ANTICIPATION AND ATTENTIONAL CONTROL:

NEURAL RESPONSES ASSOCIATED WITH ANXIETY AND DEPRESSION

by

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ABSTRACT

Anticipating future events and ignoring task-irrelevant information in order to maintain task performance are aspects of everyday life that are impaired in anxiety and depression. The present research examined the unique impact of anxious apprehension, anxious arousal, and depression on reward and loss anticipation as well as attentional control. Brain activation associated with each type of psychopathology was measured by fMRI during a modified version of the monetary incentive delay task, which included an attentional control component. During reward and loss anticipation, both anxious apprehension and anxious arousal were associated with decreased activation in areas involved in reward learning and increased activation in areas that use previous trial information to guide future behavior. These two dimensions of anxiety were differentiated by brain activity associated with top-down attentional control during the attentional control portion of the task. In addition, depression was associated with increased reliance on previous trial information during reward and loss anticipation but was not associated with attentional control. Results suggest that these three related but distinct dimensions of psychopathology are associated with different patterns of brain activity during reward and loss anticipation as well as attentional control.

Chapter 1

INTRODUCTION

Research on mental illness is moving toward classifying psychopathology on dimensions of activity in neurobiological circuits and observable behavior (Cuthbert & Insel, 2010). This initiative, known as the Research Domain Criteria (RDoC), has suggested, as examples, six basic dimensions onto which psychopathology can be mapped, each of which can be studied at multiple levels of analysis. One of these dimensions, Positive Valence Systems, is comprised of five distinct but related constructs (e.g., approach motivation, response to reward attainment, reward learning). According to the RDoC initiative, approach motivation, in part, consists of mechanisms that regulate approach towards innate or learned rewarding cues. Anxiety and depression are two highly prevalent, costly disorders that exhibit deficits in approach motivation.

1.1 Anxiety and the Anticipation of Future Events

Anxiety disorders are associated with alterations in the anticipation of future events, such that individuals with anxiety disorders tend overestimate the number of future negative outcomes as well as the actual severity of those events (Eysenck, 1997; Grillon, 2008). Beck's cognitive model of anxiety posits that anxious individuals' automatic thoughts are focused on anticipating danger or harm in relation to future events (e.g., performing poorly on an upcoming task, being involved in an accident; Beck, 1976). Furthermore, anxiety disorders are associated with impaired cognition.

Highly anxious individuals exhibit an attentional bias towards threatening and highly arousing stimuli (Compton, Heller, Banich, Palmieri, & Miller, 2000; Nitschke & Heller, 2002). Across settings, ambiguous, threatening, and arousing information capture attention and direct it away from the task at hand, which can degrade performance. Even when attention is not captured by extraneous stimuli, worrisome thoughts decrease the efficiency of goal-directed behavior, thus requiring increased effort to accomplish a task (Eysenck, Derakshan, Santos, & Calvo, 2007). In addition to anticipating more frequent and more negative future outcomes, anxious individuals increase the likelihood of poor performance due to resulting attentional control difficulties.

1.2 Types of Anxiety

The literature often construes anxiety as though it is a monolithic construct. However, several lines of research have shown that it can be separated into two related but distinct constructs: anxious apprehension and anxious arousal (e.g., Engels et al., 2007, 2010; Heller, Nitschke, Etienne, & Miller, 1997; Nitschke, Heller, Imig, McDonald, & Miller, 2001; Nitschke, Heller, Palmieri, & Miller, 1999). Anxious apprehension is characterized by persistent worry and repeated verbal rehearsal, typically about future events (Barlow, 1991). Content of worries may include perceived personal deficits, physical health, emotional threats, or other problems in the environment. The timeframe for these perceived threats can range from the subsequent moment to the distant future (Nitschke, Heller, & Miller, 2000).

Anxious arousal is characterized by symptoms of somatic tension and physiological hyperarousal (Watson, Weber, Assenheimer, Clark, Strauss, & McCormick, 1995). Symptoms include those typically associated with panic, such as

increased heart rate, shortness of breath, dizziness, and sweating (Nitschke et al., 1999). Often the symptoms of anxious arousal are the result of immediate threat rather than a distant future event. Although anxious apprehension and anxious arousal are not considered mutually exclusive, they are typically associated with distinct anxiety disorders. Specifically, anxious apprehension characterizes generalized anxiety disorder (GAD) and obsessive-compulsive disorder (OCD), whereas anxious arousal is primarily associated with panic disorder (PD).

Neuroimaging research has provided support for differentiation between these two subtypes of anxiety. Engels and colleagues (2007) found differential patterns of brain activity in response to emotionally distracting, task-irrelevant words. In addition, these dimensions of anxiety have been shown to interact with comorbid depression to impact top-down attentional control (Engels et al., 2010). Action-monitoring research has also supported this distinction, finding that anxious apprehension is associated with enhanced action monitoring, whereas anxious arousal is unrelated (Moser, Moran, & Jendrusina, 2012).

1.3 Depression and the Anticipation of Future Events

Similar to anxiety, depression has been associated with altered anticipation of future events, such that those who are depressed expect future events to be unfavorable (Beck, 1976). Research has shown that individuals diagnosed with major depressive disorder (MDD) exhibit less activation in striatal regions while anticipating receiving a reward than do healthy controls (Pizzagalli et al., 2009; Smoski et al., 2009). In addition to these deficits in reward anticipation, depression is associated with difficulty disengaging from emotional stimuli (Caseras et al., 2007; Eizenman et al., 2003; Rinck & Becker, 2005). Furthermore, attentional biases towards negative

information appear to play an important role in vulnerability to depression (Joormann & Gotlib, 2007; Joorman, Talbot, & Gotlib; 2007). Thus, depression and anxiety are associated with deficits in similar domains, specifically in that they have biased views towards future events and difficulties performing well when those events occur.

The ability to accurately anticipate future events plays a key role in planning a course of action leading to these events. An overgeneralized sense of danger regarding future events could lead individuals to avoid many innocuous situations, as is the case in posttraumatic stress disorder (PTSD). Additionally, if individuals with depression predict that they will not enjoy upcoming activities, they will engage in avoidance rather than approach-related behaviors. Accurate anticipation of future rewarding and aversive events is important for healthy interactions with one's environment and goal achievement. Providing a better understanding of the neural mechanisms by which dysfunctional anticipation of future events contributes to the symptoms of anxiety and depression will allow for assessment that is better able to differentiate these disorders as well as more specific treatments for these disorders.

1.4 Anticipation of Future Events

Research has focused on the neural correlates of anticipating rewarding and aversive events. Reward anticipation, part of the Positive Valence Systems, as well as anticipation of aversive outcomes, has been associated with increased activation in anterior cingulate cortex (ACC) and striatal areas (Dillon et al., 2008; Knutson, Westdrop, Kaiser, & Hommer, 2000; Knutson, Fong, Adams, Varner, & Hommer, 2001). The striatum is a subcortical brain area that can be subdivided into a dorsal region, consisting of the caudate and putamen, and a ventral region, consisting primarily of the nucleus accumbens (NAc). The caudate is thought to be involved in

reinforcing actions that lead to reward and is activated during reward anticipation when behavioral performance is related to outcome (Tricomi, Delgago, & Fiez, 2004). The putamen is associated with prediction errors (O'Doherty, 2007), and plays a role in affective learning (Delgado, 2007). The NAc has been shown to respond to the anticipation of reward and loss, with its activity increasing as a function of the magnitude of the reward (Knutson, Adams, Fong, & Hommer, 2001). Although there has been little investigation into the role that ACC plays in reward anticipation in humans, animal research has found that ACC plays a role in evaluating effort and reward, as well as in using previous information to guide goal-directed actions (Cowen, Davis, & Nitz, 2012).

A growing body of research has investigated the role that neural activity associated with reward/loss anticipation plays in psychopathology, particularly in depression. Pizzagalli et al. (2009) found that unmedicated patients diagnosed with major depressive disorder (MDD) exhibited less activity in a portion of the left putamen in response to reward cues, as well as during the receipt of rewards, than did healthy controls. Individuals with remitted MDD exhibited greater activation in response to reward cues in ACC and middle frontal gyrus (MFG) than did individuals without a history of MDD (Dichter, Kozink, McClernon, & Smoski, 2012). In addition, patients diagnosed with OCD exhibited reduced NAc activity when anticipating rewards (Figee et al., 2011). Further exploration of the distinct roles that anxious apprehension and anxious arousal play in striatal reactivity to reward and loss anticipation may lead to a more nuanced understanding of avoidance in anxiety. For example, individuals high in anxious apprehension may exhibit dysfunction in striatal

regions because of the biased, future leaning nature of the disorder, wherease those high in anxious arousal may not exhibit deficits until triggered by the actual event.

