AFFECT, RISK-TAKING, AND FINANCIAL DECISIONS: INVESTIGATING THE PSYCHOLOGICAL AND NEURAL MECHANISMS BY WHICH CONSCIOUS AND UNCONSCIOUS AFFECTIVE PROCESSES INFLUENCE DECISIONS

by

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DEDICATION

This dissertation is dedicated to my mother Janet and my grandmother Millie who have provided unconditional love and support to me throughout my studies and life. I also dedicate this dissertation to my aunt Jerry and my grandparents, Asa and Mazie, who are greatly missed. Lastly, I dedicate this dissertation to researchers striving to solve the mysterious puzzle of human emotions.

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ABSTRACT

AFFECT, RISK-TAKING, AND FINANCIAL DECISIONS: INVESTIGATING THE PSYCHOLOGICAL AND NEURAL MECHANISMS BY WHICH CONSCIOUS AND UNCONSCIOUS AFFECTIVE PROCESSES INFLUENCE DECISIONS

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This dissertation consists of three studies designed to elucidate the psychological and neural mechanisms by which affect influences risk-taking in financial decisions. The mechanisms underlying conscious and unconscious affective processes are investigated using multiple methods and approaches from personality and social psychology, cognitive psychology, and affective neuroscience. Results show that affect plays a crucial role in financial decisions and that there may be two interactive systems by which affect influences decisions. The unconscious system exerts valence-based effects on decisions, responds preferentially to implicit measures and implicitly processed affective cues, and is likely mediated predominantly by subcortical brain structures. The conscious system exerts emotion-specific effects on decisions, responds preferentially to explicit measures and mood induction methods that result in more lasting changes in affect, and is likely mediated predominantly by cortical brain structures. Study 1 uses fMRI to examine the effects of subliminally and supraliminally presented positive and negative affective primes on financial risk-taking and neural markers of anticipatory arousal. Results show that happy facial expressions increase financial risk-taking and activation in the nucleus accumbens, an effect that was significantly stronger in unconscious than conscious conditions. Study 2 tests valence-based and emotion-specific theories of risk by using affective primes of the same valence, fearful and angry faces, presented at 3 stimulus durations (subliminal, short, long) and examining their effect on financial risk-taking. Results show that both fearful and angry faces reduce financial risk-taking after short stimulus presentations, but only fearful faces reduce financial risk-taking after long stimulus presentations. Study 3 investigates the role of individual differences in affect on financial risk-taking using implicit versus explicit measures of affect. Individuals high in negative affect as measured through two versions of a mood implicit association test made more safe bond choices on an investment task whereas explicit measures of individual differences in affect had no effect on financial risk-taking. Taken together, these findings provide support for the idea of a dual process model of risk.

CHAPTER I

INTRODUCTION

Research on judgment and decision making is moving away from the idea that most decisions are purely cognitive in nature, involving the rational and deliberate calculation of costs and benefits for all potential alternatives. Recently, the field has seen a proliferation of lesion, pharmacological, psychophysiological, and functional neuroimaging (fMRI) studies to demonstrate that many decisions, particularly those involving a high degree of risk or uncertainty, involve more subtle processes that depend upon emotion. For example, research indicates that anticipated emotions, such as regret, play a role in risky decision making (Mellers, Schwarz, Ho, & Ritov, 1999). Other researchers have found that affect can directly influence risk estimates (Johnson & Tversky, 1983; Lerner & Keltner, 2001). In addition, Finucane and colleagues (2000) provide evidence for an affect heuristic, the idea that affect helps individuals to respond more efficiently in many decisions, particularly when the decision is complex or cognitive resources are limited.

The interaction between affect and cognition has been prominent in dual-process models of information processing, which make distinctions between automatic or affect-based modes of processing and more controlled, cognition-based modes (Epstein, 1994). Slovic and colleagues (2005) proposed a dual-process model for how risks are evaluated, which they termed “risk-as-analysis” and “risk-as-feelings.” These two modes of processing interact, but respond to different characteristics of a situation with the cognitive mode sensitive to outcomes and probabilities and the feelings mode sensitive to affective considerations. This dual-process approach to risky decision making is consistent with the “risk-as-feelings” hypothesis, which argues that affect influences decision making through the interaction with cognition (Loewenstein et al., 2001).

This dissertation seeks to test the dual-process approach to risky decisions by investigating how both conscious and unconscious affective processes influence financial risk-taking and the neural systems associated with anticipatory affect during choice in three papers. Affect is experimentally manipulated in the first two studies through the presentation of subliminal and supraliminal affective primes. In the third study, affect is measured using individual difference measures consisting of implicit methods in addition to explicit, self-report measures. Study 1 uses fMRI in combination with subliminally and supraliminally presented happy, angry, and neutral affective primes and a dynamic financial investment task. This chapter is formatted as a brief report for journal submission. Study 1 reviews evidence from the field of neuroeconomics and presents three main findings. First, both conscious and unconscious happy affective primes lead to increases in financial risk-taking. Second, both conscious and unconscious happy affective primes lead to increased activation in the nucleus accumbens, a neural marker associated with positive anticipatory arousal. In addition, conscious and unconscious angry affective primes lead to greater activation in the insula, a neural marker associated with negative anticipatory arousal. Third, nucleus accumbens activation is stronger after unconscious than conscious happy affective primes.

Study 2 contrasts valence-based versus emotion-specific approaches using fearful, angry, and neutral affective primes presented at three durations: subliminal (30 msec), short (230 msec), and long (1000 msec). Whereas both fearful and angry affective primes reduced financial risk-taking after short stimulus presentations, only fearful affective primes reduced financial risk-taking after long stimulus presentations, demonstrating that shorter affective cues have a valence-based effect on risk-taking while longer cues have an emotion-specific effect.

Study 3 builds upon the previous two dissertation studies and attempts to replicate the affective priming effects seen in Studies 1 and 2 using a larger sample size. This study investigates the role of individual differences in affect on financial risk-taking and contrasts the effectiveness of implicit versus explicit measures in assessing the role of affect in decision making. This study replicates the results seen in Study 1: happy affective primes led to increases in financial risk-taking relative to neutral, angry, and fearful affective primes. Furthermore, individuals high in negative affect as measured through two versions of a mood implicit association test made more safe bond choices on a financial investment task. Individual differences in positive and negative affect measured through commonly used explicit, self-report measures had no effect on financial risk-taking. These findings highlight the potential benefit of adding implicit measures to study the mechanisms by which affect influences decision making.

Taken together, these three studies demonstrate that affect plays an important role in influencing financial decisions and neural markers of anticipatory arousal, particularly at an unconscious level. Results imply that individuals may be able to improve the quality of their financial decisions by becoming more aware of their affective states and learning to manage affective states that lead to errors in investment choices. Results also suggest that unconscious and implicit measures of affect may serve as excellent additions to studies that traditionally use explicit, self-report measures of affect, which require individuals to describe affective states they may not consciously be aware of or willing to report.

The studies in this dissertation advance a model for affect and decision making that brings together research findings employing multiple methods and approaches, which illustrate the effects of positive and negative affective primes in increasing and decreasing financial risk-taking, respectively. First, they clarify how affective primes influence decision making, specifically financial risk-taking on an investment task. Second, they help to better understand how affective primes influence activity in neural markers associated with anticipatory arousal. Third, they illustrate that affective primes can influence financial risk-taking even when they are presented unconsciously. Fourth, they demonstrate that shorter affective cues have a valence-based effect on risk-taking whereas longer affective cues have an emotion-specific effect on risk-taking. Fifth, they indicate that implicit measures of individual differences in affect are more strongly associated with financial risk-taking behavior than explicit measures.

In addition to illustrating the important role of affect in financial decision making, this dissertation examines both conscious and unconscious affective processes measured through the experimental manipulation of affect and through implicit and explicit individual difference measures of affect to illustrate how affect influences the psychological and neural mechanisms involved in financial decision making. Findings from this dissertation suggest that there may be two interactive systems by which affect influences financial decisions: an explicit, conscious affective system which can best be investigated through mood induction methods and self-report measures of affect and an implicit, unconscious affective system which can best be studied through implicit measures of affect, such as implicitly processed facial expressions and measures such as implicit association tests.

References

Epstein, S. (1994). Integration of the cognitive and psychodynamic unconscious. *American Psychologist, 49,* 709-724.

Finucane, M. L., Alhakami, A., Slovic, P., & Johnson, S. M. (2000). The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making, 13.* 1-17.

Johnson, E. J., & Tversky, A. (1983). Affect, generalization, and the perception of risk. *Journal of Personality and Social Psychology, 45(1).* 20-31.

Lerner, J. S., & Keltner, D. (2001). Fear, anger, and risk. *Journal of Personality & Social Psychology, 81(1),* 146-159.

Loewenstein, G., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin, 127,* 267-286.

Mellers, B., Schwarz, A., Ho, K., & Ritov, I. (1999). Decision affect theory: Emotional reactions to the outcomes of risky options. *Psychological Science, 8,* 423-429.

Slovic, P., Peters, E., Finucane, M. L., & MacGregor, D. G. (2005). Negative affect, risk, and decision making. *Health Psychology, 24,* 35-40.

CHAPTER II

THE EMOTIONS OF INVESTMENTS: FMRI EVIDENCE FOR THE ROLE OF UNCONSCIOUS AFFECT ON FINANCIAL DECISIONS

Coauthored with Richard D. Gonzalez, Chandra Sripada, and Oliver C. Schultheiss

Economic models have focused on decision making as a cognitive process involving the cold, rational calculation of expected utility. However, humans often make irrational decisions in their personal and professional lives – behavior that cannot always be explained even by relaxing the rational model to include cognitive biases and limitations. In the last decade, cognitive and affective neuroscience research using lesion patients, psychophysiology, and fMRI has demonstrated that decisions involving risk or uncertainty utilize subtle, implicit affective processes. However, the mechanisms by which these processes influence decisions remain unclear.

Research evidence shows that positive affect leads to optimistic risk estimates and increased risk-taking, such as purchasing behavior, whereas negative affect promotes pessimistic risk estimates and risk-averse behavior, such as selling (*1*-*4*). Research has identified affect as a likely cause of market price anomalies. For example, sunshine increases positive affect and leads to greater stock index returns whereas cloud cover has the opposite effect and reduces purchasing behavior (*5*).

Research has indicated that basic positive and negative affective reactions may be elicited by affective primes (i.e., facial expressions of emotion) even when they are not consciously perceived by the observer (*6, 7*). Facial expressions of emotion are potent, social cues that are processed by core affective neurobiological systems (*8, 9*). The affective reactions elicited by facial expressions of emotion have effects on judgments and behavior as well as physiological and neural consequences even when they are presented subliminally (*6, 7, 10-12*).

Recent evidence from the field of cognitive neuroscience demonstrates the role of emotion in decision making (*13, 14*). Patients with damage in neural systems subserving emotion take risks on gambling and investment tasks even when they result in huge losses. For example, Bechara and colleagues (*13*) found that patients with ventromedial prefrontal cortex lesions were more likely than healthy controls to choose card decks with large initial rewards, but greater subsequent losses presumably because they failed to generate anticipatory skin conductance responses associated with losses in the disadvantageous decks. Furthermore, Shiv and colleagues (*14*) found that patients with lesions in brain regions subserving emotion were less affected than healthy controls or patients with lesions in brain regions unrelated to emotion by how much they won or lost on an investment task in previous rounds.

In the neuroeconomics literature, recent fMRI studies have shown distinct neural markers linked to the anticipation of gains and losses (*15-20*). Specifically, activation of the nucleus accumbens (NAcc) has been implicated as a neural marker of positive anticipatory arousal and activation of the insula as a neural marker of negative anticipatory arousal. Studies have shown that the anticipation of both monetary and nonmonetary rewards, such as erotic images, increases activation in the NAcc (*15-18*) while the insula shows activation during the anticipation of losses and risk-averse choices (*18-20*).

The insula also shows activation when people crave drugs, empathize with others, feel pain, and eat chocolate, for example (*21-24*). Converging evidence from disparate findings suggests that the insula reads the physiological state of the body and generates subjective feelings that keep the body in balance. Information from the insula is relayed to multiple brain regions including those involved in decision making, particularly the anterior cingulate and prefrontal cortex.

The NAcc is considered to be involved with the integration of information related to cognitive, sensory, and emotional processing. Converging evidence from electrophysiological, pharmacological, lesion, and functional imaging studies suggests that the NAcc mediates functions involved in both reward and aversion (*25*). While the NAcc has traditionally been linked with reward, research has found that aversion induced by a painful stimulus activates the NAcc (*26, 27*). Although the NAcc is only one component of the reward system, it appears to play a crucial role in hedonic state and motivated behavior by evaluating stimulus valence.

Neuroimaging research further indicates that activation in neural markers of anticipatory affect is associated with self-reported measures of positive and negative aroused affect (*19*, *28*, *29*). For example, Bjork and colleagues (*28*) found that activation in the NAcc during the anticipation of monetary gains was associated with self-reports of excitement about the gain cue. Similarly, Knutson and colleagues (*29*) found that NAcc activation to anticipated gain probability was correlated with self-reports of positive affect. In addition, Paulus and colleagues (*19*) found that anterior insula activation during risky choices was correlated with trait measures of negative affect.

