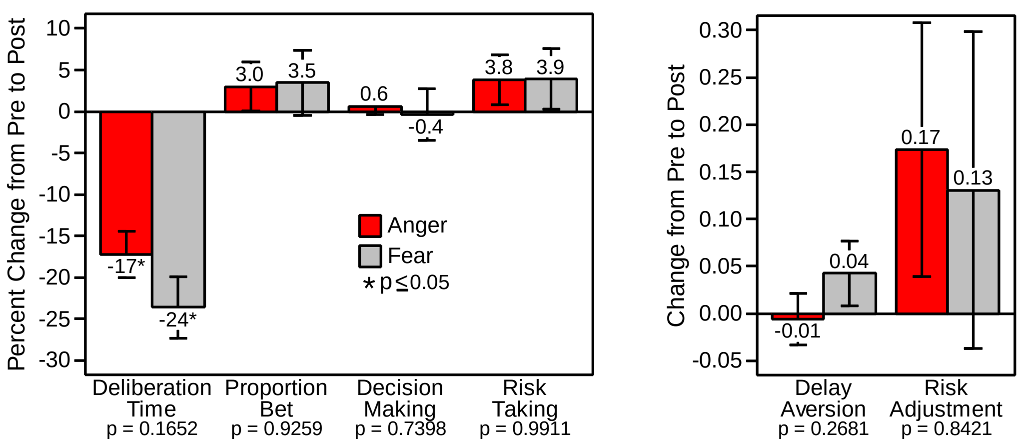

Figure 6. Risk-Taking Behavior

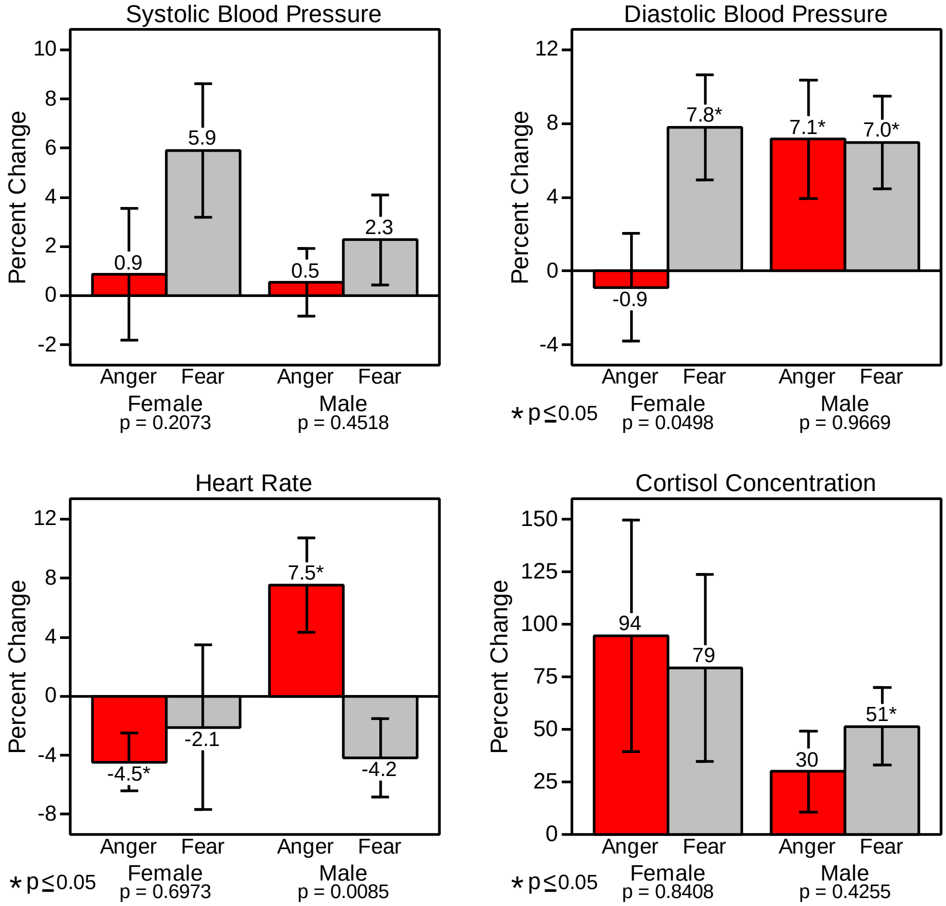

Figure 7. Cardiac and Endocrine Data

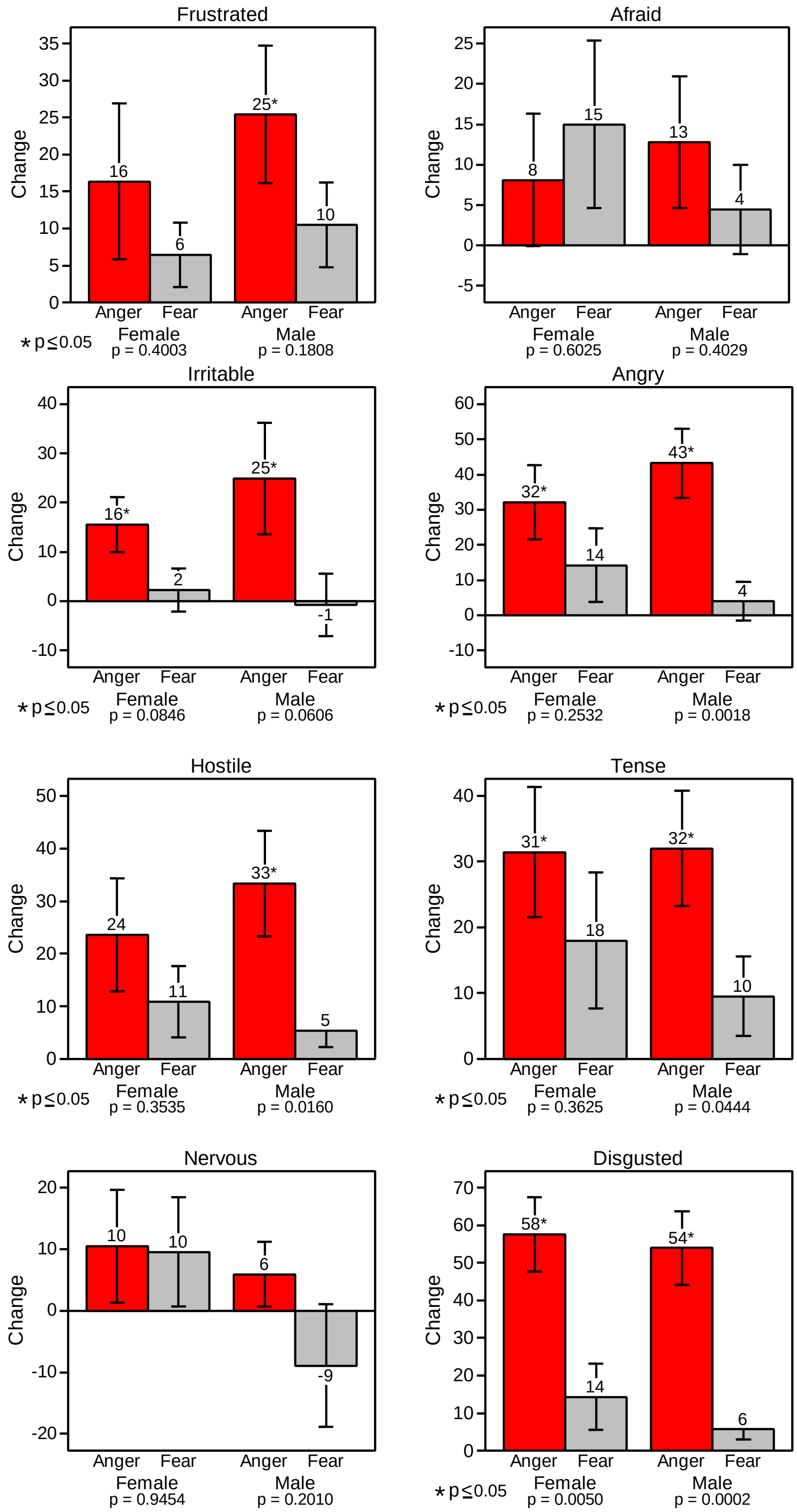

Figure 8. Subjective Affect

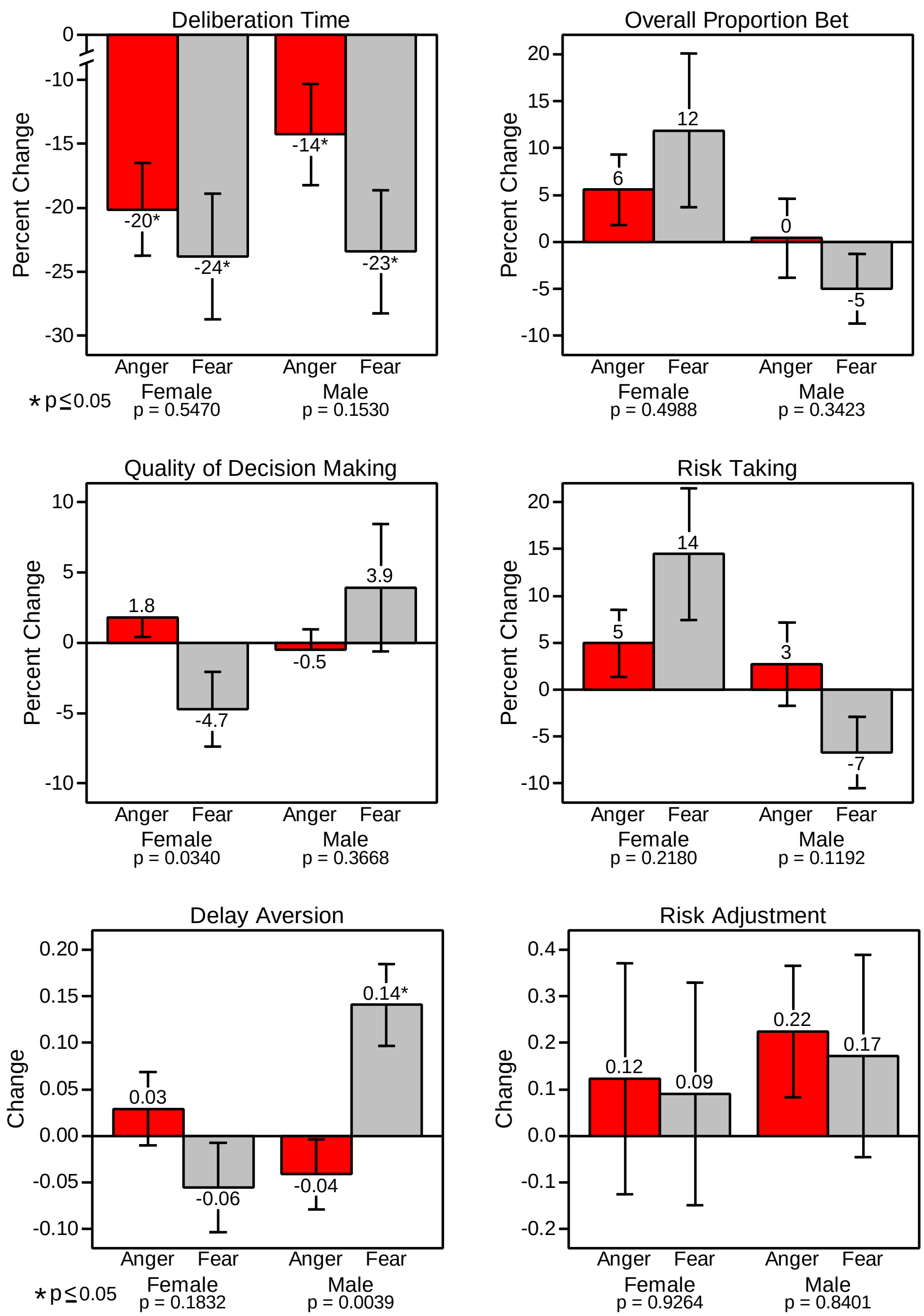

Figure 9. Risk-Taking Behavior