In daily life, individuals behave in ways that increase or decrease the chances of future positive and negative events. It has been well established that depression and anxiety are associated with difficulties in attention that can decrease the efficiency of task performance. A network comprised of several areas, including left dorsolateral prefrontal cortex (DLPFC) and dorsal anterior cingulate cortex (dACC), appears to implement top-down attentional control in support of goal-directed behavior (Banich, 2009). More specifically, when faced with competing information, DLPFC biases processing of task-relevant information, whereas dACC is involved in late-stage response selection and evaluation. Research supporting this network model has found that the degree of late-stage selection as indexed by dACC activity is high when LDLPFC activity is low (Silton et al., 2010). Furthermore, this relationship was shown to be degraded in depressed individuals as well as those with depression and co-morbid anxiety (Silton et al., 2011).

1.5 Present Study

The aim of the present study was to explore the unique neural correlates of anxious apprehension, anxious arousal, and depression during reward/loss anticipation, as well during the implementation of top-down attentional control, to better understand the mechanism by which these disorders harmfully interact with the environment. Individuals with varying levels of anxious apprehension, anxious arousal, and depression completed a modified version of a monetary incentive delay (MID) task. This paradigm allowed for the investigation of the anticipation of rewards

and losses, top-down attentional control in the face of distracting emotional words, and their interaction with psychopathology.

The present study is the first MID task to employ a balanced cue design such that participants had the opportunity to win or lose money on the same trial, rather than separate trials, allowing for the investigation of the interaction of contemporaneous processes involved in reward and punishment. In addition, the task modified the standard MID task to incorporate emotionally distracting targets. One goal was to replicate reward/loss anticipation results consistent with those found in the literature involving the original MID task, thus validating the use of the task to examine altered anticipation of future events in psychopathology. It was hypothesized that the anticipation of rewards and losses would be associated with increased activation in caudate, putamen, NAc, and ACC. In addition, it was hypothesized that arousing words would capture attention and increase activation in areas involved in top-down attentional control, specifically DLPFC and dACC.

After validating the task, the central goal of the study was to examine the distinct effects of anxious apprehension, anxious arousal, and depression on the anticipation of rewards and losses, as well as on the implementation of attentional control in such a context. For the anticipation of rewards and losses, it was hypothesized that anxious apprehension would be associated with increased striatal and ACC activation in response to cues signaling rewards and losses. It was also hypothesized that anxious apprehension would be associated with distraction by highly arousing words, with increased activation in DLPFC and dACC to compensate for this distraction. Anxious arousal was hypothesized to exhibit no association with the anticipation of rewards or losses, but that highly arousing words would be

distracting and DLPFC and dACC would compensate, similar to anxious apprehension. It was hypothesized that depression would be associated with decreased striatum activation in anticipation of rewards and increased striatum activation in anticipation of losses, as well as increased dACC in anticipation of both rewards and losses. Finally, it was hypothesized that depression would be associated with increased distraction by highly arousing words.

Chapter 2

METHOD

2.1 Participants

Participants were recruited from a large pool of undergraduates who completed various questionnaires as partial fulfillment of enrollment in a psychology course. During group screening sessions, potential participants completed a series of questionnaires, including the Negative Affect (NA) and Positive Affect (PA) subscales of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Participants were instructed to rate the extent to which they felt 10 positive and 10 negative emotions during the past few weeks as part of screening for several studies. They received course credit for completing questionnaires and were contacted to participate in the present study (1) if they scored at or above the 80^{th} percentile ($\geq$ 29) on the NA subscale of the PANAS and at or below the 50^{th} percentile ($\leq$ 34) on the PA subscale; (2) if they scored at or above the 80^{th} percentile ($\geq$ 41) on the PA subscale and at or below the 50^{th} percentile ($\leq$ 22) on the NA subscale; (3) if they scored at or below the 50^{th} percentile ($\leq$ 22 on the NA subscale and $\leq$ 34 on the PA subscale) on the NA and PA subscales. Percentile cutoff scores were determined using a similar, large independent sample of college students. Group membership was ignored in data analyses for the present study because the hypotheses focused on dimensional measures of anxiety and depression.

Individuals who gave written informed consent to participate were given a laboratory tour, during which they completed various questionnaires and were

screened for a history of serious brain injury, abnormal hearing or vision, claustrophobia, left-handedness, metal in their body, pregnancy, and nonnative English-speaking. A total of 90 participants completed the fMRI protocol, which was approved by the Institutional Review Board of the University of Illinois at Urbana-Champaign. Data were not retained for participants who (1) moved more than 2.13 mm between adjacent fMRI volumes; (2) committed errors on 13% or more of the trials; or (3) provided incomplete questionnaire data. These exclusions left a total of 77 predominantly Caucasian, non-Hispanic/Latino participants included in present analyses (49% female; 82% Caucasian). Table 1 provides the final N for each PANAS group, although PANAS grouping was not used in the present study.

Table 1 Group Sample Sizes by Gender

	High PA and low NA	Low NA & PA	High NA and low PA
Male	15	13	10
Female	9	14	15
Total	24	27	25

Note: One participant from the final sample did not meet criteria for a group.

2.2 Questionnaires

Participants completed measures of anxiety and depression during the laboratory tour. The 16-item Penn State Worry Questionnaire (PSWQ) was used to measure worry or anxious apprehension (Meyer, Miller, Metzger, & Borkovec, 1990; Molina & Borkovec, 1994). Participants responded to questions such as "Many situations make me worry," by rating how characteristic each statement was of them on a scale from 1 ("not at all typical") to 5 ("very typical"). Participants also completed the Anxious Arousal and Anhedonic Depression subscales of the Mood and Anxiety Symptom Questionnaire (MASQ; Watson, Clark, et al., 1995; Watson, Weber, et al., 1995) in which they rated how much they had experienced each item during the previous week on a scale from 1 ("not at all") to 5 ("extremely"). The MASQ Anxious Arousal subscale (MASQ-AA) is comprised of 17 items in which participants responded to statements such as "Heart was racing or pounding." The eight-item MASQ Anhedonic Depression subscale (MASQ-AD8) was used as it has been shown to predict current and lifetime depressive disorders (Bredemeir et al., 2010), as well as reflect depressed mood (Nitschke, Heller, Imig, McDonald, & Miller, 2001). The MASQ-AD8 scale consists of items such as "Felt like nothing was very enjoyable."

2.3 Stimuli and Experimental Design

Participants completed a modified version of the monetary incentive delay (MID) task (modified from Knutson et al., 2000) during an fMRI and EEG session. A session consisting of a battery of neuropsychological measures was always completed between fMRI and EEG sessions, but the order of neuroimaging sessions was

counterbalanced across participants. Participants were paid for their participation in each part of the study. Only MRI data from the modified MID task will be discussed here.

The modified MID task consisted of a practice block containing 24 trials followed by 3 blocks of 48 trials, yielding a total of 144 task trials. Task timing was determined using a modified version of the genetic algorithm (modified from Wager & Nichols, 2003), which was designed for the optimization of event-related fMRI designs. At the beginning of each trial, a visual cue appeared on the screen for 1.5 s signaling one of four potential monetary outcomes: (1) potential reward or loss, (2) potential reward, (3) potential loss, or (4) neither reward nor loss. A fixation dot then appeared for a variable interstimulus interval (ISI; 3, 4.5, 6, 7.5 s) before a target emotion word (positive, neutral, or negative) appeared on screen and changed color after a variable amount of time (see below). The emotion word remained on screen for a total of 1.5 s and was followed by a variable ISI (3, 4.5, 6, 7.5 s), after which visual feedback (1.5 s) indicated to participants whether they had won or lost money, if there was no money change, or if they had made an error. Errors were defined as pressing a button before the target word appeared, pressing a button other than the designated button, which was under the right index finger during the target period, or failing to press a button in response to the target. Trials were separated by variable intertrial intervals (ITIs, 3, 4.5, 6, and 7.4 s).