The current study investigates the influence of conscious versus unconscious affective processes on financial risk-taking and anticipatory neural activity in the NAcc and insula. We predict that positive affective primes (i.e., happy faces) will be associated with greater financial risk-taking and increased activation of the NAcc, that negative affective primes (i.e., angry faces) will be associated with decreases in financial risk-taking and increased activation of the insula, and that the effect of unconscious affective primes on financial risk-taking and neural markers of anticipatory arousal will be as strong, if not stronger, than the effects of conscious affective primes. In contrast to previous neuroeconomics studies investigating the role of emotion in decision making, the current study directly manipulates affect through subliminally and supraliminally presented affective primes (i.e., happy, angry, and neutral faces).

Method

Twenty-four undergraduate students aged 18-25 participated in this study, including 12 men and 12 women (18 Caucasian, 4 African American, 2 Asian American). Participants were excluded from participation if they were left-handed, below the age of 18, not native English speakers, were pregnant, had any metal in their bodies, had a current or past diagnosis of a psychiatric disorder, or were currently using any psychoactive medications. Participants gave informed consent in compliance with the Institutional Review Board guidelines at the University of Michigan. They received $50 for their participation plus their winnings if they performed in the top 10 percentile on the investment task.

Participants completed a practice version of the experimental task before entering the scanner. Using a mixed block and event-related fMRI design, participants completed 4 runs of affective priming trials in the following order: unconscious, conscious, unconscious, conscious. Each run consisted of 8 blocks of 6 trials each for a total of 192 trials per session. As shown in Figure 2.1, conscious affective priming trials consisted of a 230-ms supraliminal affective prime immediately followed by a 1000-ms investment task. Unconscious affective priming trials consisted of a 30-ms subliminal affective prime followed by a 200-ms scrambled face mask, which was immediately followed by a 1000-ms investment task.

Sixteen color photographs of faces (8 men, 8 women) were used from the NimStim Face Stimulus Set (*30*). We used a happy, an angry, and a neutral face photograph of each individual in addition to12 trials of an additional control ('No Face') condition consisting of a plain black background.

After each affective prime, participants completed a modified version of the Behavioral Investment Allocation Strategy task (BIAS: *18*), which required participants to decide among two risky, high-payoff stocks and a safe, low-payoff bond (Figure 2.1). We decreased the monetary outcomes of the stock choices and increased the monetary outcome of the bond choice in the BIAS task from the original study in order to avoid a floor effect of the bond choice as suggested by preliminary data collection.

Without the participants' knowledge, one of the two stocks was randomly assigned to be the "good" stock while the other was assigned to be the "bad" stock at the beginning of each affective priming block. For the good stock, participants win $5 with 50% probability, lose $5 with 25% probability, and no change with 25% probability. For the bad stock, participants lose $5 with 50% probability, win $5 with 25% probability, and no change with 25% probability. The bond pays $3 with 100% probability.

Imaging parameters:

Images were acquired with a 3T General Electric MRI scanner. Twenty-nine axial slices (4 mm thick) were collected from the mid-pons to the top of the skull. Functional scans were acquired with a T2* sensitive gradient echo spiral-in/out pulse sequence (TR = 2 s, TE = 40 ms, flip angle = 90°, FOV = 24 cm) to minimize signal dropout in subcortical regions of interest (*31*).

Data analysis:

For the behavioral data, percentages of risky stock choices relative to safe bond choices were calculated for the 'Happy Face,' 'Angry Face,' and 'Neutral Face' conditions during both 'Unconscious' and 'Conscious' conditions. For the fMRI data, participants' functional volumes were realigned to the first scan and co-registered to their anatomical MRI using statistical parametric mapping software (SPM2; Wellcome Department of Imaging Neuroscience, University College London, UK). Default SPM2 settings were used to warp volumetric MRIs to fit a standardized template and normalized parameters were applied to participants' co-registered functional images. Images were smoothed with a 6 mm kernel. Contrasts were created between conditions of interest (e.g., 'Happy Face' vs 'Neutral Face,') during the 'Pre-Choice' stage of the investment task. Spherical 8 mm diameter VOIs based on MNI coordinates from previous studies on risk and decision making generated our a priori ROIs, the NAcc and insula, with an uncorrected threshold of $p < .05$ and an extent threshold of 10 voxels.

Results

Behavioral data

Participants made more risky stock choices after happy than neutral faces during conscious trials, $t(23) = 2.46$, $p = .022$, and unconscious trials, $t(23) = 2.18$, $p = .040$. However, participants were not more likely to make more safe bond choices after angry than neutral faces, $t(23) = -0.56$, NS. The affect × consciousness interaction did not reach statistical significance. The percentage of risky stock choices as a function of affect and consciousness is shown in Figure 2.2.

fMRI data

NAcc activation was greater during the 'Happy Face' relative to the 'Neutral Face' contrast (38 voxels in right NAcc, peak at [9 9 -3], $p < .01$), but was not greater in the 'Angry Face' vs 'Neutral Face' contrast. NAcc activation was significantly stronger during 'Unconscious Happy Face' versus 'Conscious Happy Face' trials (Figure 2.3a, right NAcc, peak at [9 7 -9], $p < .01$).

Insula activation was greater during the 'Angry Face' condition relative to the 'Neutral Face' condition (14 voxels in right insula, peak at [36 3 12], $p < .01$ (Figure 2.3b), but insula activation was not greater in the 'Happy Face' vs 'Neutral Face' contrast. These insula ROI analyses did not differ across 'Unconscious Angry' and 'Conscious Angry' trials.

Financial risk-taking was positively correlated ($r = .41$, $p < .05$) with NAcc activation during 'Happy Face' vs 'Neutral Face' trials (Figure 2.4a). Conversely, financial risk-taking was negatively correlated ($r = -.38$, $p < .05$) with insula activation during 'Angry Face' vs 'Neutral Face' trials (Figure 2.4b). NAcc activation was not greater during the 'Angry Face' vs 'Neutral Face' contrast. Our results indicate a double dissociation between neural responses in the NAcc and insula in response to 'Happy Face' vs 'Angry Face' affective primes.

Discussion

This study investigated how affect can both consciously and unconsciously influence financial investment decisions and neural markers of anticipatory affect. As predicted, participants made riskier investment decisions after happy versus neutral face primes in both conscious and unconscious conditions. They showed more NAcc activation after happy versus neutral face primes, an effect that was significantly stronger for unconscious versus conscious primes. Financial risk-taking was positively correlated with NAcc activation during happy face trials. These findings show that positive affective cues, even when they are unconscious, can influence financial risk-taking and may do so through the nucleus accumbens, a neural marker for positive anticipatory affect (*15, 16, 18*).

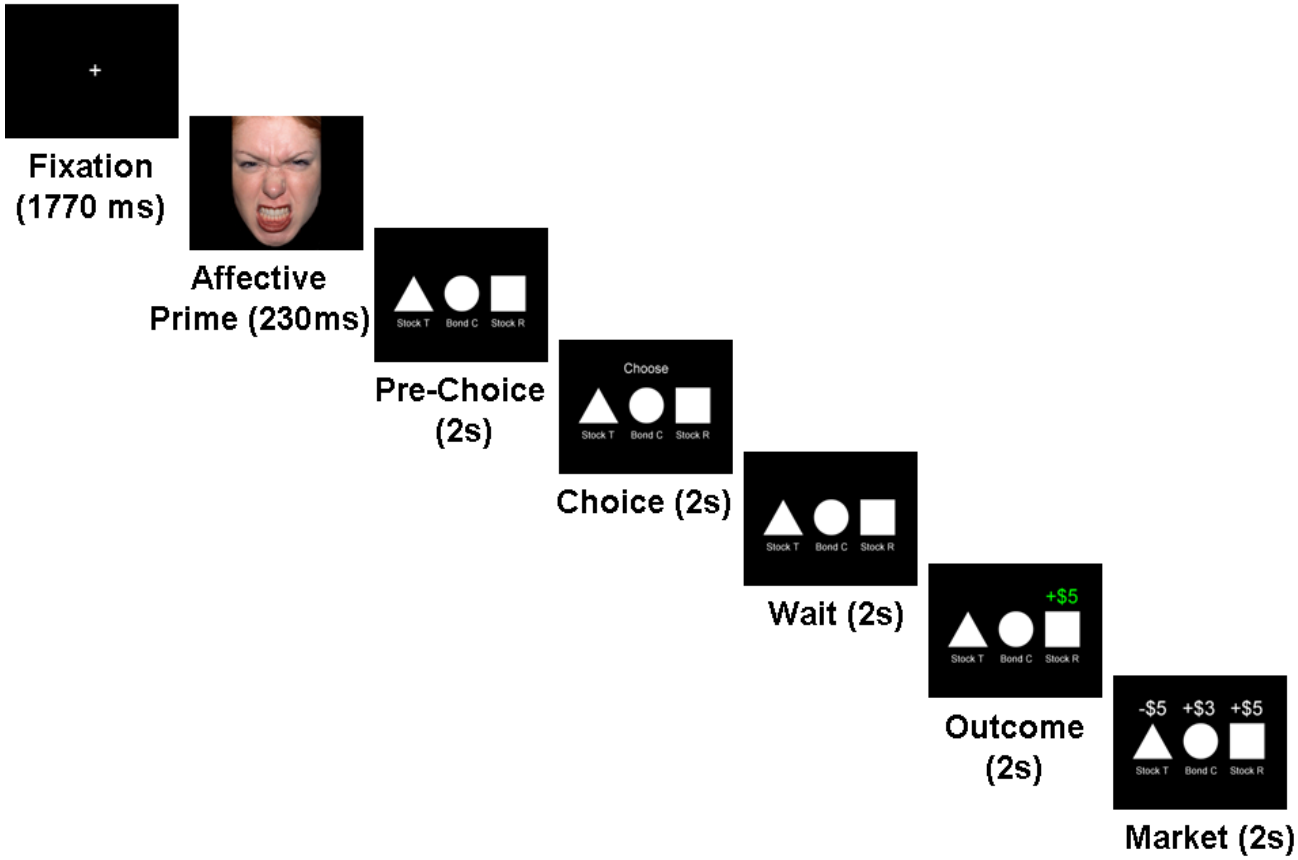
Negative affective primes led to increases in insula activation in both conscious and unconscious conditions. Financial risk-taking was negatively correlated with insula activation during negative affective priming trials. These results suggest that negative affective cues may increase activation in the insula, a neural marker associated with negative anticipatory affect (*18-20*). Contrary to our predictions, negative affective primes did not produce changes in risk-taking behavior.

This study shows that affective cues, even when they are not consciously perceived, can influence financial risk-taking and may do so through neural markers of anticipatory affect. Previous research found correlations between activation in neural markers of anticipatory affect and decisions on investment and gambling tasks in which feedback on each trial could guide behavior on the next trial. However, our study used affective cues that had no relation to the earnings on the task, thus could not be used to guide future behavior.

Our findings have broad implications for the use of affective cues in marketing and financial arenas. They may explain why casinos are so effective in getting customers to engage in risk-taking behavior. Our model argues that the positive affective cues (e.g., cheap hotel rates, free alcohol and gifts, attractive dancers and staff) abundant in the casino environment increase activate the NAcc and increase positive anticipatory affect. Conversely, insurance companies use negative affective cues in their commercials (e.g., fear-inducing car crashes and funeral scenes). These ads may be effective in decreasing risk-taking behavior by activating the insula and increasing negative anticipatory affect.

This research implies that individuals can improve the quality of their financial decisions by learning to recognize and manage affective states that lead to errors in investment choices (e.g., overconfidence after gains, anxiety after losses). Unconscious measures of affect may serve as excellent alternatives or additions to traditional conscious and self-report measures of affect in studying decision making.