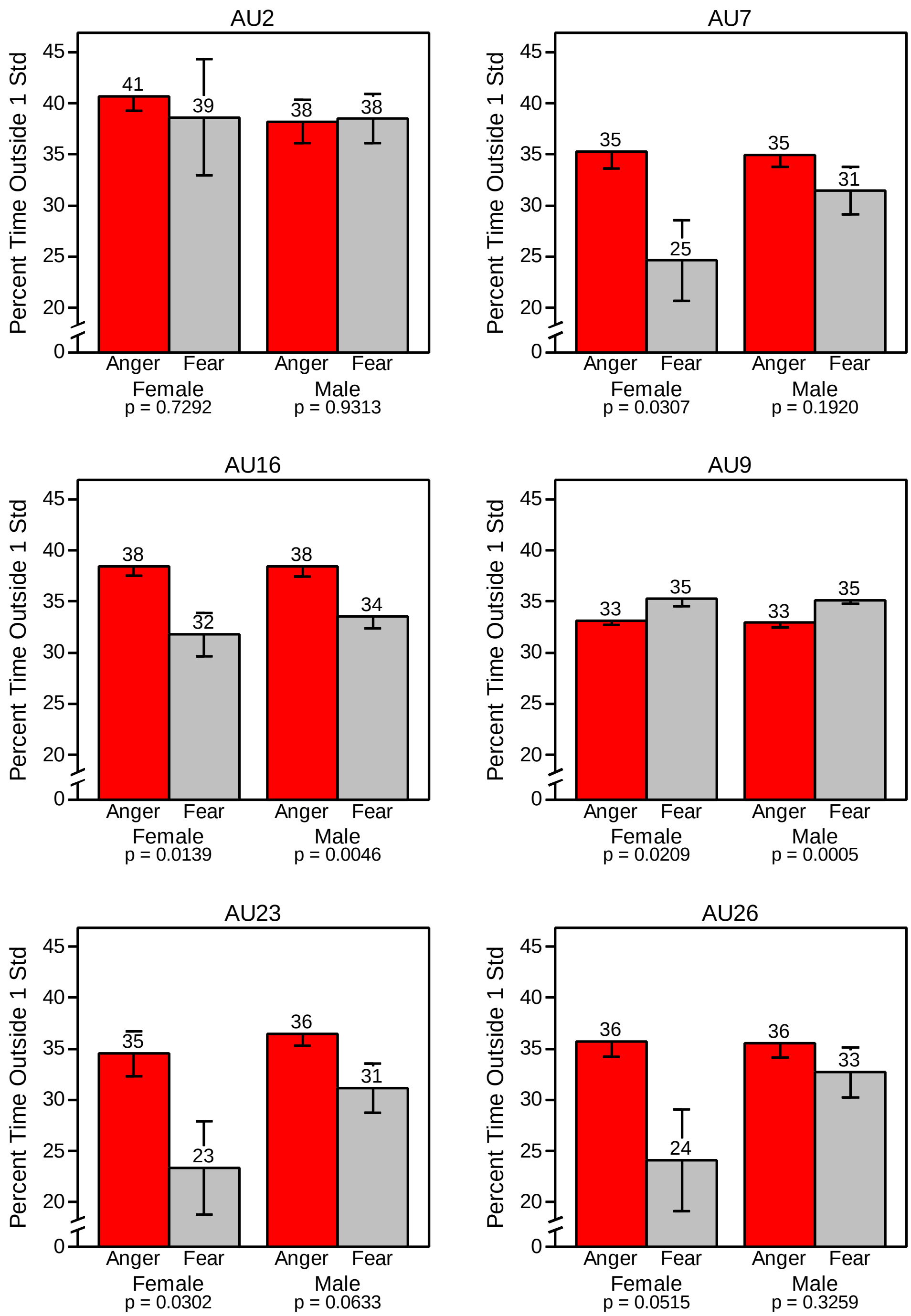

Figure 10. Facial Muscle Contractions by Action Unit

The literature on negative emotion and changes in cortisol concentration is contradictory. Moons, Eisenberger, and Taylor (2010) found that increases in subjective anger were correlated with increased cortisol concentration, whereas increases in subjective fear were related to decreases in cortisol concentration. However, Lerner, Dahl, Hariri, and Taylor (2007) found that the longer a person displayed anger on the face, the lower the cortisol responses at peak stress (*b*