Participants were instructed that the outcome of each trial was based on their how fast they pressed the button after the emotion word appeared on the screen. Their success was determined by whether they pressed the button before the word changed color. The amount of time before the word changed color varied for each participant in

a way that optimized obtaining an equal number of successful and failed trails. To accomplish this, a distribution of the reaction times (RTs) from the previous block (practice block in the case of the first block) was used to identify RTs corresponding to the 15th and 85th percentiles. On trials that participants were expected to be successful, the word changed color after the amount of time corresponding to the 85th percentile of the participant's RT distribution. On trials that the participant was expected to fail, the word changed color after the amount of time corresponding to the 15th percentile. Word color change times varied around those two set points in order to mask the predetermined nature of the trials.

Successful performance on potentially rewarding trials was associated with a monetary reward ranging from $1.80 to $2.35 (mean: $2.08), while unsuccessful performance on loss trials was associated with a monetary loss of the same range of values. Cues did not indicate reward/loss magnitudes, only the potential for reward or loss. Participants were informed that, at the end of the three task blocks, receiving a bonus block was contingent upon their overall task performance. The term "overall task performance" was left vague and may have been interpreted by participants as the cumulative monetary outcome; however, this was determined by the experimenter as generally performing the task as it was instructed. In the bonus block, participants were only able to win money. The possibility of the bonus block served to maintain motivation on trials where there was no money at stake. All participants exhibited appropriate behavior to complete the bonus block. Participants did not receive feedback about cumulative earnings during either the task or bonus blocks.

The 144 emotion words used in the task were selected from the Affective Norms for English Words (ANEW) set (see Table 2; Bradley & Lang, 1999). Forty-

eight positive (e.g., joy, fun), 48 neutral (e.g., glass, statue), and 48 negative (e.g., war, cancer) words were selected on the basis of established norms for arousal, valence, word length, and frequency of use in the English language (Bradley & Lang, 1999). Positive and negative words were selected to be highly arousing, whereas neutral words were selected to be low in arousal.

Stimuli for the modified MID task were displayed using back projection, and presentation and RT measurement were controlled by laboratory-written Matlab code (version 2009a, The MathWorks, Natick, MA), using Psychophysics Toolbox extentions (version 2.54; Brainard, 1997; Pelli, 1997).

Table 2 Word Characteristics

	Positive words	Neutral words	Negative words
Average arousal	6.59	3.73	6.56
Average valence	7.80	5.23	2.49
Average frequency	51.50	51.81	51.98
Average word length	5.78	5.33	5.38

Note: Word stimuli were selected from the Affective Norms for English Words (ANEW) set (Bradley & Lang, 1999). Arousal and valence data from the ANEW set are measured on a scale ranging from 1 to 9, with 9 corresponding to the most arousing and pleasant ratings, respectively. Frequency information was obtained from Toglia and Battig (1978).

2.4 fMRI Data Acquisition

MR data were acquired using a Siemens Magnetom Trio 3T scanner. While participants performed the practice block, two MPRAGE structural sequences were acquired (192 axial slices, slice thickness 0.90 mm, in-plane voxel size: 0.45 mm x 0.45 mm) for registering each participant's functional data to standard space. Upon completion of structural scans and the practice trial block, gradient field maps were collected to correct for geometric distortions in the functional data caused by magnetic field inhomogeneities (Jezzard & Balaban, 1995). Nine hundred and ninety-three functional images were then collected across 3 task blocks using a Siemans gradient echo-planar imaging sequence (repetition time [TR]: 3000 ms, echo time [TE]: 25 ms, flip angle: 90°, field of view [FOV]: 256 mm). Fifty oblique axial slices (slice thickness 2.40 mm, in-plane voxel size: 2.13 mm x 2.13 mm) were acquired parallel to the anterior and posterior commissures. Three volumes at the beginning of each task block were omitted to allow the scanner to reach steady state.

2.5 fMRI Data Reduction and Analysis

Functional neuroimaging data processing and statistical analysis were implemented primarily using the FMRI Expert Analysis Tool, version 5.98 (FEAT, http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FEAT), part of the FSL analysis package (http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/). Functional data for each participant were motion-corrected using rigid-body registration implemented in FSL's linear registration tool, MCFLIRT (Jenkinson, Bannister, Brady, & Smith, 2002). This process registers the functional volume at each time point to the volume corresponding to the middle time point. The data were then temporally filtered with a nonlinear high-

pass filter that attenuated frequencies below 1/180 Hz, spatially smoothed using a 3-D Gaussian kernel (full width at half maximum = 5 mm), and slice-time-corrected. Each time series was then corrected for geometric distortions caused by magnetic field inhomogeneity.

Level 1 regression analyses were then performed for each block of each participant's preprocessed functional time series data using FMRIB's Improved Linear Model with autocorrelation correction (FILM; Woolrich et al., 2001). Statistical maps were generated via multiple regression computed for each intracerebral voxel. A separate explanatory variable (EV) was entered for each of the four types of cue, each of the three emotion-word types, and each feedback type (success and failure). Three additional predictors of no interest were included to account for performance errors, one modeling each period of the task (cue, emotion word, feedback). Each EV was convolved with a gamma function (mean lag: 6 s, *SD:* 3 s, phase: 0 s) to approximate the temporal course of the blood-oxygen-level-dependent (BOLD) hemodynamic response function. Each EV yielded a per-voxel effect-size parameter estimate (β) map representing the magnitude of activation associated with that EV for that participant. To create comparisons of interest, β values were contrasted for the relevant parameters. For the cue period, two contrasts were created: (1) a reward comparison (REW) was created by contrasting cues signaling the potential to win money with cues signaling no potential to win money and (2) a loss comparison (LOSS) was created by contrasting cues signaling the potential to lose money with cues signaling no potential to lose money. For the word period, an arousal comparison (ARO) was created by averaging the positive and negative word conditions and contrasting this average with neutral-word condition.

Level 2 analyses were performed to combine the three task blocks within each subject. A weighted average of each contrast across the three task blocks for each participant was computed using a fixed-effects model. Given that only the within-block variance is used in this model, and a new variance term is not estimated, inferences from this step are only applicable to the specific blocks for the specific subject.

Functional activation maps for each participant were then warped into a common stereotaxic space (the 2009 Montreal Neurological Institute [MNI] 152 symmetrical 1 mm x 1 mm x 1 mm template, resampled to 2 mm x 2 mm x 2 mm; Fonov et al., 2009) using FMRIB's Non-Linear Image Registration Tool (FNIRT; Andersson et al., 2007). The common template was resampled to an isotropic resolution that more closely resembled the functional data resolution. To do this, the first structural image was registered to the second structural image using a rigid-body registration (only allowing *xyz* translation and rotation). The two structural images were then averaged together, to increase the signal-to-noise ratio. Next, the motion corrected functional data from each block was registered to the average of the two structural images using rigid-body registration. The average structural image was then registered to the resampled MNI template using a two-step process. First, a linear registration was carried out, which allowed for *xyz* translation, rotation, zoom, and shear. Second, a non-linear registration using cubic b-spline basis functions and a warp resolution of 10 mm was carried out, with the results from the linear registration as a starting point. The three registration steps (rigid-body functional to average structural, affine structural to MNI, and non-linear structural to MNI) were

concatenated to create a warp that mapped functional to MNI space and was then applied to the β maps.

Level 3 group inferential statistical analyses of brain activation were carried out using FLAME (FMRIB's Local Analysis of Mixed Effects). To identify brain regions where REW and LOSS were uniquely moderated by PSWQ, MASQ-AA, or MASQ-AD8, scale scores were converted to *z* scores and simultaneously entered as independent variables (IVs) into third-level regression analyses that were used to predict REW and LOSS. Mean effects were modeled using a column of ones and corresponded to the activation at the mean score on PSWQ, MASQ-AA, and MASQ-AD8. Each third-level regression analysis produced four β maps: one for each scale and one for the mean activation.