Figure 2.1



+
Fixation
(1770 ms)
Affective
Prime (230ms)
Stock T
Bond C
Stock R
Pre-Choice
(2s)
Choose
Stock T
Bond C
Stock R
Choice (2s)
Stock T
Bond C
Stock R
Wait (2s)
+$5
Stock T
Bond C
Stock R
Outcome
(2s)
-$5
+$3
+$5
Stock T
Bond C
Stock R
Market (2s)

Figure 2.2

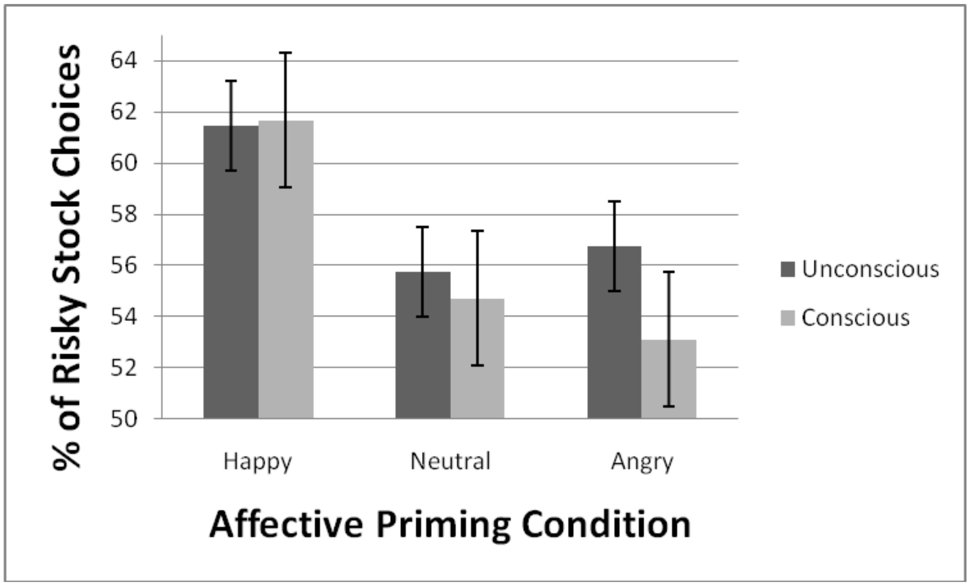

% of Risky Stock Choices
64
62
60
58
56
54
52
50
Happy
Neutral
Angry
Affective Priming Condition
Unconscious
Conscious

Figure 2.3a

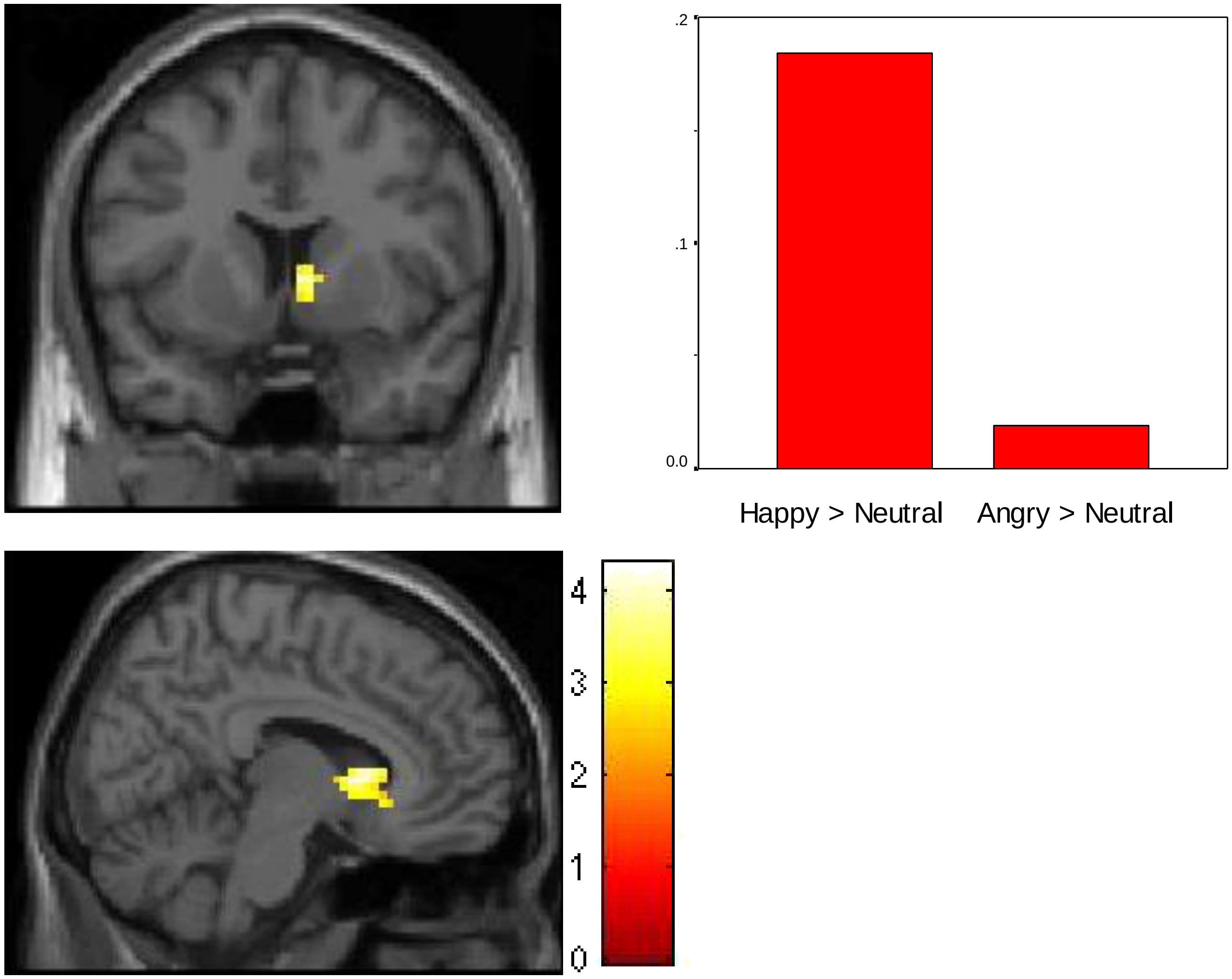


Figure 2.3b

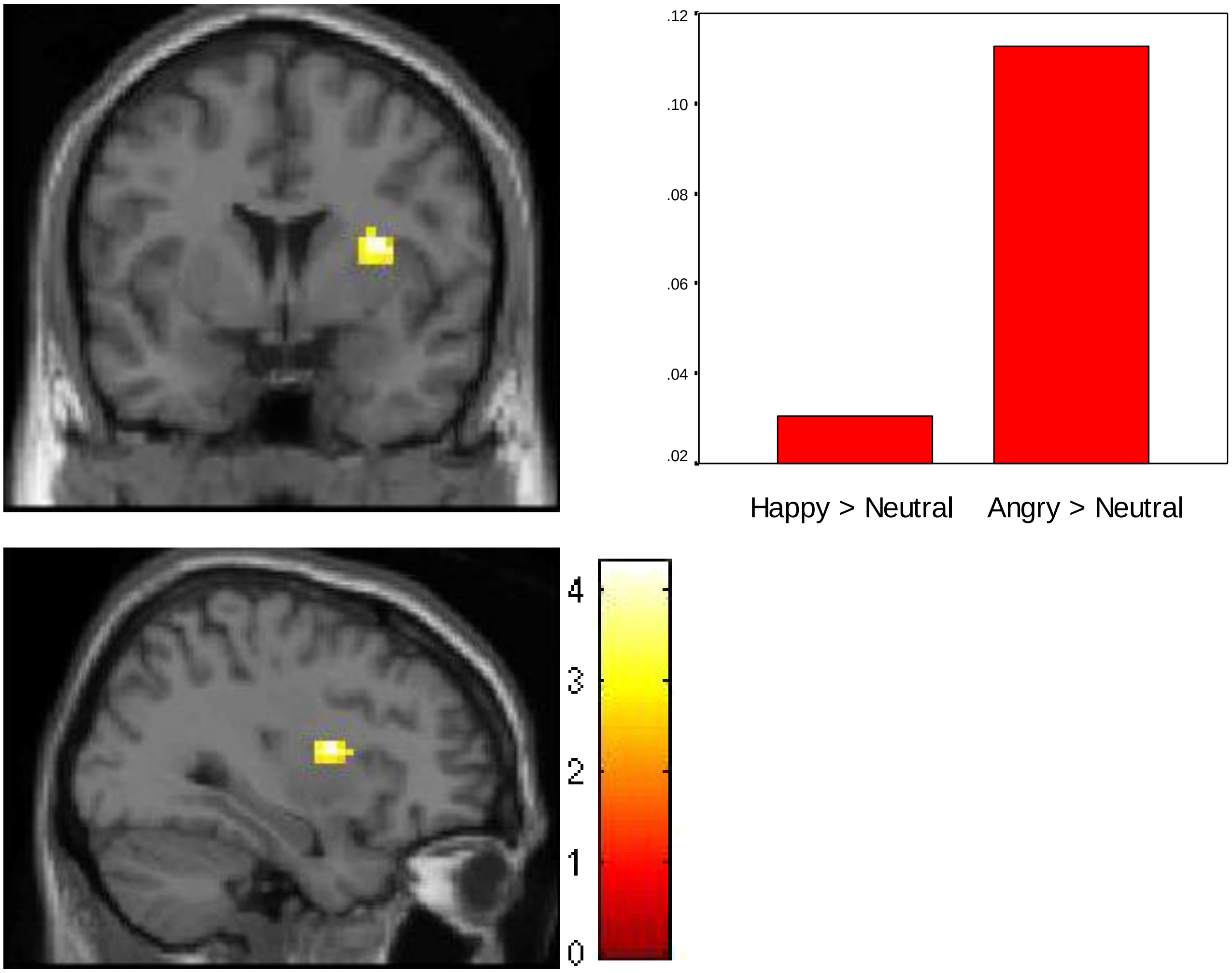


Figure 2.4a

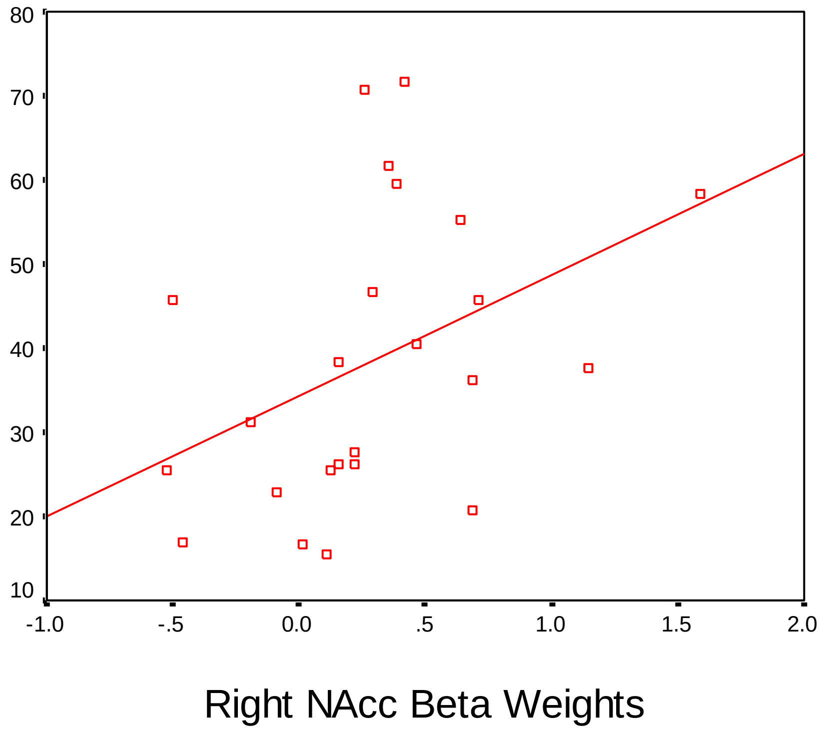
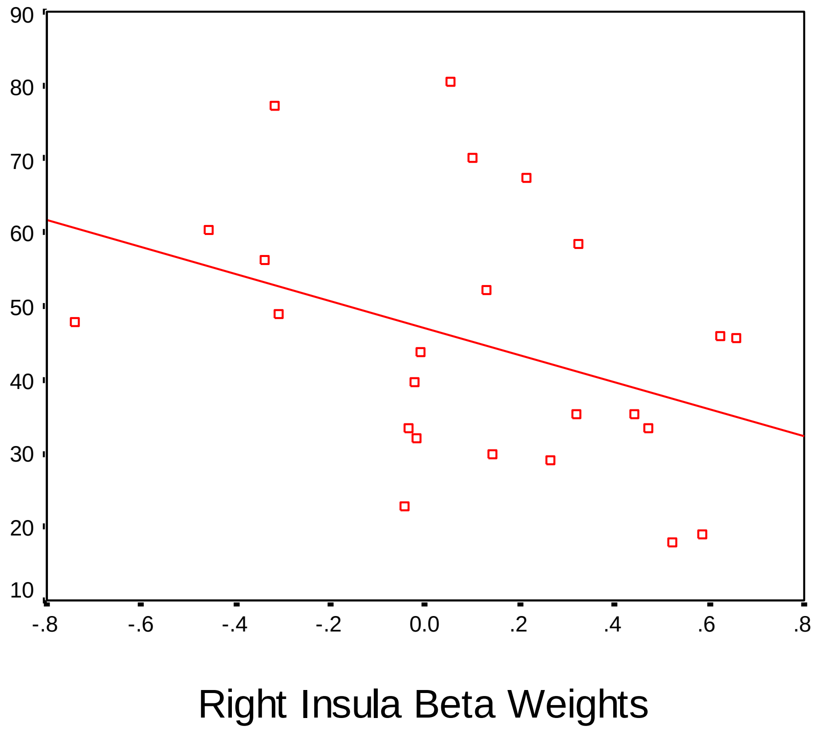


Figure 2.4b


90
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40
30
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-.8
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-.4
-.2
0.0
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.4
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.8
Right Insula Beta Weights