= -.21) and recovery (*b* = -.23). In addition, they found that the more intensely a person displayed a fearful face, the higher the cortisol concentration at peak stress (*b* = .26). These differences may be due to a lack of relationship between subjective and objective emotional experience. The participants in the current study showed increases in cortisol concentrations in both the fear and anger conditions, but this finding does not take into account the degree of emotion.

The participants in the fear condition showed increases in systolic (SBP) and diastolic blood pressure (DPB). This is consistent with Lerner, Dahl, Hariri, and Taylor's (2007) finding that the more intensely a person displayed a fearful face, the higher the systolic blood pressure (*b* = .21), and diastolic blood pressure (*b* = .33). It is important to note that increases in "afraid" or "nervous" (as subjectively reported in the VAS) did not occur in the fear condition. Although individuals are not perfect at rating their emotional experiences (SBP and DBP did significantly increase), it is possible that the fear elicitation was not successful in the full-scale experiment. The finding that EMG activity was significantly greater in the anger condition for the majority of action units may lend support to this possibility.

An interaction between gender and condition was found for risk-taking behavior with females taking greater risks than males in the fear condition. There are two possible explanations for this finding. One explanation could be that the attempt to elicit fear may have not been effective for males. Subjectively, with the exception of frustration, females reported greater increases in emotions following the fear clip (though not significant, see Figure 9). Another explanation is that men respond differently to emotional reactivity than women. McRae, Ochsner, Mauss, Gagrieli, and Gross (2008) suggest that gender differences in emotional responding might be due, not to gender differences in emotional reactivity, but instead to gender differences in emotion regulation. They found that men and women show comparable response in the amygdale to negative images, but men showed greater down-regulation than women (as indexed by decreases in amygdala activity during reappraisal). Furthermore, men showed significantly less activity than women in prefrontal regions that have been previously observed as being more active during the cognitive regulation of emotion. Therefore, it may be that the emotional reactivity was quickly down-regulated; thus, it did not affect behavior.

3.3 Modeling risk-taking behavior

Table 4 contains predictive models for the rank of change from baseline to post emotion elicitation for the 6 performance variables (i.e. dependent variables). The physiological variables (systolic BP, diastolic BP, heart rate, and cortisol concentration), along with the 8 subjective variables and the 6 face sites for contractions, were all used as independent variables. Only first order models were considered (no interactions, squared terms, etc.) and were limited to 3 independent variables to help with interpretation. Additionally, models with 4 or more independent variables had relatively small increases in the percentage of variance explained (R^2) as compared to the 3 variable models, which also justified only using first order models. Table 4 contains first order models for each condition separately where gender was used as a dummy independent variable (0 = male, 1 = female). Table 5 contains first order models where genders were fit separately. Gender was used as a dummy independent variable, not only for completeness, but also because exploratory analysis indicated many instances of differing effects for the genders. Rather than including interaction terms with gender, the genders were fit separately. The procedure for model selection was Max R^2 regression with the constraint that for a model to be considered, the F-test for the entire model must have $p \leq 0.05$, and the t-test for each independent variable must have $p \leq 0.05$. The model(s) was then chosen from among the qualifying models based on R^2 and for the interpretability of the slope signs. There may be multiple models for a particular dependent variable. Unfortunately, this study cannot confirm which models may be reliable as a predictive tool, because these models need to be validated with further research.

The following tables contain all first order models fit to the performance variables. Gender was included as an independent variable (0 = male, 1 = female). For each condition, models are ordered from top to bottom by number of independent variables and then descending R^2. Before each model is the overall p-value and R^2. The slope sign is shown in front of each independent variable.

Table 4. First order models for each condition separately where gender was used as a dummy independent variable

Risk Taking					
Anger			***Fear***		
P value	R^2	Predictors	P value	R^2	Predictors
			0.0148	0.24	+gender
			0.0486	0.17	-au7

Risk Adjustment					
Anger			***Fear***		
P value	R^2	Predictors	P value	R^2	Predictors
0.0203	0.20	+au26	0.0130	0.25	+au7
0.0393	0.17	+au16			

Delay Aversion					
Anger			***Fear***		
P value	R^2	Predictors	P value	R^2	Predictors
0.0002	0.44	-au16	0.0035	0.33	-gender
0.0005	0.41	-au23	0.0010	0.55	-gender +au16 -au23
0.0026	0.32	-au26	0.0126	0.41	-systolic -au23 +au26
0.0040	0.30	+au9			
0.0207	0.20	-au7			
0.0023	0.48	+au9 -angry +disgusted			

Overall Proportion Bet					
Anger			***Fear***		
P value	R^2	Predictors	P value	R^2	Predictors
0.0228	0.28	+systolic -diastolic	0.0429	0.17	+gender

Quality of Decision Making					
Anger			***Fear***		
P value	R^2	Predictors	P value	R^2	Predictors
0.0068	0.27	-cortisol	0.0116	0.26	-irritable