Based on a priori hypotheses, masks based on the Harvard-Oxford probabilistic atlas available in FSL were used to limit the number of voxels under consideration in order to help control family-wise error rate. Regions of interest (ROIs) for REW and LOSS contrasts included (1) nucleus accumbens (NAc), (2) putamen, (3) caudate, (4) striatum, (5) thalamus, (6) amygdala, (7) orbitofrontal cortex (OFC), and (8) cingulate and paracingulate gray matter. Masks for subcortical ROIs contained a noncontiguous pair of sets of contiguous voxels in order to capture areas in the left and right hemispheres. Two-tailed *t* tests were conducted on the βs for each scale and then converted to *z* scores to determine the significance of the βs compared to zero. To correct for multiple comparisons, Monte Carlo simulations were carried out via AFNI's AlphaSim (Ward, 2000) program to estimate the appropriate cluster size for each mask at an overall family-wise error rate of .05. Using an individual voxel *z* threshold of 2.17, these estimates indicated that requiring a minimum cluster size of 16

(NAc), 46 (putamen), 36 (caudate), 60 (striatum), 66 (thalamus), 34 (amygdala), 98 (OFC), and 85 (cingulate and paracingulate gray matter) voxels would achieve that familywise error-rate control.

To identify brain regions where ARO was uniquely moderated by PSWQ, MASQ-AA, and MASQ-AD8, scale scores were converted to *z* scores and simultaneously entered as IVs into third-level regression analyses that were used to predict ARO. Mean effects were modeled using a column of ones and corresponded to the activation at the mean score on the PSWQ, MASQ-AA, and MASQ-AD8. Four β maps were produced for each third-level regression analysis: one for each scale score and one for the mean activation.

Based on a priori hypotheses, several masks were used to limit the number of voxels under consideration. These masks were based on the Harvard-Oxford probabilistic atlas available in FSL. Regions of interest (ROIs) ARO included (1) amygdala, (2) cingulate and paracingulate gray matter, (3) frontal cortex, and (4) OFC. The amygdala mask contained a noncontiguous pair of sets of contiguous voxels in order to capture the left and right amygdala. Two-tailed *t* tests were conducted on the βs for group and then converted to *z* scores to determine the significance of the βs. To correct for multiple comparisons, minimum clusters sizes were approximated using Monte Carlo simulations as implemented in AlphaSim (Ward, 2000) for an overall familywise error rate of .05. An individual voxel *z* threshold of 2.17 was used in combination with a minimum cluster size of 34 (amygdala), 85 (cingulate and paracingulate gray matter), 143 (frontal cortex), and 97 (OFC).

2.6 Behavioral Data

Average RTs were calculated for each cue type and word type for each participant. RT differences were then computed for each subject in a way that paralleled the fMRI analyses. Specifically, two cue RT contrasts were created: (1) a REW_RT contrast was created by subtracting the average RT of trials signaling no potential to win money from the average RT of trials signaling the potential to win money, and (2) a LOSS_RT contrast was created by subtracting the average RT of trials signaling no potential to lose money from the average RT of trials signaling the potential to lose money. For the word period, an arousal RT contrast was created by subtracting the average RT of neutral-word trials from the mean of the average RT of positive-word and negative-word trials.

Mirroring the neuroimaging analyses, PSWQ, MASQ-AA, and MASQ-AD8 scores were simultaneously entered as IVs into a series of regression analyses predicting each RT contrast. Regression analyses were conducted using IBM SPSS Statistics version 20.

Chapter 3

RESULTS

3.1 Behavioral Performance

A repeated-measures ANOVA ($F(3, 201) = 24.43$, $p < 0.001$, with Huynh-Feldt correction) and *post hoc* paired *t*-tests, indicated that RT for no reward/no loss trials ($M = 293$ ms, $SD = 47$ ms) was longer than RT for reward/loss ($M = 277$ ms, $SD = 46$ ms), reward/no loss ($M = 274$ ms, $SD = 44$ ms), and no reward/loss trials ($M = 279$ ms, $SD = 50$ ms). There were no differences in RT for the different types of emotion words ($F(2, 152) = .92$, $p = .40$, with Huynh-Feldt correction).

Table 3 lists the results from regression analyses in which PSWQ, MASQ-AA, and MASQ-AD8 were entered to predict REW_RT and LOSS_RT. PSWQ was negatively associated LOSS_RT. Table 4 lists the results from regression analyses in which the same measures were used to predict ARO_RT.

Table 3 Regression Analyses for Behavioral Data (Cue)

	DV = REW_RT		
Variable	Beta[a]	*P*	R^2
PSWQ	.01	.93	.00
MASQ-AA	.05	.69	
MASQ-AD8	.00	.98	

	DV = LOSS_RT		
Variable	Beta[a]	*P*	R^2
PSWQ*	-.28	.04	.08
MASQ-AA	.14	.28	
MASQ-AD8	-.03	.85	

Note. PSWQ = Penn State Worry Questionnaire; MASQ-AA = Mood and Anxiety Symptom Questionnaire Anxious Arousal subscale; MASQ-AD8 = Mood and Anxiety Symptom Questionnaire Anhedonic Depression 8-item subscale. R^2 = total variance accounted for by the three scales.
[a]Standardized betas for RT contrast inference analyses.
* $p < .05$.

Table 4 Regression Analyses for Behavioral Data (Word)

	DV = ARO_RT		
Variable	Beta[t]	*p*	R^2
PSWQ	-.04	.80	.01
MASQ-AA	.11	.41	
MASQ-AD8	.02	.92	

Note. PSWQ = Penn State Worry Questionnaire; MASQ-AA = Mood and Anxiety Symptom Questionnaire Anxious Arousal subscale; MASQ-AD8 = Mood and Anxiety Symptom Questionnaire Anhedonic Depression 8-item subscale. R^2 = total variance accounted for by the three scales.
[a]Standardized betas for RT contrast inference analyses.
* $p < .05$.

3.2 Brain Regions Associated with Cue and Word Periods

Table 5 presents the mean effects of each contrast derived from the cue period (see Figure 1), and Table 6 presents the mean effects of each contrast from the word period (see Figure 2). It is important to note that, although hemisphere has been included as a descriptor, no inferences have been made regarding the lateralization of effects. The analyses tested whether individual contrasts were different from zero. In order to make claims about laterality, specific tests would be required to test whether activation in the hemispheres differed from each other, rather than each from zero.

Table 5 Mean Activation Associated with the Cue Period

Region	Cluster Size mm^3	Direction of Relationship	Mean z-value	Location		
				X	Y	Z
Reward Cue						
L nucleus accumbens[a]	680	Positive	4.12	-11	13	-9
R nucleus accumbens[a]	720	Positive	4.29	7	11	-3
L caudate[b]	1968	Positive	3.36	-17	-1	23
R caudate[b]	2872	Positive	3.56	9	9	1
L putamen[c]	1064	Positive	2.91	-15	15	-7
R putamen[c]	1368	Positive	3.04	13	9	-11
Thalamus[d]	8024	Positive	3.13	1	-5	7
Rostral anterior cingulate cortex/subgenual/medial frontal cortex[e]	7224	Negative	-2.87	1	31	-23
Posterior cingulate cortex[e]	4408	Negative	-2.97	-13	-49	33
Dorsal anterior cingulate cortex[e]	7432	Positive	2.79	-11	13	35
Posterior cingulate cortex/precuneus[e]	648	Positive	2.49	9	-43	45
L frontal pole/orbital frontal cortex[f]	5056	Negative	-2.75	-43	41	-19
Medial frontal cortex[f]	13144	Negative	-3.12	-1	49	-21
R frontal operculum/insula[f]	1936	Positive	2.71	33	23	7
L striatum (including caudate, nucleus accumbens, putamen, and pallidum)[g]	4344	Positive	3.35	-17	-1	23
R striatum (including caudate, nucleus accumbens, putamen, and pallidum)[g]	5536	Positive	3.48	7	11	-3
Loss Cue						
L caudate[b]	1784	Positive	3.14	-17	5	23
R caudate[b]	2656	Positive	3.18	17	-7	27
R nucleus accumbens[b]	544	Positive	2.99	9	19	-3
L putamen[c]	1376	Positive	3.04	-27	5	7
R putamen[c]	472	Positive	2.70	25	-1	13
Thalamus[d]	11128	Positive	3.34	1	-17	9
Dorsal anterior cingulate cortex[e]	7920	Positive	3.09	-3	17	35
Subgenual anterior cingulate cortex[e]	848	Positive	3.57	-1	19	-1
R frontal pole[f]	1344	Positive	2.60	21	53	-17

R orbital frontal cortex/inferior frontal gyrus[f]	1288	Positive	2.58	43	23	-21

Note. L = Left; R = Right; Location = Coordinates are for the maximum *z*-stat in MNI152 2009a symmetrical space.