References

1 W. Wright, G. Bower, *Organizational Behavior and Human Decision Processes* **52**, 276 (1992).

2 E. Johnson, A. Tversky, *J. Pers. Soc. Psychol.* **45**, 20 (1983).

3 N. Schwarz, G. Clore, *J. Pers. Soc. Psychol.* **45**, 513 (1983).

4 J. Lerner, D. Keltner, *J. Pers. Soc. Psychol.* **81**, 146 (2001).

5 D. Hirshleifer, T. Shumway, *J. Finance* **58**, 1009 (2003).

6 S. Murphy, R. Zajonc, *J. Pers. Soc. Psychol.* **64**, 723 (1993).

7 P. Winkielman, K. Berridge, J. Wilbarger, *Pers. Soc. Psychol. Bull.* **31**, 121 (2005).

8 R. Adolphs, *Behav. Cogn. Neurosci. Rev.* **1**, 21 (2002).

9 P. Ekman, *Approaches to Emotion* (Lawrence Erlbaum, Hillsdale, NJ, 1984).

10 P. Niedenthal, *J. Exp. Soc. Psychol.* **26**, 505 (1990).

11 M. Rotteveel, P. de Groot, A. Geutskens, R. Phaf, *Emotion* **1**, 348 (2001).

12 P. Whalen, S. Rauch, N. Etcoff, S. McInerney, M. Lee, M. Jenike, *J. Neurosci.* **18**, 411 (1998).

13 A. Bechara, H. Damasio, D. Tranel, A. Damasio, *Science* **275**, 1293 (1997).

14 B. Shiv, G. Loewenstein, A. Bechara, H. Damasio, A. Damasio, *Psychol. Sci.* **16**, 435 (2005).

15 H. Breiter, I. Aharon, D. Kahneman, A. Dale, P. Shizgal, *Neuron* **30**, 619 (2001).

16 B. Knutson, C. Adams, G. Fong, D. Hommer, *J. Neurosci.* **21**, RC159 (2001).

17 B. Knutson, G. Wimmer, C. Kuhnen, P. Winkielman, *Neuroreport* **19**, 509 (2008).

18 C. Kuhnen, B. Knutson, *Neuron* **47**, 763 (2005).

19 M. Paulus, C. Rogalsky, A. Simmons, J. Feinstein, M. Stein, *Neuroimage* **19**, 1439 (2003).

20 J. Nitschke, I. Sarinopoulos, K. Mackiewicz, H. Schaefer, R. Davidson, *Neuroimage* **29**, 106 (2006).

21 N. Naqvi, D. Rudrauf, H. Damasio, A. Bechara, *Science.* **315**, 531 (2007).

22 T. Singer, B. Seymour, J. O'Doherty, H. Kaube, R. Dolan, C. Frith, *Science.* **303**, 1157 (2004).

23 A. Ploghaus, I. Tracey, J. Gati, S. Clare, R. Menon, P. Matthews, J. Rawlins, *Science.* **284**, 1979 (1999).

24 D. Small, R. Zatorre, A. Dagher, A. Evans, M. Jones-Gotman, *Brain: A J. of Neurology.* **124**, 1720 (2001).

25 K. Berridge, T. Robinson, *Trends Neurosci,* **26,** 507 (2003).

26 I. Aharon, L. Becerra, C. Chabris, D. Borsook, *Neurosci Lett,* **392,** 159 (2006).

27 L. Becerra, H. Breiter, R. Wise, R. Gonzalez, R., D. Borsook, *Neuron,* **32,** 927 (2001).

28 J. Bjork, B. Knutson, G. Fong, D. Caggiano, S. Bennett, D. Hommer, *J. Neurosci.* **24**, 1793 (2004).

29 B. Knutson, J. Taylor, M. Kaufman, R. Peterson, G. Glover, *J. Neurosci.* **25**, 4806 (2005).

30 N. Tottenham, A. Borscheid, K. Ellertsen, D. Marcus, C. Nelson, *J. Cogn. Neurosci.* **14**, S74 (2002).

31 G. Glover, C. Law, *Magnetic Resonance in Medicine* **46**, 515 (2001).

CHAPTER III

INVESTIGATING THE EFFECTS OF FEARFUL VERSUS ANGRY AFFECTIVE PRIMES ON FINANCIAL RISK-TAKING: EVIDENCE FOR VALENCE-BASED EFFECTS AT SHORTER STIMULUS DURATIONS AND EMOTION-SPECIFIC EFFECTS AT LONGER STIMULUS DURATIONS

Although many prominent researchers have argued that emotions are primarily conscious (Clore, 1994; Frijda, 1999), recent evidence demonstrates that affective processes can also be unconscious. Several studies have found evidence that basic affective reactions may be elicited by stimuli presented implicitly or outside of conscious awareness, such as facial expressions of emotion (Murphy & Zajonc, 1993; Winkielman, Berridge, & Wilbarger, 2005a). Facial expressions of emotion are potent and highly familiar social cues that are processed by core affective neurobiological systems (Ekman, 1984). The processing of facial expressions of emotion can occur implicitly, such as when participants are told to focus on some irrelevant dimension, such as the gender of the face (Critchley et al., 2000).

Several lines of research suggest that subliminally or implicitly presented facial expressions elicit affective reactions with judgmental (Murphy & Zajonc, 1993; Niedenthal, 1990; Winkielman et al., 2005a), physiological (Rotteveel, de Groot, Geutskens, & Phaf, 2001), and neural (Whalen et al., 1998) consequences. Furthermore, the effects of these facial expressions still occur even when there are no changes in subjective feelings, which suggests mediation through direct and automatic processes as opposed to judgments based on subjective feelings (Winkielman, Zajonc, & Schwarz, 1997). The effects of subliminal affective primes seem to be differentiated based on general positive or negative valence rather than emotion specificity (Zajonc, 2000). For example, Winkielman and colleagues (2005b) found that subliminal presentations of different negative facial expressions of the same valence (i.e., fearful and angry faces) both led to similar decreases in preference ratings and similar physiological responses.

Current theories of emotion argue that implicitly processed facial expressions of emotion should activate a general positive or negative affect system (Cacioppo & Berntson, 1999; Panksepp, 1998; Zajonc, 2000). Specifically, positive facial expressions of emotion, such as happy faces, should activate the positive affect system while negative facial expressions of emotion, such as fearful and angry faces, should activate the negative affect system. On the other hand, differentiated effects of specific positive or negative facial expressions should require longer stimulus durations and more cognitive processing of the facial expression and context. Thus, subliminal presentations of negative facial expressions should increase risk-avoidant choices while subliminal presentations of positive facial expressions should decrease risk-avoidant choices regardless of the specific emotion depicted in the facial expression. On the other hand, facial expressions of emotion presented under longer stimulus durations should have an emotion-specific effect.

Previous research has shown that subliminally or implicitly presented facial expressions of emotion influence judgments (Murphy & Zajonc, 1993; Niedenthal, 1990;

Winkielman et al., 2005a), physiological responses (Rotteveel, de Groot, Geutskens, & Phaf, 2001), and neural activation (Whalen et al., 1998). For example, Niedenthal (1990) found that subliminal facial expressions of joy had a positive effect on preference ratings for cartoon characters whereas disgust faces had a negative effect. Similarly, Murphy and Zajonc (1993) showed that subliminally presented happy faces increased preferences for subsequent Chinese ideographs whereas subliminally presented angry faces decreased these preferences. Furthermore, Winkielman and colleagues (2005a) found that subliminally presented happy faces increased the pouring and consumption of a novel beverage and the perception of the beverage value whereas subliminally presented angry faces had the opposite effect. Using facial EMG, Rotteveel and colleagues (2001) found that subliminally presented angry faces were associated with more frowning to ideographs than happy faces. Furthermore, neuroimaging research has shown that subliminally presented fearful faces activate the amygdala even in the absence of explicit knowledge that the stimuli were presented (Whalen et al., 1998). In summary, research on the effects of subliminally presented facial expressions of emotion indicates that they are capable of eliciting basic affective reactions with judgmental, physiological, and neural consequences even when they do not elicit changes in subjective feelings.

Considerable evidence also shows that positive moods lead to optimistic, risk-taking behavior whereas negative moods promote pessimistic, risk-avoidant behavior. For example, Wright and Bower (1992) found consistent mood effects on subjective probability judgments. After a positive mood induction, participants overestimated the likelihood of positive events and underestimated the likelihood of negative effects. Participants in the negative mood induction condition showed the opposite effect.

Similarly, Johnson and Tversky (1983) found that participants who read tragic newspaper reports were more likely to give higher estimates of risk for a variety of potential causes of death and other undesirable events compared to participants reading happy newspaper reports. Furthermore, Schwarz and Clore (1983) found that participants in a positive mood report more happiness and life satisfaction than participants in a negative mood.

In contrast to a valence-based approach, several research groups have investigated the influence of specific emotions on decision making using experimental manipulations of affect. Many studies have focused on fear and anxiety and found that they lead to risk-avoidant judgments and choices (Lerner & Keltner, 2001; Raghunathan & Pham, 1999). For example, Raghunathan and Pham (1999) found that anxious affective mood states led to increases in preferences for low-risk, low-reward options in gambling and job-selection decisions whereas sad affective mood states had the opposite effect. Similarly, Lerner and Keltner (2001) found that fearful people made relatively pessimistic estimates about future events and made more risk-avoidant choices. On the other hand, angry people expressed risk assessments more similar to those of happy people in that they made optimistic risk assessments and engaged in more risk-taking choices (Lerner & Keltner, 2001).

The current study builds upon previous research by investigating valence-based and emotion-specific approaches to decision making using facial expressions of emotion of the same valence (i.e., fearful and angry faces) presented under three stimulus durations: subliminal (30 msec), short (230 msec), and long (1000 msec). Prior research has either investigated general valence effects or the effects of specific emotions on preferences using experimental manipulations of affect designed to elicit a change in subjective feelings. In contrast, the current study provides a direct test of valence-based versus emotion-specific approaches using two different types of facial expressions of emotions of the same valence (i.e., fearful and angry faces) presented both implicitly and long enough for conscious awareness and cognitive processing to occur.

Based on evidence from previous research on facial expressions of emotion, we predict that facial expressions will have a valence-based effect on decision making when presented implicitly at shorter durations (i.e., 30 msec, 230 msec) whereas facial expressions presented at longer durations (i.e., 1000 msec) will have an emotion-specific effect on decision making. Implicitly presented facial expressions of fear and anger will activate a general negative affect system, and will thus increase risk-avoidant choices relative to neutral facial expressions. However, facial stimuli presented for longer durations will show emotion-specific effects on decision making. Specifically, fearful faces will increase risk-avoidant choices whereas angry faces will have no effect on financial risk-taking.

Method

Participants:

Sixty-seven undergraduate students from the Introduction to Psychology subject pool at the University of Michigan participated in this study. Participants provided informed consent in compliance with the Institutional Review Board guidelines of the University of Michigan. They received course credit for their participation.

Procedure:

Experimental task. Participants completed a practice version of the experimental task before the actual task began in order to learn the instructions and structure of the investment task. Each participant completed 12 trials of each of the 3 affective prime conditions (fearful face, angry face, neutral face) under each of the 3 stimulus duration conditions (subliminal, short, long) in counterbalanced order for a total of 108 trials. Subliminal affective priming trials consisted of a 30 msec affective prime followed by a 200 msec scrambled face mask, which was immediately followed by a 1000 msec investment task. Short affective priming trials consisted of a 230 msec affective prime immediately followed by a 1000 msec investment task. Long affective priming trials consisted of a 1000 msec affective prime immediately followed by a 1000 msec investment task.

Face stimuli. We used color photographs of the faces of 12 individuals (6 men, 6 women) selected from the NimStim Face Stimulus Set (Tottenham et al., 2002). We used a fearful face, an angry face, and a neutral face photograph of each individual.

Investment task. After each affective prime, participants completed a modified version of the Behavioral Investment Allocation Strategy task (BIAS: Kuhnen & Knutson, 2005), a dynamic investment task designed to elicit a range of investment behaviors that requires the participant to decide among two risky, high-payoff stocks and a safe, low-payoff bond. We decreased the monetary outcomes of the stock choices and increased the monetary outcome of the bond choice in the BIAS task from the original study in order to avoid a floor effect of the bond choice as suggested by preliminary data collection.

Similar to the original study, our modified BIAS task consists of 5 stages, each lasting 200 ms (See Figure 2.1). During the first stage, the participant is presented with the two stocks and bond on the screen (‘Pre-Choice’). During the second stage, the participant decides which investment option they will choose when the word “Choose” appears (‘Choice’). Then participants wait for a brief period (‘Wait’) and their current earnings for that trial are displayed (‘Outcome’). In the final stage, the outcomes of all the choices are then displayed (‘Market’) followed by a 200 msec fixation cross.

Without the participants’ knowledge, one of the two stocks was randomly assigned to be the “good” stock while the other stock was assigned to be the “bad” stock at the beginning of each affective priming block. For the good stock, participants win $5 with 50% probability, lose $5 with 25% probability, and no change with 25% probability. For the bad stock, participants lose $5 with 50% probability, win $5 with 25% probability, and no change with 25% probability. The bond pays $3 with 100% probability on every trial.

Participants were told the probabilities of the good stock, the bad stock, and the bond before the actual experiment, but they were not told which stock was assigned to be good and which stock was assigned to be bad at the beginning of each block or that the good stock and the bad stock changed after every block. They were instructed that the goal of the task was to figure out which one of the two stocks was the good stock throughout the task so that they could win as much money as possible. Participants were also told that the experiment was divided into 3 sections of about 10 minutes each.

Data analysis:

Percentages of safe bond choices were calculated for the 3 affective priming conditions (fearful face, angry face, neutral face) during each of the 3 stimulus duration conditions (subliminal, short, long). Statistical tests were conducted with ANOVA and t tests.

Results

To test our main hypothesis, we calculated the percentage of safe bond choices as a function of the preceding affective prime (fearful face, angry face, neutral face) and the length of the affective prime presentation (subliminal, short, long). A 3 × 3 within subjects ANOVA revealed a significant main effect for affect, $F(2, 132) = 4.06$, $p < .05$, and for stimulus duration, $F(2, 132) = 16.80$, $p < .001$. The affective prime × stimulus duration interaction was not significant, $F(4, 264) = 1.29$, $p = .275$.