Deliberation Time					
Anger			***Fear***		
P value	R^2	Predictors	P value	R^2	Predictors
0.0049	0.29	-hostile	0.0484	0.17	-au2
0.0091	0.25	-irritable			
0.0093	0.25	-angry			
0.0093	0.25	-tense			
0.0157	0.22	-disgusted			
0.0235	0.20	-au2			
0.0031	0.39	-au2 -irritable			
0.0041	0.38	-au9 -irritable			
0.0046	0.37	-au2 -tense			
0.0009	0.52	-systolic -au9 -irritable			
0.0014	0.50	-au7 -au9 -tense			
0.0022	0.48	+frustrated -irritable -hostile			
0.0030	0.46	-au7 -au9 -hostile			
0.0064	0.42	-au7 -au9 -angry			
0.0085	0.41	-au7 -au9 -disgusted			
0.0312	0.33	-systolic +diastolic -afraid			

The following 4 pages contain all first order models fit to the performance variables. For each combination of gender and condition, models are ordered from top to bottom by number of independent variables and then descending R^2. Before each model is the overall p-value and R^2. The slope sign is shown in front of each independent variable.

Table 5. First order models where genders were fit separately

Risk Taking

Female Anger			***Male Anger***			***Female Fear***			***Male Fear***		
P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors
0.0405	0.55	+au23 -au26	0.0422	0.28	-frustrated	0.0393	0.79	+au2 -angry +hostile	0.0016	0.66	+hr -au2
0.0483	0.65	+au9 +au23 +irritable	0.0015	0.66	+au26 -frustrated				0.0006	0.78	+hr -au2 +irritable
			0.0076	0.56	+au26 -irritable						
			0.0088	0.55	+au16 -frustrated						
			0.0195	0.48	+hostile -disgusted						
			0.0277	0.45	+au7 -irritable						
			0.0003	0.80	-au7 +au26 -frustrated						
			0.0019	0.73	-hr +au26 -irritable						
			0.0021	0.72	-hr +au7 -au23						
			0.0026	0.71	+au16 +au9 -frustrated						
			0.0102	0.63	-hr +au7 -irritable						
			0.0127	0.61	-hr -au23 +au26						
			0.0373	0.52	-hr +au26 -tense						

Risk Adjustment

Female Anger			***Male Anger***			***Female Fear***			***Male Fear***		
P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors
0.0199	0.62	+au2 -frustrated	0.0009	0.59	+au7	0.0442	0.46	-hostile	0.0360	0.30	+au7
0.0326	0.58	+au2 -hostile	0.0038	0.49	+au23	0.0210	0.79	+cortisol +au9			
			0.0039	0.49	+au26	0.0193	0.73	+afraid -hostile			
			0.0076	0.43	+au16	0.0061	0.90	-au16 -hostile +nervous			
			0.0329	0.30	-au9	0.0182	0.90	+cortisol -hostile +nervous			
						0.0352	0.80	-au16 +au9 +au23			

Delay Aversion

Female Anger			***Male Anger***			***Female Fear***			***Male Fear***		
P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors
0.0308	0.42	-au16	0.0007	0.60	-au23	0.0235	0.83	+hr +au16 +afraid			
0.0085	0.70	-au2 -au16	0.0014	0.56	+au9	0.0256	0.82	-systolic +au16 -au23			
0.0160	0.64	-au2 -au26	0.0059	0.45	-au16	0.0260	0.82	-au2 +au16 -au26			
0.0009	0.89	-au2 -au16 +hostile	0.0097	0.41	-au7						
0.0031	0.85	-au2 -au16 +frustrated	0.0241	0.33	-au26						
			0.0043	0.60	+hr -au7						
			0.0008	0.77	+cortisol -au23 +frustrated						

Overall Proportion Bet

Female Anger			***Male Anger***			***Female Fear***			***Male Fear***		
P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors
0.0354	0.57	+au23 -au26	0.0433	0.28	-afraid	0.0478	0.77	+au2 -angry +hostile	0.0494	0.27	+hr
0.0367	0.68	+au9 +au23	0.0498	0.26	-frustrated				0.0012	0.68	+hr -au2

		+irritable									
			0.0135	0.51	+au26 -irritable						
			0.0174	0.49	+au26 -frustrated						
			0.0010	0.76	-au7 +au26 -frustrated						
			0.0054	0.67	+au16 +au9 -frustrated						
			0.0056	0.67	-diastolic +au26 -irritable						
			0.0075	0.65	-afraid +hostile -disgusted						
			0.0125	0.61	+au16 +au9 -irritable						
			0.0182	0.58	-diastolic +au16 -irritable						
			0.0200	0.58	-hr -au23 +au26						
			0.0392	0.52	-hr +au7 -au23						

Quality of Decision Making											
Female Anger			***Male Anger***			***Female Fear***			***Male Fear***		
P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors
			0.0001	0.75	-cortisol	0.0453	0.51	+cortisol	0.0371	0.29	+hr
			0.0001	0.83	-cortisol -nervous	0.0494	0.45	+diastolic			
			0.0479	0.40	-systolic +au16	0.0007	0.98	+diastolic +cortisol +au9			
						0.0088	0.88	+diastolic -au16 +au23			
						0.0149	0.86	+diastolic -au16 -hostile			
						0.0283	0.81	+au7 -au26 -irritable			