[a]Correction for only nucleus accumbens voxels. [b]Correction for only caudate voxels. [c]Correction for only putamen voxel. [d]Correction for only thalamus voxels. [e]Correction for only cingulate cortex and paracingulate cortex voxels. [f]Correction for only orbital frontal cortex and insula voxels. [g]Correction for only striatal voxels.

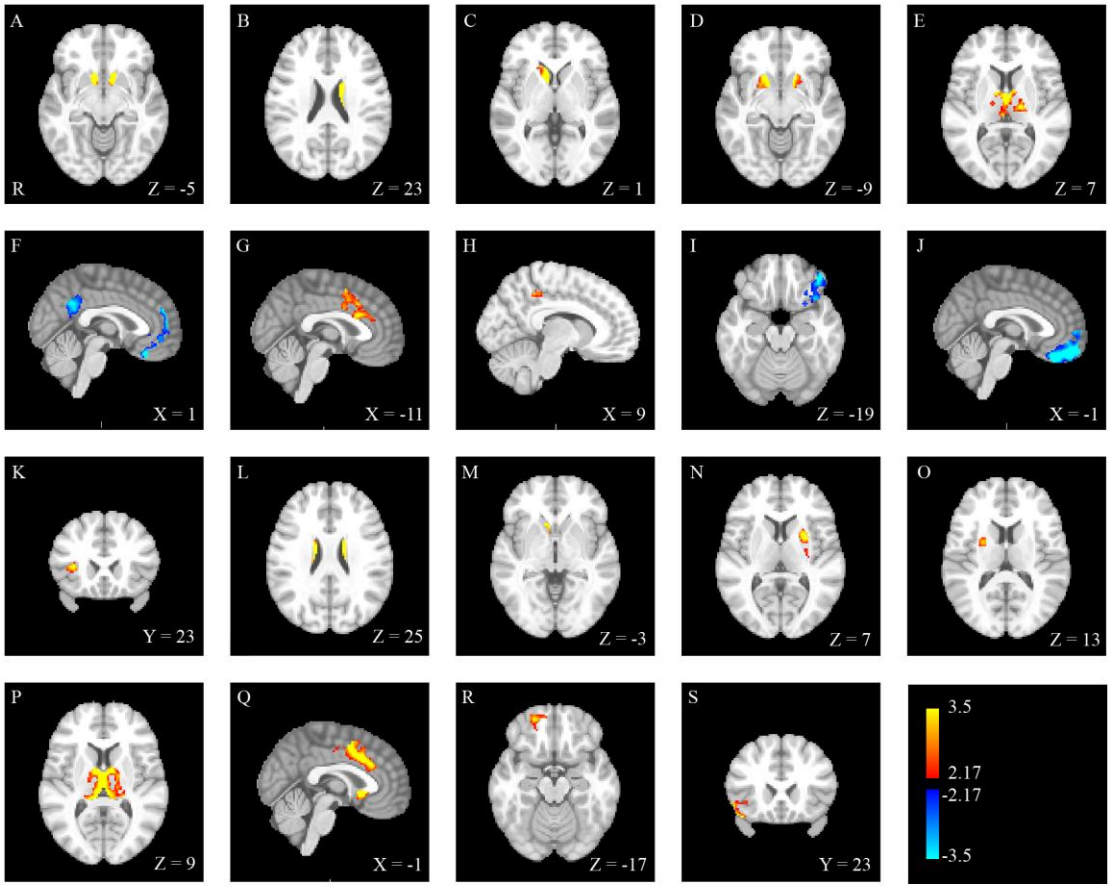

Figure 1 Areas of activation associated with the cue period. (A) Left and right NAc, (B) Left caudate, (C) Right caudate, (D) Left and right putamen, (E) Thalamus, (F) rACC/subgenual/MFC and PCC, (G) dACC, (H) PCC, (I) Left frontal pole/OFC, (J) MFC, (K), Right frontal operculum/insula, (L) Left and right caudate, (M) Right NAc, (N) Left putamen, (O) Right putamen, (P) Thalamus, (Q) dACC and sACC, (R) Right frontal pole, (S) Right OFC/IFG. Blue = decreased brain activation. Red = increased brain activation. R = right. REW = A-K. LOSS = L-S. x, y, and z = coordinates in MNI2009a space.

Table 6 Mean Activation Associated with the Word Period

Region	Cluster Size mm^3	Direction of Relationship	Mean z-value	Location		
				X	Y	Z
Arousing vs. Neutral Words						
Dorsal anterior cingulate cortex[b]	6640	Negative	-2.55	3	3	47
Posterior dorsal anterior cingulate cortex (pdACC) cortex[b]	2264	Negative	-2.75	-11	-39	49
Posterior cingulate cortex[b]	2096	Positive	2.65	-5	-53	21
R middle frontal gyrus/frontal pole[c]	20552	Negative	-2.78	41	45	17
L superior frontal gyrus[c]	4120	Negative	-2.64	-25	3	61
L inferior frontal gyrus/ orbital frontal cortex[c]	12800	Positive	3.37	-47	29	-9
Superior frontal gyrus/medial frontal cortex[c]	17504	Positive	2.95	-5	53	31

Note. L = Left; R = Right; Location = Coordinates are for the maximum *z*-stat in MNI152 2009a symmetrical space.
[a]Correction for only amygdalar voxels. [b]Correction for only cingulate cortex and paracingulate cortex voxels. [c]Correction for only frontal cortex voxels. [d]Correction for only orbital frontal cortex voxels.

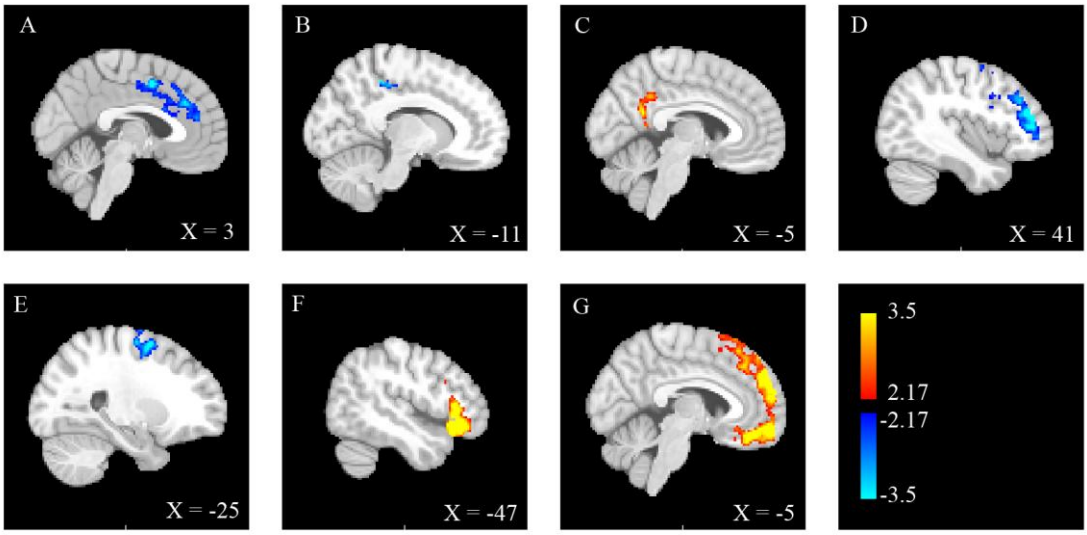

Figure 2 Areas of activation associated with the word period. (A) dACC, (B) pdACC/PCC, (C) PCC, (D) Right MFG/frontal pole, (E) Left SFG, (F) Left IFG/OFC, (G) SFG/MFC. Blue = decreased brain activation. Red = increased brain activation. R = right. x, y, and z = coordinates in MNI2009a space.

3.2.1 Reward Contrast (REW)

The REW contrast resulted in increased activation in bilateral caudate, bilateral NAc, bilateral putamen, pallidum, and thalamus. In cortical regions, there was increased activation in dorsal anterior cingulate cortex (dACC), posterior cingulate cortex/precuneus, and right frontal operculum/insula. Cortical regions that exhibited decreased activation included rostral anterior cingulate cortex (rACC)/subgenual anterior cingulate cortex (sACC)/medial frontal cortex (MFC), posterior cingulate cortex (PCC), left frontal pole/orbital frontal cortex (OFC), and MFC.