Participants were not more likely to make more safe bond choices after subliminally presented fearful faces, [$t(66) = 0.81$, NS] or angry faces, [$t(66) = -0.84$, NS] relative to neutral faces. Consistent with valence-based approaches, participants made more safe bond choices after both fearful faces [$t(66) = 2.19$, $p = .032$] and angry faces [$t(66) = 2.10$, $p = .040$] relative to neutral faces presented at short stimulus durations. Consistent with emotion-specific approaches, participants made more safe bond choices after fearful faces [$t(66) = 2.05$, $p = .044$], but not after angry faces [$t(66) = 0.11$, NS] relative to neutral faces presented at long stimulus durations. The percentage of safe bond choices as a function of affective priming condition is displayed in Figure 3.1.

An ANOVA also revealed a significant main effect for stimulus duration. Participants were more likely to make more safe bond choices after fearful faces that were presented at long [$t(66) = 4.61$, $p < .001$] and short [$t(66) = 2.21$, $p = .030$] stimulus durations relative to subliminal stimulus durations. Similarly, participants also made more safe bond choices after angry faces that were presented at long [$t(66) = 3.71$, $p < .001$] and short [$t(66) = 3.18$, $p = .002$] stimulus durations relative to subliminal stimulus durations. Participants also made more safe bond choices after neutral faces presented at long stimulus durations relative to subliminal stimulus durations [$t(66) = 2.86$, $p = .006$]. However, they did not make more safe bond choices after short relative to subliminally presented neutral faces [$t(66) = 0.82$, NS].

Discussion

The current study demonstrates that facial expressions of emotion and the amount of time that they are presented can have important effects on risk-avoidant choices in a financial investment task. Under short stimulus durations, both fearful and angry affective primes increased risk-avoidant choices, demonstrating a valence-based effect on risk-taking. On the other hand, affective primes presented at longer durations had an emotion-specific effect. Fearful affective primes presented at long stimulus durations increased risk-avoidant choices whereas angry affective primes presented at long stimulus durations had no effect on financial investment choices.

This study extends previous research investigating the role of affect in decision making. Previous studies demonstrated that facial expressions of emotion, even when they are not consciously perceived, can have effects on basic preferences and judgments (Murphy & Zajonc, 1993; Niedenthal, 1990; Winkielman et al., 2005a). The current study further demonstrates that facial expressions of emotion, even when they are presented implicitly, can influence more complex decisions, such as choices on a financial investment task.

The current study also adds to the existing literature by investigating the influence of facial expressions of emotion as implicitly and explicitly processed socioemotional cues on risk-taking in contrast to previous research that examined the effects of specific subjective feelings on decisions (Johnson & Tversky, 1983; Lerner & Keltner, 2001;

Raghunathan & Pham, 1999). These studies used experimental manipulations of affect, (e.g., reading tragic newspaper reports or emotionally evocative scenarios) designed to elicit a more lasting change in subjective feelings.

The finding that both fearful and angry faces increase risk-avoidant choices under short stimulus durations is consistent with the idea that implicitly processed facial expressions of emotion should activate general positive or negative affect systems (Cacioppo & Berntson, 1999; Panksepp, 1998; Zajonc, 2000). The finding of differential effects of fear and anger on risk-taking is consistent with previous studies that have found differential effects of specific emotions after a mood induction, such as fear and anger (Lerner & Keltner, 2001) or anxiety and sadness (Raghunathan & Pham, 1999), on decision making.

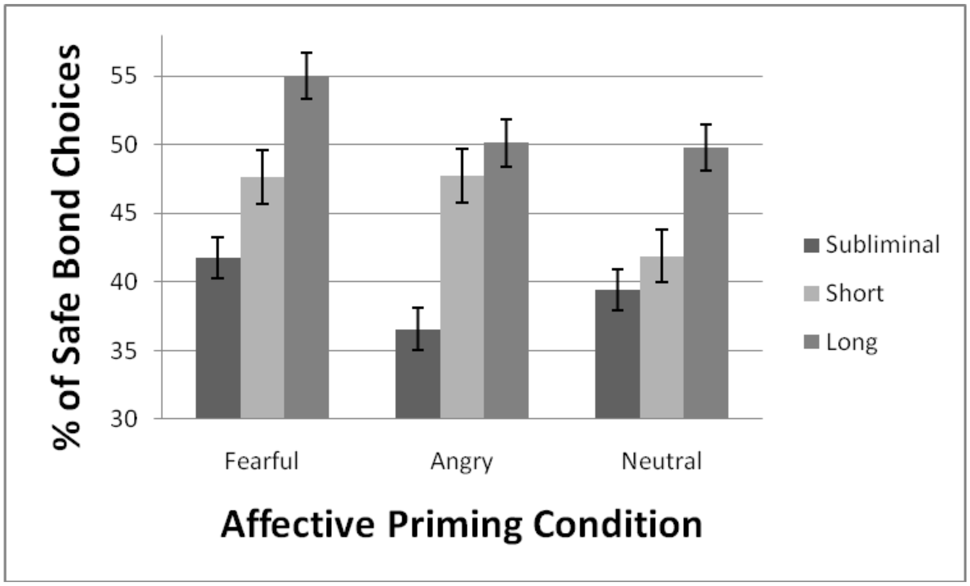
Our findings regarding the differential effects of facial expressions presented at longer stimulus intervals highlight the interplay between affective and cognitive processes in decision making. Facial expressions presented at short stimulus durations appear to activate a general positive or negative affect system and mediate risk-taking through a direct and automatic process rather than through higher-order cognitive processes. On the other hand, facial expressions presented at long stimulus durations may influence risk-taking via higher-order cognitive processes.

Several underlying mechanisms have been identified for valence-based and emotion-specific effects on decision making. One explanation for the valence-based mood effects on judgments is the feeling-as-information model, which argues that individuals use feelings as a shortcut to judgment (Schwarz & Clore, 2003). This model is supported by research findings that mood congruency effects are eliminated when individuals are given an alternative attribution for their feelings (Schwarz & Clore, 1983). An alternative explanation for mood congruency effects is priming, which suggests that affective states influence judgments by priming related cognitive categories (Forgas, 1995).

Other accounts focus on how judgments and decisions are influenced by specific emotions, such as appraisal theories (Lerner & Keltner, 2000; Smith & Ellsworth, 1985). Appraisal theories of emotion, which argue that different emotions result from unique patterns of cognitive assessments or appraisals, provide more specific predictions and seem to best explain the differential effects seen in the current study. An appraisal-tendency approach would predict that fear and anger would exert differential effects on assessments of risk because they differ along the cognitive dimensions of certainty and control (Lerner & Keltner, 2001). Whereas anger is defined by a sense of control and certainty, fear is characterized by a lack of control and uncertainty. Thus, the fearful faces that were presented at long durations may have led to appraisals of uncertainty and a lack of control, which activated pessimistic risk perceptions and resulted in increases in safe bond choices on the financial investment task. Our findings are consistent with previous research using experimental manipulations and dispositional measures of affect that fearful people make more pessimistic risk estimates and risk-avoidant choices whereas angry and happy people make more optimistic risk estimates and risk-seeking choices presumably because they both share a high certainty appraisal in common (Lerner & Keltner, 2000; 2001).

In summary, the current study demonstrates that negative facial expressions of emotion can increase risk-avoidant choices even under short stimulus durations and that risk-avoidance increases as the length of the presentation of the negative stimulus increases. The effects of facial expressions of emotion presented at short stimulus durations are non-specific and influence investment choices by a relatively direct process rather than through higher-order cognitive processes or changes in subjective feelings. By contrast, the effects of specific negative facial expressions of emotion (i.e., fearful and angry faces) become more differentiated as the presentation of the affective cue is lengthened, which suggests that cognitive processes (e.g., appraisals) may be mediating the relationship between affect and decision making when there is more time to process and evaluate the facial expressions and their implications.

Figure 3.1


% of Safe Bond Choices
55
50
45
40
35
30
Fearful
Angry
Neutral
Affective Priming Condition
Subliminal
Short
Long

References

Cacioppo, J. T., & Berntson, G. G. (1999). The affect system: Architecture and operating characteristics. *Current Directions in Psychological Science, 18,* 133-137.

Clore, G. L. (1994). Why emotions are never unconscious. In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 285-290). New York: Oxford University Press.

Critchley, H., Daly, E., Phillips, M., Brammer, M., Bullmore, E., Williams, S., et al. (2000). Explicit and implicit neural mechanisms for processing of social information from facial expressions: A functional magnetic resonance imaging study. *Human Brain Mapping, 9,* 93-105.

Ekman, P. (1984). Expression and the nature of emotion. In K. Scherer, & P. Ekman (Eds.), *Approaches to emotion* (pp. 319-343). Hillsdale, NJ: Lawrence Erlbaum.

Forgas, J. P. (1995). Mood and judgment: The affect infusion model (AIM). *Psychological Bulletin, 117,* 39-66.

Frijda, N. H. (1999). Emotions and hedonic experience. In D. Kahneman, E. Diener, & N. Schwarz (Eds.), *Well-being: The foundations of hedonic psychology* (pp. 190-210). New York: Russell Sage Foundation.

Johnson, E. J., & Tversky, A. (1983). Affect, generalization, and the perception of risk. *Journal of Personality and Social Psychology, 45(1).* 20-31.

Kuhnen, C., & Knutson, B. (2005). The neural basis of financial risk taking. *Neuron, 47,* 763-770.

Lerner, J. S., & Keltner, D. (2000). Beyond valence: Toward a model of emotion-specific influences on judgement and choice. *Cognition and Emotion, 14(4),* 473-493.

Lerner, J. S., & Keltner, D. (2001). Fear, anger, and risk. *Journal of Personality & Social Psychology, 81(1),* 146-159.

Murphy, S. T., & Zajonc, R. B. (1993). Affect, cognition, and awareness: Affective priming with optimal and suboptimal stimulus exposures. *Journal of Personality and Social Psychology, 64(5),* 723-739.

Niedenthal, P. M. (1990). Implicit perception of affective information. *Journal of Experimental Social Psychology, 26,* 505-527.

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions.* Oxford University Press: New York, NY.

Raghunathan, R., & Pham, M. T. (1999). All negative moods are not equal: Motivational influences of anxiety and sadness on decision making. *Organizational Behavior and Human Decision Processes, 79(1),* 56-77.

Rotteveel, M., de Groot, P., Geutskens, A., & Phaf, R. H. (2001). Stronger suboptimal than optimal affective priming? *Emotion, 1*, 348-364.

Schwarz, N., & Clore, G. L. (1983). Mood, misattribution and judgments of well-being: Informative and directive functions of affective states. *Journal of Personality & Social Psychology, 45*, 513-523.

Schwarz, N., & Clore, G. L. (2003). Mood as information: 20 years later. *Psychological Inquiry, 14,* 296-303.

Smith, C. A., & Ellsworth, P. C. (1985). Patterns of cognitive appraisal in emotion. *Journal of Personality and Social Psychology, 48,* 813-838.

Tottenham, N., Borscheid, A., Ellertsen, K., Marcus, D. J., & Nelson, C. A. (2002). *Categorization of Facial Expressions in Children and Adults: Establishing a Larger Stimulus Set.* Paper presented at the Cognitive Neuroscience Society Annual Meeting, San Francisco.

Whalen, P., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998). Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. *Journal of Neuroscience, 18,* 411-418.

Winkielman, P., Berridge, K. C., & Wilbarger, J. L. (2005a). Unconscious affective reactions to masked happy versus angry faces influence consumption behavior and judgments of value. *Personality and Social Psychology Bulletin, 1*, 121-135.

Winkielman, P., Berridge, K. C., & Wilbarger, J. L. (2005b). Emotion, behavior, and conscious experience: Once more without feeling. In L. Feldman-Barrett, P. Niedenthal, & P. Winkielman (Eds.), *Emotion and Consciousness.* New York: Guilford Press.

Winkielman, P., Zajonc, R. B., & Schwarz, N. (1997). Subliminal affective priming resists attributional interventions. *Cognition and Emotion, 11(4)*, 433-465.

Wright, W. F., & Bower, G. H. (1992). Mood effects on subjective probability assessment. *Organizational Behavior and Human Decision Processes, 52,* 276-291.

Zajonc, R. B. (2000). Feeling and thinking: Closing the debate over the independence of affect. In J. P. Forgas (Ed.), *Feeling and thinking: The role of affect in social cognition,* (pp. 31-58). Cambridge: Cambridge University Press.

CHAPTER IV

INDIVIDUAL DIFFERENCES IN AFFECT AND INVESTMENT DECISIONS: AN INVESTIGATION OF IMPLICIT VERSUS EXPLICIT MEASURES OF AFFECT AND THEIR RELATIONSHIP WITH FINANCIAL CHOICES

Traditionally, the dominant method of measuring affect in psychological research has been through the use of explicit, self-report measures. More recently, implicit and unconscious measures have been developed to assess emotions that respondents may not be consciously aware of or able to report. For example, prior research using subliminal affective primes, which was discussed in the previous chapter, suggests that they have powerful influences on judgments, decisions, and behaviors. Furthermore, these effects may even be stronger in unconscious than fully conscious conditions (Critchley et al., 2000; Murphy & Zajonc, 1993; Rotteveel, de Groot, Geutskens, & Phaf, 2001; Whalen et al., 1998).