Deliberation Time											
Female Anger			***Male Anger***			***Female Fear***			***Male Fear***		
P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors	P value	R^2	Predictors
0.0393	0.39	-systolic	0.0025	0.52	-hostile	0.0356	0.49	+au26			
0.0076	0.80	-hr -au2 -disgusted	0.0116	0.40	-angry	0.0097	0.79	-hr -au2			
			0.0194	0.35	-disgusted	0.0117	0.77	-au2 +au23			
			0.0210	0.35	-irritable	0.0013	0.95	-systolic -hr -au2			
			0.0409	0.28	-tense	0.0099	0.88	+au26 +afraid -irritable			
			0.0055	0.58	-au9 -angry						
			0.0015	0.74	-au9 -au23 -hostile						
			0.0040	0.69	+au16 -au23 -hostile						
			0.0042	0.68	-au9 -au23 - disgusted						
			0.0069	0.65	+au16 -au26 -angry						
			0.0097	0.63	-au7 -au9 -tense						
			0.0107	0.62	+au16 -au26 -tense						
			0.0114	0.62	-au9 -au23 -tense						
			0.0157	0.60	+au16 -au26 -disgusted						

Table 6 highlights selected models that have high predictability (though replication is warranted) and potential to explain changes in risk-taking behavior as a function of anger and fear emotion elicitation.

Table 6. Selected predictive models of changes in risk-taking behavior *[R^2]*

	Female Anger N=11	Male Anger N=15	Female Fear N=9	Male Fear N=15
Deliberation Time (amount of time to select an option)	-systolic BP *[.39]* -heart rate, -AU2, -disgusted *[.80]*	-AU9, -AU23, -hostile *[.74]*	-systolic BP, -heart rate, -AU2 *[.95]*	
Proportion Bet (overall stakes)	+AU23, +AU9, +irritable *[.68]*			+heart rate, -AU2 *[.68]*
Quality of Decision Making (selecting less risky options)		-cortisol *[.75]*	+diastolic BP, +cortisol, +AU9 *[.98]*	+heart rate *[.29]*
Delay Aversion (inability to inhibit response to make careful decisions)	-AU2, -AU16 *[.70]*	-AU23 *[.60]*	+heart rate, +AU16, +afraid *[.83]*	
Risk Adjustment (placing greater stakes in less risky options)		+AU7 *[.59]* +AU16 *[.43]* +AU23 *[.49]* +AU26 *[.49]*	+cortisol, +AU9 *[.79]*	+AU7 *[.30]*

Before discussing the results of selected models, note that models including a subjective element are included. The problem with including subjective emotion in a predictive model is that 1) they are often inaccurate and subject to personality differences and, 2) they can't be measured directly. The reason they are included in the selected models is because it is believed that the subjective element represents a conscious awareness of the emotional experience. This information is important due to the differences between conscious cognitive down-regulation of emotion and automatic emotion regulation. These differences will be discussed below. The selected models will be presented as displayed in Table 6 from left to right.

3.3.1. Female Anger

Increased systolic blood pressure alone predicted faster deliberation time [R^2 = .39] in addition to the combined contribution of heart rate, AU 2 (upper forehead), and subjective disgust [R^2 = .80]. The combined contribution of AU 23, AU 9, and subjective frustration predicted greater over all proportion bets, resembling higher risk taking. The combined contribution of AU 2 and AU 16 [R^2 = .70] predicted the ability to inhibit early responses and make careful choices.

Lerner, Dahl, Hariri, and Taylor (2007) explained that anger triggers optimistic perceptions of risk (Lerner and Keltner 2001; Lerner, Gonzalez, Small, & Fischhoff, 2003). Anger does so by triggering cognitive appraisals of certainty and control, which in turn lead to lower risk estimates (Lerner & Keltner 2001; Lerner & Tiedens, 2006). The present results show that the temporal duration of facial expression, utilizing the combination of AU 23 (lip) and AU 9 (nose cringe), together with the conscious expression of frustration for angry females leads to greater risk taking behavior. Lower estimates of risk may explain the increase in risk taking behavior. A different combination of action units (AU 2 and AU 16; upper forehead and chin) predicted the ability to inhibit high bets simply because the larger proportion bets were presented first. This expression could signify control, which would explain why an element of subjective emotion is absent in this model.

3.3.2. Male Anger

The combined contribution of AU 23, AU 9, and subjective hostility predicted faster deliberation time [R^2 = .74]. Decreases in cortisol predicted the selection of less risky options [R^2 = .75]. Temporal duration of facial muscle contraction predicted the ability to inhibit high bets, to react faster (AU 23; R^2 = .60), and to place greater stakes on safe bets [AU 7, AU 16, AU 23, and AU 26]. It is important to note that facial muscle contraction was collected during the emotion elicitation while cardiac data, subjective emotion, and cortisol were collected immediately following emotion elicitation. Thus, facial muscle contraction is the only metric in the current study that could provide information regarding real-time emotional reactivity. Lerner, Dahl, Hariri, and Taylor (2007) found that the longer a person displayed anger on the face, the lower the cortisol responses at peak stress (b = -.21) and recovery (b = -.23). The combination of facial expressivity and decreased cortisol concentration may represent automatic emotion regulation. Additionally, research has shown that males are more successful at automatic emotion regulation (McRae, Ochsner, Mauss, Gagrieli, & Gross, 2008).