3.2.2 Loss Contrast (LOSS)

The LOSS contrast was associated with increased activation in bilateral caudate, right NAc, bilateral putamen, thalamus, dACC, sACC, right frontal pole, and right OFC/inferior frontal gyrus (IFG).

3.2.3 Arousing vs. Neutral Words (ARO)

Regions that exhibited greater activation for high-arousing words (negative and positive words) than for low-arousing words (neutral words) included PCC, left IFG/OFC, and SFG/MFC. Areas exhibiting less activation for high-arousing words than for low-arousing words included dACC, posterior dorsal anterior cingulate cortex (pdACC)/PCC, right MFG/frontal pole, and left SFG.

3.3 Brain Regions Uniquely Associated with PSWQ

Table 7 presents brain regions where PSWQ scores predicted REW, LOSS, and ARO contrasts (see Figure 3). For the REW contrast, higher PSWQ scores were associated with decreased activation in left caudate and dACC/paracingulate For the

LOSS contrast, higher PSWQ scores were associated with decreased activation in right amygdala, bilateral caudate, PCC/precuneus, and dACC. Increased PSWQ scores were associated with increased activation for high arousing words versus low arousing words in pdACC/precuneus and MFG.

Table 7 Brain Areas Uniquely Associated with PSWQ for Cue and Word Contrasts

Region	Cluster Size mm^3	Direction of Relationship	Mean z-value	Location		
				X	Y	Z
Reward Contrast						
L caudate[b]	384	Negative	-2.62	-9	9	5
Dorsal anterior cingulate cortex/paracingulate[e]	1208	Negative	-2.48	-5	41	27
Loss Contrast						
L caudate[b]	712	Negative	-2.62	-15	-3	23
R caudate[b]	872	Negative	-2.56	15	-5	21
Posterior cingulate cortex/precuneus[e]	2104	Negative	-2.52	-5	-41	45
Dorsal anterior cingulate cortex[e]	736	Negative	-2.61	1	9	43
Arousing vs. Neutral Words						
Posterior dorsal anterior cingulate cortex (pdACC) cortex/precuneus[e]	720	Positive	2.55	-9	-29	47
L Middle frontal gyrus[h]	2608	Positive	2.57	-31	39	37

Note. L = Left; R = Right; Location = Coordinates are for the maximum *z*-stat in MNI152 2009a symmetrical space.

[a]Correction for only nucleus accumbens voxels. [b]Correction for only caudate voxels. [c]Correction for only putamen voxel. [d]Correction for only thalamus voxels. [e]Correction for only cingulate cortex and paracingulate cortex voxels. [f]Correction for only orbital frontal cortex and insula voxels. [g]Correction for only striatal voxels. [h]Correction for only frontal lobe voxels.

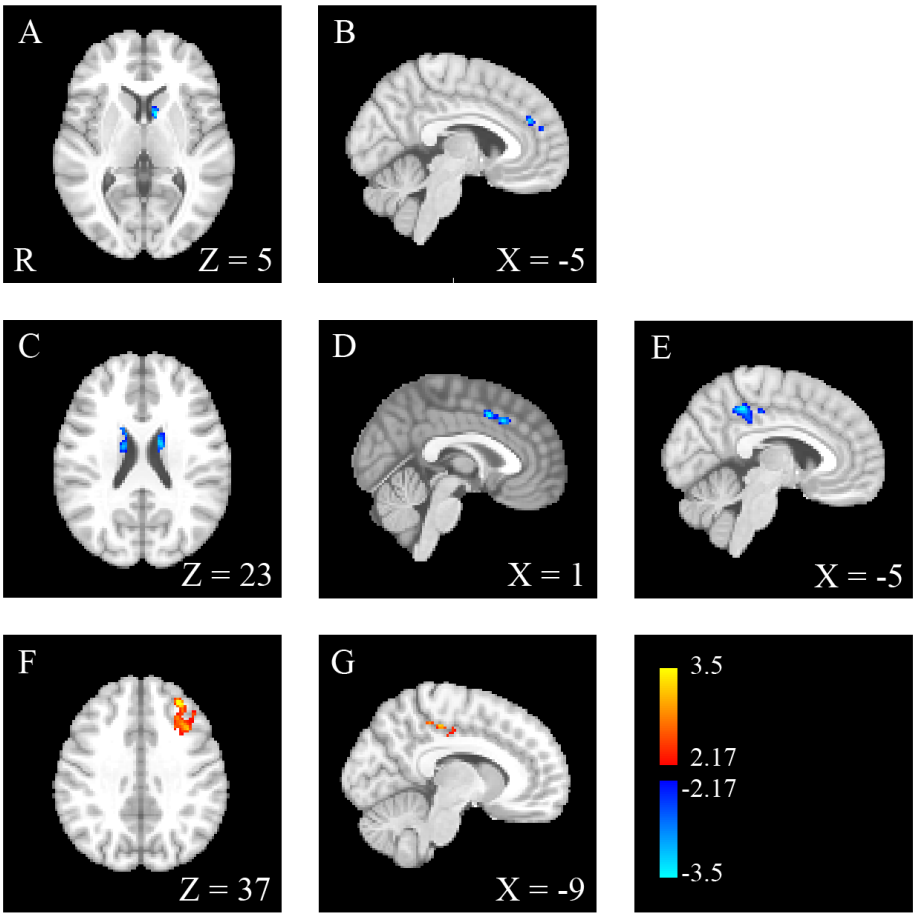

Figure 3 Areas uniquely associated with PSWQ. (A) Left caudate, (B) dACC/paracingulate, (C) Left and right caudate, (D)dACC, (E) PCC/precuneus, (F) Left MFG, (G) pdACC. Blue = decreased brain activation. Red = increased brain activation. R = right. REW = panels A-B. LOSS = C-D. ARO = F-G. x, y, and z = coordinates in MNI2009a space.

3.4 Brain Regions Uniquely Associated with MASQ-AA

Table 8 lists brain areas where MASQ-AA scores predicted REW, LOSS, and ARO contrasts (see Figure 4). For the REW contrast, higher MASQ-AA scores were associated with decreased activation in dACC. For the LOSS contrast, increased MASQ-AA scores were associated with increased activation in right pallidum/putamen. Increased MASQ-AA scores were associated with increased activation for high-arousing words versus low-arousing words in PCC/precuneus, paracingulate/dACC, left frontal pole/SFG/paracingulate, and right frontal pole/MFG/SFG.

Table 8 Brain Areas Uniquely Associated with MASQ-AA for Cue and Word Contrasts

Region	Cluster Size mm^3	Direction of Relationship	Mean z-value	Location		
				X	Y	Z
Reward Contrast						
Dorsal anterior cingulate cortex[e]	1456	Negative	-2.57	11	21	27
Loss Contrast						
R pallidum/putamen[g]	640	Positive	2.54	27	3	-5
Arousing vs. Neutral Words						
Posterior cingulate cortex/precuneus[e]	1264	Positive	2.52	-9	-51	39
Paracingulate/dorsal anterior cingulate cortex[e]	1968	Positive	2.54	-3	37	31
Left frontal pole/superior frontal gyrus/paracingulate[f]	7224	Positive	2.59	-15	61	17
Right frontal pole/middle frontal gyrus/superior frontal gyrus[f]	1904	Positive	2.61	21	45	35

Note. L = Left; R = Right; Location = Coordinates are for the maximum *z*-stat in MNI152 2009a symmetrical space.

[a]Correction for only nucleus accumbens voxels. [b]Correction for only caudate voxels. [c]Correction for only putamen voxel. [d]Correction for only thalamus voxels. [e]Correction for only cingulate cortex and paracingulate cortex voxels. [f]Correction for only orbital frontal cortex and insula voxels. [g]Correction for only striatal voxels. [h]Correction for only frontal lobe voxels.