For example, Murphy and Zajonc (1993) exposed participants to subliminally and supraliminally presented happy and angry facial expressions of emotion and found that the valence of the facial expressions only influenced judgments of novel stimuli during subliminal, but not supraliminal, presentations. Rotteveel and colleagues (2001) found further evidence for stronger affective priming in suboptimal than optimal conditions in that only subliminally presented angry faces resulted in more frowning behavior to unknown ideographs. Neuroimaging research demonstrates that subliminally presented fearful faces activate the amygdala and limbic structures without explicit knowledge that the stimuli were presented (Whalen et al., 1998). Furthermore, Critchley and colleagues (2000) found that consciously presented facial expressions activate these structures more under implicit processing conditions (when participants are asked to classify the faces based on gender) rather than under explicit processing conditions (when participants are asked to classify the faces based on facial expression).

Models of economic decision making have focused on explaining aggregate behavior even though there is considerable variability in these responses. Relatively little attention has been paid to how individual differences can mediate decision making. Given the crucial role that affect plays in decision making, surprisingly few studies have investigated the role of individual differences in affect on decision making. Understanding the relationship between individual differences in transient and more chronic levels of affect and risk-taking behavior would aid in understanding the psychological mechanisms behind decision making.

Research suggests that there are large and stable individual differences in risk preferences that emerge in early childhood (Levin & Hart, 2003). There is also evidence that decision making can be strongly influenced by individual differences in affective processing and the tendency to experience particular emotions. For example, Lerner and Keltner (2001) found that individual differences in the tendency to experience specific emotions influenced cognitive processes associated with decision making. Emotions signal the presence of potential rewards or threats, which promote cognitive processes that help individuals avoid threats and acquire rewards (Schwarz & Clore, 1983).

Emotions such as fear promote risk-avoidant behavior whereas emotions such as anger increase risk-taking behavior (Lerner & Keltner, 2001).

Several studies have found associations between dispositional measures of anxiety, which is characterized by a heightened sensitivity to the presence of threat and negative outcomes, and risk-avoidant appraisals (Lerner & Keltner, 2000) and decisions (Maner et al., 2007). However, it is unclear whether this association is due to the presence of negative affect in general or is specifically due to anxiety. The findings from Study 2 of this dissertation strongly suggest that there may be differential effects on decision making based on the specific type of emotion rather than a general valence effect.

The current study builds upon the previous two dissertation studies by investigating how individual differences in affect influence financial risk-taking and also attempts to replicate our affective priming effects using a larger sample size. We used facial expressions of emotion (i.e., fearful faces, angry faces, happy faces, neutral faces) presented under three stimulus durations: subliminal (30 msec), short (230 msec), and long (1000 msec) in combination with the investment task used in the previous two studies. Individual differences in affect were assessed with commonly used self-report measures of state and trait measures of affect in addition to two mood implicit association tests (IAT) using emotional words and faces.

The current study extends previous research on individual differences in affect and their association with decision making in several important ways. First, this study investigates both state and dispositional measures of affect in contrast to previous studies, which focused exclusively on dispositional affect. Second, this study includes measures of general positive and negative affect in addition to individual difference measures of specific emotions, specifically anxiety and depression, in order to more firmly establish whether links between specific negative emotions and risk-avoidant behavior are due simply to the presence of negative affect rather than the specific emotion. In addition to explicit measures of affect, the current study also includes implicit measures of affect, which have been shown to have stronger effects on judgments and behaviors (Murphy & Zajonc, 1993; Rotteveel et al., 2001) and neural activation (Critchley et al., 2000; Hall, Gonzalez, Sripada, & Schultheiss, in preparation; Whalen et al., 1998) than more conscious measures. In summary, the current study investigates how individual differences in state and trait affect, measured both explicitly and implicitly, influence complex investment decisions involving risk and seeks to replicate our previous findings implicating the influence of facial expressions of emotion on financial risk-taking.

Based on past literature and findings from the previous two dissertation studies, we predict that happy facial expressions will lead to increases in financial risk-taking and that angry facial expressions will lead to decreases in financial risk-taking across all stimulus duration conditions. Fearful facial expressions will also reduce financial risk-taking for subliminal and short stimulus durations. We also predict that implicit measures of affect will be more strongly associated with financial risk-taking on our investment task compared to traditional, self-report measures. Participants assessed as high in positive affect through implicit measures will be more likely to pick risky stock options whereas participants assessed as high in negative affect will be more likely to pick safe bond choices.

Method

Participants:

One hundred forty-seven undergraduate students were recruited from the Introduction to Psychology subject pool at the University of Michigan. These participants included 69 men and 78 women between the ages of 18-23 (101 Caucasian, 5 African American, 22 Asian American, 7 Hispanic, 12 Other). Participants provided informed consent in compliance with the Institutional Review Board guidelines of the University of Michigan. They received course credit for their participation.

Procedure:

Explicit measures of affect. Participants completed several commonly used explicit, self-report measures of current mood prior to the investment task. These measures included the Positive and Negative Affect Schedule (PANAS: Watson, Clark, & Tellegen, 1988), the Mood Adjective Checklist (MAC), and the State scale of the State-Trait Anxiety Inventory (STAI: Spielberger, Gorsuch, & Lushene, 1970). The PANAS consists of 10 positive affect words (e.g., interested, excited) and 10 negative affect words (e.g., distressed, upset) where participants must rate how strongly they felt these emotions during the past 2 weeks, including today. For the MAC, participants must rate how strongly they felt a list of 8 positive (e.g., happy, joyful) and 8 negative moods (e.g., hopeless, depressed) during the past 2 weeks, including today. The STAI consists of 40 items, which measure the temporary condition of state anxiety (e.g., "I feel tense") and the more general and chronic trait anxiety (e.g., "I am a steady person").

Participants also completed self-report trait measures of affect after the investment task, including the Beck Anxiety Inventory (BAI: Beck, Epstein, Brown, &

Steer, 1988), the Beck Depression Inventory (BDI: Beck, Ward, Mendelsohn, Mock, & Erbaugh, 1961), and the Trait scale of the State Trait Anxiety Inventory (Spielberger et al., 1970). The BAI consists of 21 items describing common symptoms of anxiety (e.g., “numbness or tingling,” “feeling hot”). The BDI is a commonly used 21-item scale measuring characteristic symptoms and attitudes of depression (“I am so sad or unhappy that I can’t stand it,” “I feel my future is hopeless and will only get worse”).

Implicit measures of affect. Participants also completed two versions of a mood implicit association test (Mood IAT: Hall, 2006). The Mood IAT was adapted from the original implicit association test (IAT: Greenwald, McGhee, & Schwarz, 1998) to assess nonconscious moods of negative and positive valence. During the word version of the Mood IAT, participants were asked to sort words as quickly as possible into the following categories for 5 trials: Me vs. Others, Good vs. Bad, Me or Good vs. Others or Bad, Others vs. Me, Others or Good vs. Me or Bad. Me words include “I,” “my,” “myself,” and “mine,” and Other words include “they,” “them,” “their,” and “theirs.” The Good category words consist of positively valenced emotion words from the Mood Adjective Checklist: “happy,” “joyful,” “glad,” “pleased,” “satisfied,” “contented,” “cheerful,” and “hopeful.” The Bad category words consist of negatively valenced emotion words from the Mood Adjective Checklist: “unhappy,” “joyless,” “sad,” “displeased,” “dissatisfied,” “sorry,” “depressed,” and “hopeless.”

Participants also completed a faces version of the Mood IAT, in which they sorted 8 positively and 8 negatively valenced faces from the NimStim Face Stimulus Set (Tottenham et al., 2002) into Me vs. Others and Good vs. Bad categories with the idea that individuals high in positive affect would be faster at classifying words and faces into

Me or Good / Others or Bad pairings than Me or Bad / Others or Good pairings whereas those high in negative affect would be faster at classifying words and faces into Me or Bad / Others or Good pairings versus Me or Good / Others or Bad pairings. Both versions of the IAT were scored by obtaining a difference score in the response times between matched and mismatched classifications. Thus, greater difference scores would represent higher levels of negative affect.

Experimental task. Participants completed a practice version of the experimental task before the actual task began in order to learn the instructions and structure of the investment task. Participants completed affective priming trials in each of the 3 stimulus durations presented in counterbalanced order. Each participant completed 12 trials of each of the 4 affective prime conditions (fearful face, angry face, neutral face, happy face) under each of the 3 stimulus duration conditions (subliminal, short, long) in counterbalanced order for a total of 144 trials. Subliminal affective priming trials consisted of a 30 msec affective prime followed by a 200 msec scrambled face mask, which was immediately followed by a 1000 msec investment task. Short affective priming trials consisted of a 230 msec affective prime immediately followed by a 1000 msec investment task. Long affective priming trials consisted of a 1000 msec affective prime immediately followed by a 1000 msec investment task.

Face stimuli. We used color photographs of the faces of 12 individuals (6 men, 6 women) selected from the NimStim Face Stimulus Set (Tottenham et al., 2002). We used an angry face, a fearful face, a neutral face, and a happy face photograph of each individual.

Investment task. After each affective prime, participants completed a modified version of the Behavioral Investment Allocation Strategy task (BIAS: Kuhnen & Knutson, 2005), a dynamic investment task designed to elicit a range of investment behaviors that requires the participant to decide among two risky, high-payoff stocks and a safe, low-payoff bond. We decreased the monetary outcomes of the stock choices and increased the monetary outcome of the bond choice in the BIAS task from the original study in order to avoid a floor effect of the bond choice as suggested by preliminary data collection.

Similar to the original study, our modified BIAS task consists of 5 stages, each lasting 200 ms (See Figure 2.1). During the first stage, the participant is presented with the two stocks and bond on the screen ('Pre-Choice'). During the second stage, the participant decides which investment option they will choose when the word "Choose" appears ('Choice'). Then participants wait for a brief period ('Wait') and their current earnings for that trial are displayed ('Outcome'). In the final stage, the outcomes of all the choices are then displayed ('Market') followed by a 200 msec fixation cross.

Without the participants' knowledge, one of the two stocks was randomly assigned to be the "good" stock while the other stock was assigned to be the "bad" stock at the beginning of each affective priming block. For the good stock, participants win $5 with 50% probability, lose $5 with 25% probability, and no change with 25% probability. For the bad stock, participants lose $5 with 50% probability, win $5 with 25% probability, and no change with 25% probability. The bond pays $3 with 100% probability on every trial.

Participants were told the probabilities of the good stock, the bad stock, and the bond before the actual experiment, but they were not told which stock was assigned to be good and which stock was assigned to be bad at the beginning of each block or that the good stock and the bad stock changed after every block. They were instructed that the goal of the task was to figure out which one of the two stocks was the good stock throughout the task so that they could win as much money as possible. Participants were also told that the experiment was divided into 3 sections of about 10 minutes each.

Data analysis:

Percentages of safe bond and risky stock choices were calculated for the 4 affective priming conditions (fearful face, angry face, neutral face, happy face) during each of the 3 stimulus duration conditions (subliminal, short, long). Statistical tests were conducted with ANOVA and t tests. Correlations were computed between our individual difference measures of affect and percentage of safe bond choices by risk across trials and by affective prime and stimulus duration conditions.

Results

We first calculated the percentage of safe bond choices as a function of the preceding affective prime (fearful face, angry face, neutral face, happy face) and the length of the affective prime presentation (subliminal, short, long). A 4×3 within subjects ANOVA revealed a significant main effect for affect, $F(3, 438) = 5.61$, $p < .001$, and for stimulus duration, $F(2, 292) = 24.90$, $p < .001$. The affective prime × stimulus duration interaction was also significant, $F(6, 876) = 3.14$, $p < .005$.

Participants were not more likely to make more safe bond choices after subliminally presented fearful faces, angry faces, or happy faces relative to neutral faces.

Participants made fewer safe bond choices after happy faces relative to neutral faces presented at both short [$t(146) = -3.71$, $p < .001$] and long [$t(146) = -3.28$, $p = .001$] stimulus durations. Contrary to predictions, participants were not more likely to make safe bond choices after fearful faces relative to neutral faces in short or long stimulus durations. Participants also did not make more safe bond choices after angry faces relative to neutral faces regardless of stimulus duration condition. The percentage of safe bond choices as a function of affective priming condition is displayed in Figure 4.1.

Mean scores for each of the individual difference measures of affect divided by gender is shown in Table 4.1. There were no differences between males and females for any of the individual difference measures. To investigate how individual differences in affect are associated with financial risk-taking, we computed correlations between our implicit (Mood IAT - Words, Mood IAT - Faces) and explicit (PANAS, MAC, STAI, BAI, BDI) measures of affect and percentages of safe bond choices. Correlations between our affective measures and safe bond choices are displayed in Figure 4.2. Safe bond choices were positively and significantly correlated with our implicit measures of affect. The Mood IAT - Words version was positively correlated ($r = .23$, $p < .01$) with safe bond choices and the Mood IAT - Faces version was positively correlated ($r = .29$, $p < .01$) with safe bond choices. No significant correlations were found between safe bond choices and our explicit measures of affect. We also computed correlations between our individual difference measures of affect and safe bond choices by affective prime and stimulus duration conditions. These correlations are displayed in Table 4.2. As shown, none of the explicit measures of affect were significantly correlated with safe bond choices across all affective priming and stimulus duration conditions. Correlations were significant between our implicit measures of affect and safe bond choices across all affective priming and stimulus duration conditions. Correlations ranged from 0.17-0.26 for our Mood IAT - Words measure and from 0.22-0.33 for our Mood IAT - Faces measure across affective priming conditions. Correlations ranged from 0.19-0.24 for our Mood IAT - Words measure and from 0.20-0.30 for our Mood IAT - Faces measure across stimulus duration conditions.