Mauss, Cook, Cheng, and Gross (2007) explained that automatic emotion control is an adaptive regulatory strategy and is related to effective reduction in anger. Moon and Lord (2006) identified that pre-attentive processing of emotional stimuli may have a critical role in predicting task performance. This study was performed under the pretense that the conscious processing of emotional stimuli is intrusive to cognitive processing and that automatic emotion regulation may protect working memory and facilitate goal striving. Winkielman and Berridge (2004) found that unconscious affect was powerful enough to modulate the role of thirst (significantly changed drinking activity). Further research should be done to identify differences in individual abilities to utilize automatic emotion regulation. In addition, replication of the finding from this study, that facial muscle contraction may predict changes in risk-taking behavior, is warranted.

3.3.3. Female Fear

The combined contribution of systolic blood pressure, heart rate, and action unit 2 (upper forehead) predicted faster deliberation time [R^2 = .95]. The combined contribution of increase diastolic blood pressure, increased cortisol, and action unit 9 (nose cringe) predicted the selection of less risky options [R^2 = .98]. Increased heart rate, AU 16 (chin) contraction, and subjective fear predicted the inability to inhibit high bets simply because the high proportion bets were presented first [R^2 = .83]. Finally, increases in cortisol and AU 9 contraction predicted placing greater stakes on less risky options [R^2 = .79].

Recall that AU 9 is the only measured site in the current study that participants contracted for a longer period of time in the fear condition as compared to the anger condition. In combination with other physiological and biological changes, AU 9 appears to contribute to the prediction of more conservative risk-taking behavior in females upon fear elicitation. Lerner, Dahl, Hariri, and Taylor (2007) found the intensity of facial expressions of fear predicted increases in cortisol, but the same is not true of temporal duration. However, the temporal duration of contraction for AU 9 and increases in cortisol may together predict safe betting. A different combination of predictors, including subjective fear, emerged to predict impulsive betting or task aversion. Reports of subjective fear reveal an awareness of the fear emotion, and this is thought to be important for predicting impulsive reactions. McRae, Ochsner, Mauss, Gagrieli, and Gross (2008) also reported that females utilize conscious emotion regulation. However, Moon and Lord (2006) explain that conscious processing of emotional stimuli is intrusive to cognitive behavior. This may explain the lack of ability to inhibit a response as a function of increased heart rate, subjective fear, and increased cortisol.

3.3.4. Male Fear

The male group, as a whole, behaved more conservatively in the fear condition than females. However, increased heart rate and less contraction for AU 2, together, predicted overall proportion bets or higher risk taking [R^2 = .68]. This could be a function of unsuccessful emotion regulation or denial of emotions. This finding is difficult to interpret due to a significant positive correlation between heart rate and AU 2 contraction duration [r = .60, p = .02]. Heart rate alone predicted the selection of safe options [R^2 = .29], and AU 7 alone predicted placing greater stakes on less risky options [R^2 = .30]. Therefore, while heart rate contributes to less risky options, it also contributes to taking bigger overall risks.

4.0 CONCLUSION

The current study was designed to assess the ability of facial muscle contraction to reveal information regarding the biological response to fear and anger, as well as assess performance outcomes. The cognitive domain of risk-taking and decision making was selected due to the association of approach and avoidance behavior. It was expected that temporal increases in facial muscle contractions, decreases in the endocrine response, and decreases in cardiac reactivity would lead to greater risk-taking behavior (in combination with the ability to inhibit impulsive betting) in the anger condition. It was also expected that increases in facial muscle contractions, increases in endocrine response, and increases in cardiac reactivity would lead to more conservative risk-taking behavior (in combination with the inability to inhibit impulsive betting) in the fear condition.

The results of this study revealed that temporal increases in facial muscle contraction and decreases in the endocrine response predicted more conservative risk-taking behavior, in combination with the ability to inhibit impulsive betting for males in the anger condition only. In addition, the present study showed that temporal increases in facial muscle contractions, particularly for AU 9 (nose cringe), in combination with increases in endocrine and cardiac reactivity predicted conservative risk-taking behavior in combination with the inability to inhibit impulsive betting for females in the fear condition only.

In general, the present study revealed changes in risk-taking behavior and also revealed that gender differences exist in the factors that influence risk-taking as a function of negative emotion elicitation. With the exception of speed in choice selection, temporal increases in facial muscle contractions appear to only be predictive in combination with increases in endocrine and/or cardiac reactivity for females exposed to fear. However, temporal increases in facial muscle contractions appear to alone account for changes in risk-taking behavior for males exposed to anger. While both scenarios led to more conservative responses, females exposed to fear exhibited an *inability* to inhibit impulsive behavior; this inability to inhibit impulsive behavior was accompanied by a combination of subjective fear, increases in heart rate, and temporal increases in facial contraction. In contrast, angry males exhibited an *ability* to inhibit impulsive behavior, and this ability was accompanied by temporal increases in facial contraction. The combination of facial expressivity and decreased cortisol concentration may represent automatic emotion regulation. Research has shown that males are more successful at automatic emotion regulation (McRae, Ochsner, Mauss, Gagrieli, & Gross, 2008).