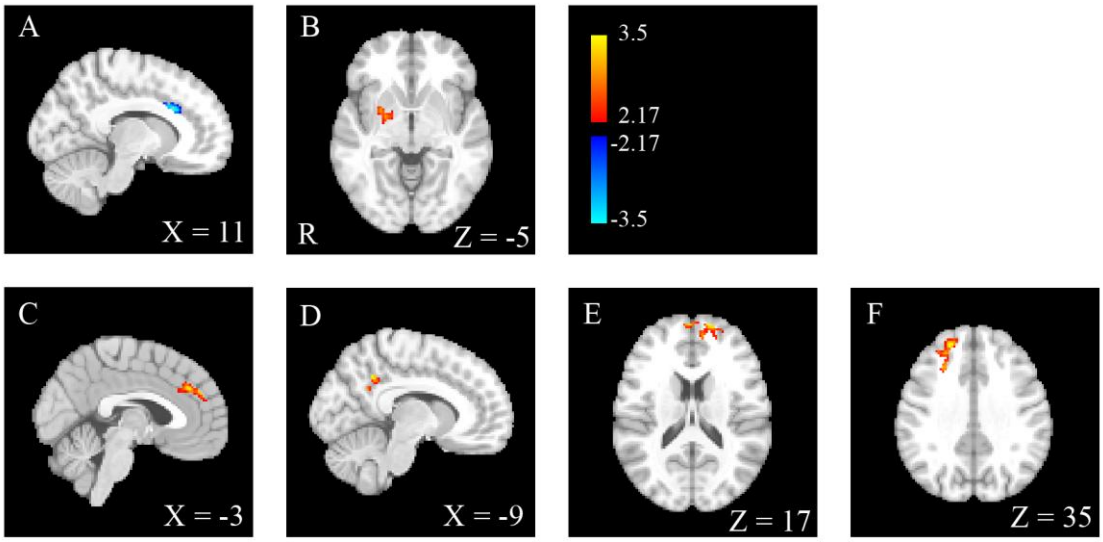

Figure 4 Areas uniquely associated with MASQ-AA. (A) dACC, (B) Right pallidum/putamen, (C) paracingulate/dACC, (D) PCC/precuneus, (E) Left frontal pole/SFG/paracingulate, (F) Right frontal pole/MFG/SFG. Blue = decreased brain activation. Red = increased brain activation. R = right. REW = A. LOSS = B. ARO = C-F. x, y, and z = coordinates in MNI2009a space.

3.5 Brain Regions Uniquely Associated with MASQ-AD8

Table 9 presents brain regions in which scores on MASQ-AD predicted REW, LOSS, and ARO contrasts (see Figure 5). For the REW contrast, increased MASQ-AD8 scores were associated with increased activation in dACC/paracingulate. For the LOSS contrast, increased MASQ-AD8 scores were associated with increased activation in dACC/paracingulate. There no brain regions in which MASQ-AD8 scores uniquely predicted the ARO contrasts.

Table 9 Brain Areas Uniquely Associated with MASQ-AD8 for Cue and Word Contrasts

Region	Cluster Size mm^3	Direction of Relationship	Mean z-value	Location		
				X	Y	Z
Reward Contrast						
Dorsal anterior cingulate cortex/paracingulate[e]	3848	Positive	2.55	-3	43	25
Loss Contrast						
Dorsal anterior cingulate cortex/paracingulate[e]	2360	Positive	2.54	3	9	43

Note. L = Left; R = Right; Location = Coordinates are for the maximum *z*-stat in MNI152 2009a symmetrical space.

[a]Correction for only nucleus accumbens voxels. [b]Correction for only caudate voxels. [c]Correction for only putamen voxel. [d]Correction for only thalamus voxels. [e]Correction for only cingulate cortex and paracingulate cortex voxels. [f]Correction for only orbital frontal cortex and insula - voxels. [g]Correction for only striatal voxels. [h]Correction for only frontal lobe voxels.

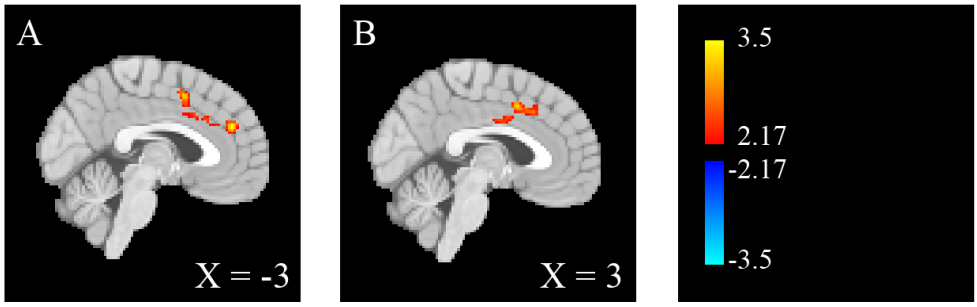

Figure 5 Areas uniquely associated with MASQ-AD8. (A) dACC/paracingulate, (B) dACC/paracingulate. Blue = decreased brain activation. Red = increased brain activation. R = right. REW = panel A. LOSS = panel B. x, y, and z = coordinates in MNI2009a space.

Chapter 4

DISCUSSION

The goals of this study were twofold. First, it was important to validate a modified version of the MID task, in order to ensure that participants anticipated rewards and losses and that the emotion words interfered with goal-directed behavior. Second, the present study sought to understand neural mechanisms by which dysfunction in the anticipation of future events and deficits in attentional control contribute to anxious apprehension, anxious arousal, and depression.

4.1 Main Effects of the Task

As evidenced by both overt behavioral performance and regional brain activation patterns, results confirmed that the present modified MID task engaged the psychological processes of interest, specifically anticipation of rewards and losses and goal-directed attentional control. Performance data indicated that individuals responded faster to trials on which there was a monetary incentive. This finding is consistent with other MID studies (e.g., Dillon et al., 2008; Knutson et al., 2001, 2003) and suggests that people are able to enhance their performance when incentives, either rewarding or punishing in nature, are available. Additionally, RTs did not differ by word type, indicating that overall performance was intact, though this finding therefore does not speak to differences in neural processes (e.g., Engels et al., 2010).

Regional brain activation was then examined to identify neural mechanisms by which dysfunction in the anticipation of future events and deficits in attentional

control contribute to internalizing psychopathology. Incentive cues prompted increased activation for dorsal (caudate and putamen) and ventral (NAc) striatum for both REW and LOSS contrasts. Regarding the emotion-word period, the ARO contrast was associated with increased activation in PCC, left IFG/OFC, and SFG/MFC. Present results indicate that participants may engage in emotion-regulation strategies in order to maintain task performance, as evidenced by equivalent RTs across emotion word types. The activated brain regions are part of a larger network typically referred to as the default mode network, which has been implicated in emotion regulation, self-referential activities, future planning, and self inspection (Sylvester et al., 2012). Furthermore, the ARO contrast was associated with decreased activation in pdACC/PCC, dACC, right MFG/frontal pole, and left SFG.

Reduced pdACC and dACC activation suggests that arousing words were associated with a reduction in late-stage processing and response evaluation, an indication that, at the average level of anxious apprehension, anxious arousal, and depression, these processes were not required because early-stage processing was sufficient to maintain task performance. Banich (2009) proposed that an area in pdACC that is responsible for selecting incoming information that should guide task behavior. Subsequently, a more anterior area in dACC is thought to be associated with evaluating the response that has been made. Although arousing words were distracting, as evidenced by increased default-mode network activity, they did not require late-stage selection of information.

Regarding reduced right MFG/frontal pole and left SFG activation, research on action planning has suggested an anterior to posterior gradient within the prefrontal cortex (PFC; Badre & D'Esposito, 2007) such that anterior regions are associated with

more abstract goals (e.g., preparing dinner), and posterior regions are associated with more proximate subgoals (e.g., cutting vegetables). In light of this gradient, present results suggest that arousing words are associated with decreased higher-order goal planning (pressing the button when the emotion word appears on the screen). This implies that highly arousing words do in fact direct attention away from goal-oriented processes.

4.2 Psychopathology

The present study also investigated whether anxious apprehension, anxious arousal, and depression uniquely moderated brain activation in response to cues signaling potential reward and loss. It was hypothesized that anxious apprehension would be uniquely associated with increased activation in dorsal striatum and ACC. The observed relationship was in the opposite direction, such that higher PSWQ scores were associated with reduced reward-related signals. These results suggest that worry impairs processes involved in reward learning (Delgado, 2007). Individuals who are consumed by worrisome thoughts may fail to attend to important reward-related signals that can guide future behavior. Further, this reduced activation may indicate that in worrying about future events individuals are less likely use information from previous events to inform their future actions.

In reward learning, dACC has been implicated in using past experiences to guide future behavior (Kennerely, Walton, Behrens, Buckley, & Rushworth, 2006). The negative relationship between dACC activation and PSWQ scores suggests that increases in worry are associated with decreases in reliance on previous information to guide future behavior. Thus, individuals who worry may instead rely on worrisome thoughts and fears to guide their behavior and actions. As mentioned above, reduced

caudate activation corroborates this hypothesis, as it indicates that worry is associated with problems in reward learning when faced with anticipatory cues.