Discussion

The current study replicates findings found in Study 1 that happy facial expressions of emotion lead to increased financial risk-taking in an investment task. Furthermore, this study provides evidence for a link between individual differences in negative affect and risk-avoidant decisions. Higher scores on our two Mood IAT measures, reflecting higher levels of negative affect, were positively correlated with more safe bond choices. On the other hand, no correlations were found between scores on explicit measures of affect and safe bond choices.

Our findings linking implicit levels of negative affect and safe bond choices is consistent with prior research, which found associations between experimentally manipulated and dispositional measures of fear and pessimistic, risk-avoidant choices (Lerner & Keltner, 2001). It is unclear from our findings whether this observed link is due specifically to anxiety or merely negative affect since our Mood IAT measures were not designed to assess specific emotions. It is also important to consider whether the link between negative affect and safe bond choices is due to transient or more chronic levels of negative affect. The Mood IAT measures were designed to assess current mood, but they may also be measuring more chronic levels of negative affect. Disentangling these processes are potential avenues for future research.

The current findings may also have clinical implications for understanding decision making processes in clinical disorders characterized by negative affect, such as anxiety and depression. For example, individuals with anxiety disorders may exhibit more risk-avoidant behaviors because anxiety signals threat and promotes responses to avoid that threat. Alternatively, anxious individuals may make more risk-avoidant decisions because their anxiety promotes pessimistic appraisals of future outcomes, which play an important role in shaping decisions.

One explanation for the lack of overlap found between self-report measures of affect and financial risk-taking is that individuals may be less capable of rating their own affect. This theory is consistent with research indicating that individuals in general have limited insight into their own motives (Nisbett & Wilson, 1977). Our findings are also consistent with previous research indicating stronger affective effects under less conscious than fully conscious conditions (Critchley et al., 2000; Murphy & Zajonc, 1993; Rotteveel et al., 2001; Whalen et al., 1998).

While our findings indicate that implicit measures of affect are more strongly associated with risk-avoidant choices whereas explicit measures show no relationship, others have found associations between decisions involving risk and explicit measures of affect (Lerner & Keltner, 2001; Maner et al., 2007). Discrepancies in research findings suggest that the presence or absence of affective effects may depend critically on how affect is measured as well as the specific type of responses (e.g., neural activation, physiological responses, judgments) affect is hypothesized to influence in each particular study. Our findings suggest that there may be two modes of processing by which affective processes influence decisions: a system whereby affect influences decisions through conscious and more controlled processes and another system in which affect influences decisions through unconscious and more automatic processes. The conscious affective system may be more amenable to investigation through the use of mood induction methods or explicit measures of affect. On the other hand, the unconscious affective system may be best investigated using implicit measures of affect and implicitly processed affective cues, such as facial expressions of emotion.

This idea is consistent with the theory of two motivational systems proposed by McClelland and colleagues (1989). The explicit motivational system represents motivational dispositions that individuals can verbally report, which guide controlled forms of behavior. By contrast, the implicit motivational system represents motivations that occur outside of conscious awareness, which guide automatic and spontaneous forms of behavior. Schultheiss (2008) provides compelling evidence that explicit and implicit motivational systems do not overlap, respond to different types of stimuli, and predict different types of behaviors. According to the information-processing model of motives (Schultheiss, 2001), implicit motives are more likely to respond to nonverbal cues and to have an impact on declarative measures of motivation, such as physiological responses, neural activation, and instrumental learning. By contrast, explicit motives respond preferentially to verbal cues and are more likely to have an influence on declarative measures of motivation, such as attitudes and judgments.   Similarly, our Mood IAT measures may have been assessing an implicit affective system, which predicted risk-avoidance on our investment task. Our results also provide some support for the idea that implicit systems are more responsive to nonverbal cues in that correlations between implicit mood and risk-avoidant investment choices were somewhat higher when assessing implicit mood using pictures of facial expressions of emotion compared to verbal cues consisting of positively and negatively valenced emotion words.

There is also a growing body of evidence for separate brain systems for goal-directed, conscious motivational processes that drive behavior in response to incentives and are mediated predominantly by subcortical brain structures and for automatic, nonconscious motivational processes involved in the explicit regulation of behavior, which are mediated by cortical structures (Berridge & Robinson, 2003; LeDoux, 2002). Studies already indicate that implicit and explicit systems involved in emotional processing and motivation compete with and suppress each other (e.g., Ochsner, Bunge, Gross, & Gabrieli, 2002; Lieberman et al, 2007) and that individual differences in implicit motives for power and affiliation influence activation in motivational brain structures in response to facial expressions of emotion (Hall, Stanton, & Schultheiss, 2010; Schultheiss et al., 2008). Future neuroimaging research may further our understanding of how individual differences in implicit and explicit affect influence activation in these two brain systems, which may highlight the ways that these two processes operate independently and with each other.

In conclusion, our findings demonstrate a link between individual differences in negative affect and risk-avoidant choices. Implicit measures of individual differences in affect were more strongly correlated with financial decisions on an investment task. These findings highlight the potential benefit of adding implicit measures to more traditionally used explicit measures to study the mechanisms by which affect influences decision making. They also suggest that there may be two modes of processing by which affect influences financial decisions: an explicit, conscious affective system which may best be investigated through mood induction methods and self-report measures of affect and an implicit, unconscious affective system which may best be studied through implicit measures of affect, such as implicitly processed facial expressions and implicit association tests, which tap into unconscious moods that individuals may not be willing or able to report.

Figure 4.1

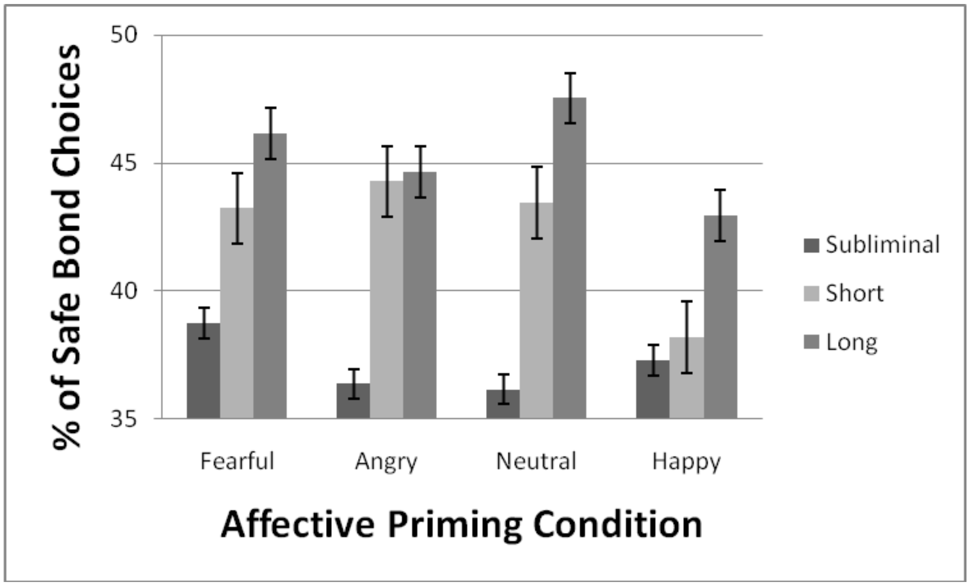

50
45
40
35
% of Safe Bond Choices
Fearful
Angry
Neutral
Happy
Affective Priming Condition
Subliminal
Short
Long

Figure 4.2

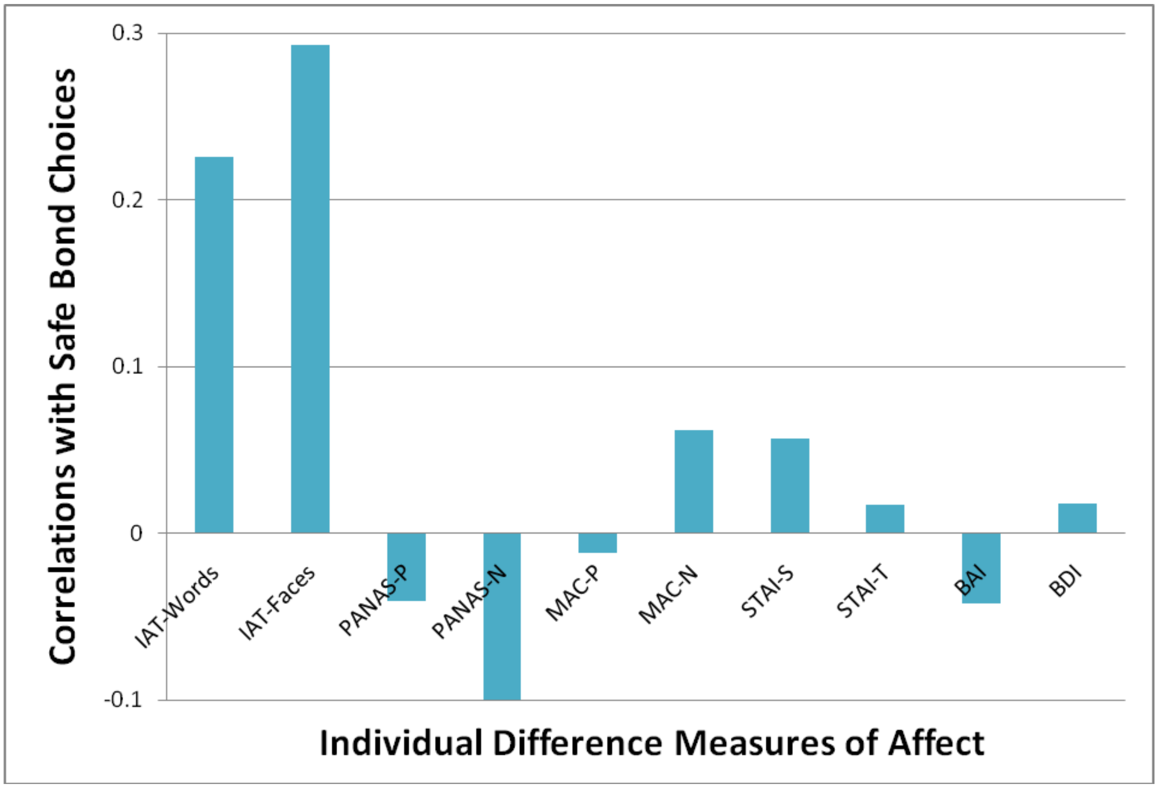

0.3
0.2
0.1
0
-0.1
Correlations with Safe Bond Choices
IAT-Words
IAT-Faces
PANAS-P
PANAS-N
MAC-P
MAC-N
STAI-S
STAI-T
BAI
BDI
Individual Difference Measures of Affect

Table 4.1

	Gender	
	Males	Females
Measure		
Mood IAT - Words	237.18	282.90
Mood IAT - Faces	164.05	134.64
PANAS - Positive	33.53	32.99
PANAS - Negative	19.74	21.34
MAC - Positive	27.25	27.97
MAC - Negative	14.78	14.70
STAI - State	36.03	37.29
STAI - Trait	38.37	41.05
BAI	9.97	13.05
BDI	9.07	10.53

Table 4.2

	Condition						
	Fear	Anger	Neutral	Happy	Uncon	Con	Long
Measure							
Mood IAT - Words	0.17*	0.26**	0.19*	0.23**	0.24**	0.19*	0.19*
Mood IAT - Faces	0.22**	0.26**	0.33**	0.27**	0.30**	0.20*	0.28**
PANAS - P	-0.08	-0.02	-0.01	-0.04	-0.13	-0.03	0.02
PANAS - N	-0.10	-0.08	-0.08	-0.11	-0.09	-0.05	-0.12
MAC - P	-0.05	0.02	0.01	-0.02	-0.04	-0.03	0.03
MAC - N	0.06	0.06	0.08	0.02	0.03	0.12	0.02
STAI - S	0.03	0.07	0.05	0.06	0.06	0.09	0.01
STAI - T	0.03	0.00	0.01	0.02	0.06	0.05	-0.05
BAI	-0.04	-0.05	-0.03	-0.04	-0.04	-0.03	-0.04
BDI	0.05	-0.03	0.00	0.04	0.02	0.70	-0.03

References

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: Psychometric properties. *Journal of Consulting and Clinical Psychology, 56(6),* 893-897.

Beck, A. T., Ward, C. H., Mendelsohn, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4,* 561-571.

Berridge, K. C., & Robinson, T. E. (2003). Parsing reward. *Trends in Neurosciences, 26(9),* 507-513.

Critchley, H., Daly, E., Phillips, M., Brammer, M., Bullmore, E., Williams, S., et al. (2000). Explicit and implicit neural mechanisms for processing of social information from facial expressions: A functional magnetic resonance imaging study. *Human Brain Mapping, 9,* 93-105.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality & Social Psychology, 74,* 1464-1480.