Recent efforts to identify successful emotion regulation have focused on automatic emotion regulation, which is a process that occurs without conscious thought and is found to be related to a quick decrease in negative affect during demanding situations (Koole & Coenen, 2007). While a great amount of information regarding affect and decision making was gained from this study, the degree of emotional experience is only half of the emotional stress response. This study only took one assessment following emotion elicitation and did not monitor biomarkers post elicitation. Thus, automatic emotion regulation and conscious emotion regulation could not be studied. It is recommended that further studies include post elicitation assessments and cortical/subcortical brain activation. Neurological evidence has been found differentiating conscious emotional stress appraisals from automatic emotion regulation (Phillips, Ladouceur, & Drevets, 2008). Finally, automatic emotion regulation has also been found to predict successful performance under negative emotional stress (Moon & Lord, 2006).

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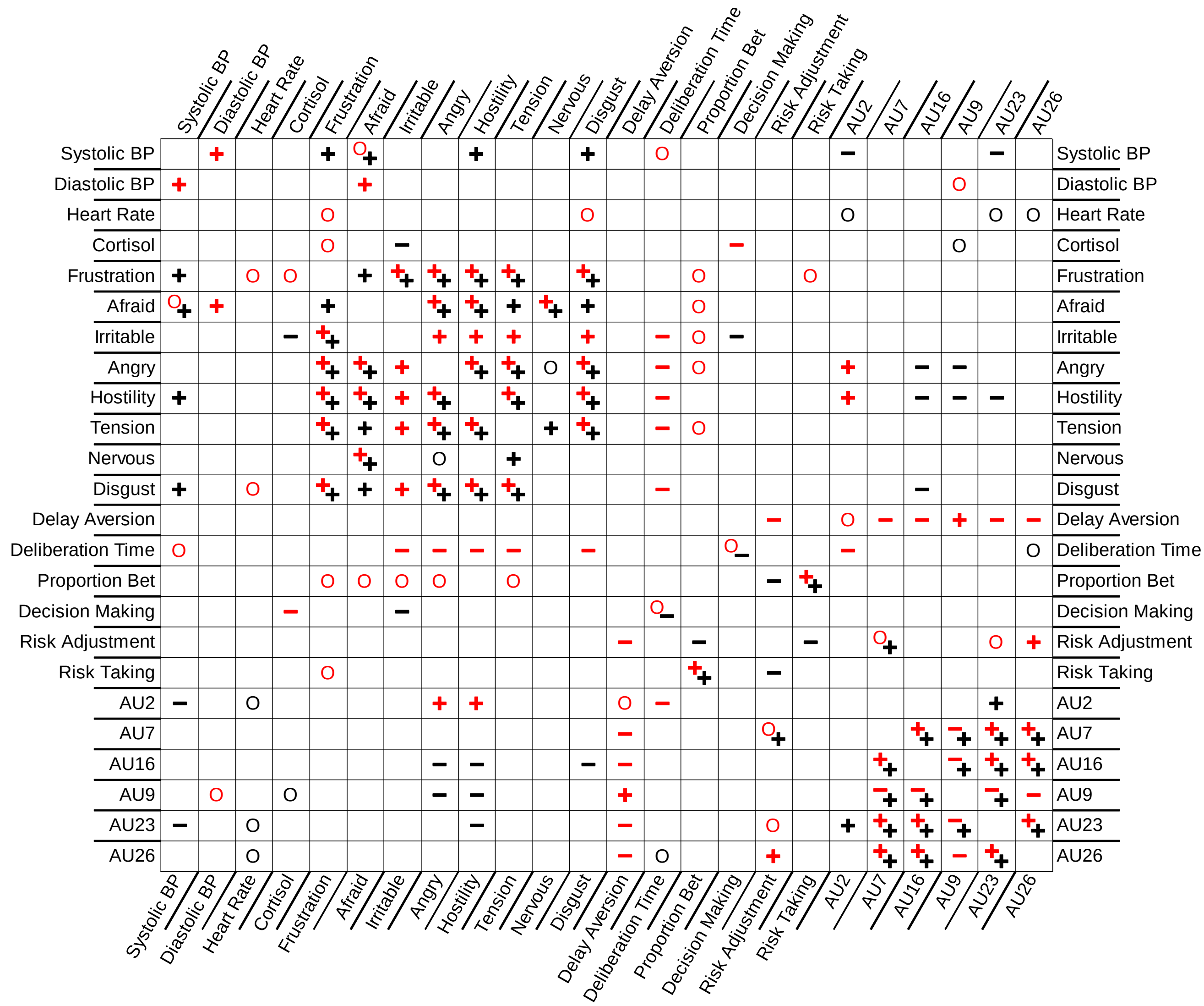
APPENDIX A

In the figure, red is for anger and black is for fear. A significant positive partial correlation has a + symbol while a significant negative partial correlation has a – symbol. If the linear relationship was significantly different between the genders, a circle is shown.



SYMBOLS

RHPB – Human Effectiveness Directorate, Biosciences and Performance Division, Applied Biotechnology Branch

ABBREVIATIONS

fMRI	Functional Magnetic Resonance Imaging
AFSOC	Air Force Special Operations Command
SVU	Special Victims Unit
VAS	Visual Analog Scale
CGT	Cambridge Gambling Task
BLU	Bomb Live Unit
AU	Action Unit
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure

ACRONYMS

SAM	sympathetic-adrenomedullary
CANTABeclipse	Cambridge Neuropsychological Assessment Battery: Eclipse
EMG	Electromyography
ECG	Electrocardiography
FO	Fundamental frequency