Hall, J. L. (2006). *Mood IAT: The development of an Implicit Association Test to assess unconscious moods.* Unpublished manuscript.

Hall, J. L., Gonzalez, R. D., Sripada, C., & Schultheiss, O. C. (manuscript in preparation). The emotions of investments: fMRI evidence for the role of unconscious affect on financial decisions.

Hall, J. L., Stanton, S. J., & Schultheiss, O. C. (2010). Biopsychological and neural processes of implicit motivation. In O. C. Schultheiss & J. C. Brunstein (Eds.), Implicit motives (pp. 279-307). New York, NY: Oxford University Press.

Kuhnen, C., & Knutson, B. (2005). The neural basis of financial risk taking. *Neuron, 47,* 763-770.

LeDoux, J. E. (2002). *The synaptic self*. New York, NY: Viking.

Lerner, J. S., & Keltner, D. (2000). Beyond valence: Toward a model of emotion-specific influences on judgement and choice. *Cognition and Emotion, 14(4),* 473-493.

Lerner, J. S., & Keltner, D. (2001). Fear, anger, and risk. *Journal of Personality & Social Psychology, 81(1),* 146-159.

Levin, I.P., & Hart, S. S. (2003). Risk preferences in young children: Early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision-Making, 16,* 397-413.

Lieberman, M. D., Eisenberger, N. I., Crockett, M. J., Tom, S. M., Pfeifer, J. H., & Way, B. M. (2007). Putting feelings into words: affect labeling disrupts amygdala activity in response to affective stimuli. *Psychological Science, 18*(5), 421-428.

Maner, J. K., Richey, J. A., Cromer, K., Mallott, M., Lejuez, C. W., Joiner, T. E., et al. (2007). Dispositional anxiety and risk-avoidant decision making. *Personality and Individual Differences, 42,* 665-675.

McClelland, D. C., Koestner, R., & Weinberger, J. (1989). How do self-attributed and implicit motives differ? *Psychological Review, 96*, 690-702.

Murphy, S. T., & Zajonc, R. B. (1993). Affect, cognition, and awareness: Affective priming with optimal and suboptimal stimulus exposures. *Journal of Personality and Social Psychology, 64(5),* 723-739.

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84*, 231-259.

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. (2002). Rethinking feelings: An fMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience, 14*(8), 1215-1229.

Rotteveel, M., de Groot, P., Geutskens, A., & Phaf, R. H. (2001). Stronger suboptimal than optimal affective priming? *Emotion, 1*, 348-364.

Schultheiss, O. C. (2001). An information processing account of implicit motive arousal. In M. L. Maehr & P. Pintrich (Eds.), Advances in motivation and achievement (pp. 1-41). Greenwich, CT: JAI Press.

Schultheiss, O. C. (2008). Implicit motives. In O. P., John, R. W. Robins, & L. A. Pervin (Eds.), Handbook of personality: Theory and research (pp. 603-633). New York: Guilford.

Schultheiss, O. C., Wirth, M. M., Waugh, C. E., Stanton, S. J., Meier, E. A., & Reuter-Lorenz, P. (2008). Exploring the motivational brain: Effects of implicit power motivation on brain activation in response to facial expressions of emotion. *Social Cognitive and Affective Neuroscience, 3*, 333-343.

Schwarz, N., & Clore, G. L. (1983). Mood, misattribution and judgments of well-being: Informative and directive functions of affective states. *Journal of Personality & Social Psychology, 45*, 513-523.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Tottenham, N., Borscheid, A., Ellertsen, K., Marcus, D. J., & Nelson, C. A. (2002). *Categorization of Facial Expressions in Children and Adults: Establishing a Larger Stimulus Set.* Paper presented at the Cognitive Neuroscience Society Annual Meeting, San Francisco.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality & Social Psychology, 54,* 1063-1070.

Whalen, P., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998). Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. *Journal of Neuroscience, 18,* 411-418.

CHAPTER V

CONCLUSION

Research on decision making in the last few decades has begun to address the powerful role of affect in what was once an exclusively cognitive field. Several classic studies have demonstrated that positive affect leads to optimistic risk estimates whereas negative affect promotes pessimistic risk estimates (Johnson & Tversky, 1983; Wright & Bower, 1992). More recent research has also established how specific emotions influence risk estimates and choices (Lerner & Keltner, 2001). Neuroimaging studies have also highlighted the important role of positive and negative anticipatory affect and their neural markers in financial risk-taking (Kuhnen & Knutson, 2005). While this research has furthered our understanding of the psychological and neural mechanisms by which affect influences decisions, many of these studies have used only one approach to investigate affective influences (e.g., valence-based or emotion-specific approaches, conscious or unconscious affective primes, explicit or implicit measures of affect, trait or state measures of affect).

The three studies in this dissertation fill this gap by using multiple methods (e.g., fMRI, behavioral measures, implicit association tests, individual difference measures) and approaches (e.g., valence-based and emotion-specific approaches, affective primes varying in 3 levels of consciousness, implicit and explicit measures of affect, trait and state measures of affect) to compare and contrast the different ways that affect influences decisions depending on how it is measured. Across all three studies is the conclusion that affect plays an important role in complex financial decisions involving risk and that there may be at least two modes of processing by which affective influences can shape decisions. Several speculations about these two systems can be made from our findings. The first is an automatic, unconscious affective system that exerts valence-based effects on decisions, responds preferentially to implicit measures (e.g., IAT) and implicitly processed affective cues (e.g., facial expressions of emotion), and primarily involves subcortical brain regions, particularly the nucleus accumbens and amygdala. The second is a conscious affect system that exerts emotion-specific effects on decisions through more controlled cognitive processes (e.g., appraisal), responds preferentially to explicit measures (e.g., traditional self-report scales) and longer-lasting mood induction methods, and primarily involves more cortical brain structures. The potential existence of two modes of processing highlights the importance of paying careful attention to how affect is measured and including multiple methods and approaches that would allow an investigation of how both modes influence decision making.

The three studies presented in this dissertation illustrate how affect can shape financial decisions using a diverse set of methods and approaches. The first study used fMRI in combination with subliminal and supraliminal affective primes to investigate how affect influences financial risk-taking and activity in neural markers associated with anticipatory arousal, the nucleus accumbens and insula. Our findings demonstrate that happy affective primes lead to increases in financial risk-taking and activation in the nucleus accumbens, an effect that was significantly stronger for unconscious compared to conscious affective primes. Next, we reviewed existing research demonstrating that subliminally presented facial expressions of emotion can influence judgments, decisions, and behaviors even without eliciting changes in subjective feelings. Study 2 extended these effects to more complex financial investment decisions, and demonstrated that facial expressions of emotion can have a range of effects depending on how long they are presented, from a general valence effect for facial expressions presented at short stimulus durations to differentiated emotion-specific effects for facial expressions presented at long stimulus durations. Lastly, Study 3 demonstrated that individual differences in affect when measured implicitly were more strongly associated with financial risk-taking than explicit measures of affect. Given that other studies have found associations between explicit measures of affect and judgments, our findings suggest that there may be at least two modes of processing involved in risky decisions. Thus, the inclusion of both implicit and explicit measures of affect in research studies may provide a more comprehensive understanding of the interplay between cognitive and affective processes in decision making.

These three dissertation studies demonstrate that facial expressions of emotion, even when presented very briefly, can influence financial risk-taking and activity in neural markers of anticipatory arousal (i.e., nucleus accumbens, insula), a finding that is particularly important given the abundance of facial expressions in our everyday lives. In addition, these influences do not seem to require conscious awareness or a change in subjective feelings. These findings suggest several possible underlying psychological and neural mechanisms by which affect influences financial decision making. One potential psychological mechanism for how facial expressions influence financial risk-taking is through changes in the systems governing approach or avoidance behaviors. For example, happy faces could signal a favorable environment and activate the positive affect system whereas fearful faces could signal an unfavorable environment and activate the negative affect system. Thus, happy faces could promote exploration whereas fearful faces could promote caution. An alternative explanation is that facial expressions could result in changes in the perception of the value or riskiness of an option. For example, happy faces could make risky stock choices seem more valuable or less risky. Both explanations are consistent with findings from Study 1 that happy faces increase the propensity to choose risky stocks.

In terms of a potential neural explanation, facial expressions may influence financial risk-taking by activating subcortical structures, such as the amygdala or the nucleus accumbens, and their connections to the prefrontal cortex, which is involved in the representation of value (Kuhnen & Knutson, 2005). The amygdala shows activation to subliminally presented fearful faces even without explicit knowledge that they were presented (Whalen et al., 1998). Furthermore, it projects to the nucleus accumbens, a neural marker of positive anticipatory arousal, which showed greater activation to unconsciously presented happy faces relative to consciously presented happy faces in Study 1.

Neuroscience research indicates that basic affective reactions are mediated largely by subcortical structures that evolved early, including the amygdala, nucleus accumbens, hypothalamus, and lower brain stem. These reactions are fast and automatic and do not require consciousness in contrast to cortical systems that evolved later, which are involved in conscious affective processes (Berridge, 2003; LeDoux, 2002). Thus, there may be two neural circuits by which unconsciously and consciously presented facial expressions of emotion influence decision making. Unconscious facial expressions of emotion may exert a general valence-based effect on decision making through a relatively direct and automatic pathway involving subcortical brain regions. This process may occur independently from cortical structures that underlie conscious affective reactions and does not involve a change in subjective feelings or higher-order cognitive processes. On the other hand, facial expressions of emotion presented for longer stimulus durations show emotion-specific effects on decision making. For example, implicitly presented fearful and angry faces both decreased financial risk-taking in Study 2, but when they were presented for longer durations, only fearful faces decreased financial risk-taking. This process may involve an interaction of subcortical (e.g., amygdala, nucleus accumbens) and cortical structures (e.g., prefrontal cortex) and may also involve conscious feelings and higher-order cognitive processes, such as appraisal.

While emotions have traditionally been viewed as inherently conscious, the empirical evidence discussed in this dissertation suggests that emotions can also be unconscious and that unconscious affective influences play an important role in decision making. Subliminal presentations of facial expressions of emotion lead to changes in judgments, decisions, and behaviors as well as physiological and neural responses even when they are not consciously perceived or associated with changes in subjective feelings. Neuroscience research supports the existence of two neural pathways involving cortical and subcortical regions that may be involved in conscious and unconscious affect. While later-evolved cortical regions may likely play a role in conscious affective processes, unconscious affective reactions are likely mediated largely by early-evolved subcortical regions.

While the evidence presented in this dissertation provides clues to the psychological and neural mechanisms involved in affect and decision making, there are several limitations and important questions that should be addressed in future research. Our findings from Study 1 show that happy faces lead to increases in financial risk-taking and nucleus accumbens activation. However, since we used only one type of positive affective prime, it is not clear whether increases in financial risk-taking were due to the happy faces specifically or merely general positive affect. In addition, Study 1 did not find changes in financial risk-taking following angry faces. It would be useful to include fearful faces, which did decrease financial risk-taking in Study 1, and other negative facial expressions in future neuroimaging research in order to more accurately assess their influence on risk-taking and neural markers of negative anticipatory arousal.

There are a number of other potentially informative avenues for future research. For example, it would be useful to see whether the influence of facial expressions depends on whether they change subjective feelings. The current study exclusively used subliminal and supraliminal facial expressions of emotion to investigate affective influences on decision making. In future research, it would be useful to see whether other manipulations of affect (e.g., mood induction methods) or other types of affective cues (e.g., IAPS pictures) would exert the same influence on financial risk-taking. In addition, the use of clinical populations may allow a better way to understand the link between affect and financial risk-taking given that the range of affect is relatively limited in normative populations. Furthermore, it would be informative to experimentally investigate whether cognitive processes, such as appraisal, mediate the effects of affect on decision making. Lastly, it would be valuable to conduct an fMRI study to investigate predictions about the psychological and neural processes involved in the two affect systems that were proposed in this dissertation.

While investigating conscious processes and subjective feelings of emotion such as those assessed by self-report measures are certainly an important component of understanding the role of affect in decision making, this research should be complemented with research that explores both conscious and unconscious affective influences using multiple methods and approaches. The studies presented in this dissertation along with past research further our understanding about the basic psychological and neural mechanisms by which affect influences decision making and provide support for a dual-process model of risky decisions. Knowledge about these mechanisms and an understanding of the importance of investigating affect using unconscious, implicit measures will aid in the design of future research studies, which will further clarify the processes by which affect influences decision making.

References

Berridge, K. C. (2003). Pleasures of the brain. *Brain and Cognition, 52,* 106-128.

Johnson, E. J., & Tversky, A. (1983). Affect, generalization, and the perception of risk. *Journal of Personality and Social Psychology, 45(1).* 20-31.

Kuhnen, C., & Knutson, B. (2005). The neural basis of financial risk taking. *Neuron, 47,* 763-770.

LeDoux, J. E. (2002). *The synaptic self*. New York, NY: Viking.

Lerner, J. S., & Keltner, D. (2001). Fear, anger, and risk. *Journal of Personality & Social Psychology, 81(1),* 146-159.

Whalen, P., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998). Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. *Journal of Neuroscience, 18,* 411-418.

Wright, W. F., & Bower, G. H. (1992). Mood effects on subjective probability assessment. *Organizational Behavior and Human Decision Processes, 52,* 276-291.