It was also hypothesized that anxious apprehension would be associated with increased cognitive control during the emotion-word period due to the preparatory nature of worry. This hypothesis was supported, as increased PSWQ scores were associated with increased activation in DLPFC and pdACC. These results suggest that worry is associated with increased top-down attentional control as indexed by DLPFC activity and with increased late-stage processing as indexed by pdACC activity. Individuals who are constantly worrying may require additional top-down attentional control to disengage in their worries and focus on task-relevant information.

It was hypothesized that anxious arousal, characterized by physiological hyperarousal and somatic tension, would exhibit no relationship with REW or LOSS. The results did not support this hypothesis and instead indicated that increased levels of anxious arousal are associated with decreased activation in dACC for REW. Similar to anxious apprehension, this suggests that individuals who are high in anxious arousal rely less on previous information to guide future behavior. Additionally, increased MASQ-AA scores were associated with increased activation in right pallidum/putamen for LOSS. Smith and Berridge (2005) demonstrated that stimulation of the anterior portion of the pallidum in rats was associated with decreased "liking" reactions and eating in response to food, whereas both types of responses were increased after stimulation of the posterior of the pallidum. Calder et al. (2007) showed support for this functional division in humans using disgusting and appetizing food. Results from the present study suggest that heightened anxious arousal is associated with greater aversive reactions to loss cues.

Further, it was hypothesized that arousing words would be distracting for individuals high in anxious arousal and would be associated with increased activation in PCC and MFC, which is associated with emotion regulation (Sylvester et al., 2012). This hypothesis was partially supported, in that increased MASQ-AA scores were associated with increased activation in PCC, which is thought to index engagement in emotionally salient stimuli (for a review, see Maddock, 1999). Higher MASQ-AA scores were also associated with increased activation in dACC, an area that is involved in response evaluation (Milham & Banich, 2005; Banich, 2009). Individuals with high levels of anxious arousal found arousing words engaging, and subsequent response evaluation indicated that increased top-down attentional control was needed on the next trial in order to focus on task-relevant information. Left frontal pole/SFG/paracingulate and right frontal pole/MFG/SFG activity may index increased higher-order goal planning, such that individuals who are high in anxious arousal are able to maintain the task goal despite distracting emotional information.

Taken together, present findings suggest that both anxious apprehension and anxious arousal are associated with deficits in reward learning, as evident by decreased activity in dACC, which is thought to incorporate previous information to guide future behavior. However, these two anxiety dimensions were differentiated by activity in subcortical regions as well as activity in regions involved in implementing top-down attentional control in the face of emotional distractors. Anxious apprehension was associated with greater deficits in reward learning and increased DLPFC and pdACC activation to maintain task performance, whereas anxious arousal was characterized by an increased aversion to losing money, increased engagement in

task irrelevant emotional information, and increased dACC activity signaling the need for increased top-down attentional control on subsequent trials.

It was hypothesized that elevated depression, here higher MASQ-AD8 scores, would be associated with decreased activation in the striatum for REW and increased activation in the striatum for LOSS. Additionally, it was hypothesized that increased depression would be associated with increased activation in dACC, reflecting increased reliance on previous information to guide future behavior. However, increasing MASQ-AD8 scores were not associated with any portion of the striatum for REW or LOSS. This is somewhat surprising, given that depression is in part characterized by anhedonia, and research has shown that depression is associated with decreased activation of the striatum during the anticipation and receipt of reward (Knutson, Bhanji, Cooney, Atlas, & Gotlib, 2008; Pizzagalli et al., 2009). However, in line with hypotheses, increasing levels of depression were associated with increased dACC activation in REW and LOSS, supporting the proposal that depression is associated with increased dependence on previous trial information. A key characteristic of depression is the engagement of rumination or repetitively focusing on symptoms of distress. These thoughts are past-oriented and typically focus on the potential causes and results of these symptoms. Individuals who typically engage in rumination and repetitive thinking about the past may tend to rely on information from previous trials in the current task in order to guide their behavior on the current trial.

Further, it was hypothesized that depression would not be associated increased distraction in the face of arousing words due to opposite attentional biases for negative and positive words. Consistent with this hypothesis, no brain regions were uniquely associated with MASQ-AD8 scores for ARO.

In the present study, depression was differentiated from both types of anxiety during the anticipation of rewards and losses in that it was associated with an increased reliance on information from the previous trial. This parallels the difference in repetitive thoughts between the two types of disorders. Worry is typically future-oriented, whereas rumination focuses on events of the past. Additionally, while anxiety was associated with changes in top-down attentional control in response to arousing words, depression was unrelated to brain activity engaged by arousing words. It may be the case that depression is related to engagement by the valence of the word rather than the level of arousal.

4.3 Implications for Treatment

Several results have important implications for the treatment of anxiety and depression. First, these results suggest that anxious apprehension and anxious arousal are associated with a failure to use information from previous trials to guide goal-directed behavior. Exposure treatments for various types of anxiety focus on repeatedly exposing the individual to a feared stimulus, until they learn that the stimulus is harmless. Second, present findings support the idea that these individuals need repeated exposure, because they tend to disregard information from previous experiences. Third, anxious apprehension and anxious arousal were in part differentiated by striatal response to reward/loss anticipation. These results suggest that anxious apprehension is related to a perceived disconnect between efforts on a task and performance, whereas anxious arousal is associated with an aversion response to loss situations. Treatment for anxious apprehension may benefit from focusing on reinforcing the connection between an individual's actions and outcomes in his/her life, while treatment for anxious arousal might center around decreased an individual's

intense reaction to the anticipation of potentially negative events. In the present study, depression was associated with an increase in attention to previous events, implying a propensity to overuse information from previous experiences. This is consistent with rumination, which is often a target of treatment for depression.

4.4 Strengths and Limitations

The present study has several strengths, including a sample size that is quite large by the standards of the fMRI literature, which potentially provides the dataset with enhanced statistical power. A dimensional data analytic approach further increases power, as well as facilitating the understanding of disorder-specific deficits on a dimension. The present study also extends the literature on reward/loss anticipation and top-down attentional control. However, the present study also has limitations. For one, the present study only investigated the unique contribution of anxious arousal, anxious apprehension, and depression and did not take into account interactions. Future research should include these interactions as anxiety and depression frequently co-occur. In addition, the design of the study is correlational, which does not provide researchers to make inferences regarding whether psychology precedes changes in brain activation or vice versa.

The present study suggests neural mechanisms by which dysfunction in the anticipation of future events contributes to anxious apprehension, anxious arousal, and depression. Furthermore, adjustments in top-down attentional control were associated only with anxiety, and the two types of anxiety were differentated by the stage at which top-down attentional control was implemented. Aside from treatment implications, this study was able to tease apart neural mechanisms associated with three commonly distinguished but related disorders.

REFERENCES

Badre, D. & D'Esposito, M. (2007). Functional magnetic resonance imaging evidence for a hierarchical organization of the prefrontal cortex. *Journal of Cognitive Neuroscience, 19*(12), 2082-2099.

Banich, M. T. (2009). Executive function: The search for an integrated account. *Current Directions in Psychological Science, 18*(2), 89-94.

Banich, M. T., Milham, M. P., Atchley, R. A., Cohen, N. J., Webb, A., Wszalek, T., … Brown, C. (2000a). Prefrontal regions play a predominant role in imposing an attentional "set": Evidence from fMRI. *Cognitive Brain Research, 10*, 1-9.

Banich, M. T., Milham, M. P., Atchley, R. A., Cohen, N. J., Webb, A., Wszalek, T., … Brown, C. (2000b). fMRI studies of Stroop tasks reveal unique roles of anterior and posterior brain systems in attentional selection. *Journal of Cognitive Neuroscience, 12*, 988-1000.

Barlow, D. H. (1991). Disorders of emotion. *Psychological Inquiry, 2*, 58-71.

Beck, A. T. (1976). *Cognitive therapy and emotional disorders.* New York: International Universities Press.

Berridge, K. C. & Kringelbach, M. L. (2008). Affective neuroscience of pleasure: Rewards in humans and animals. *Psychopharmacology, 199*,457-480.

Brainard, D. H. (1997) The Psychophysics Toolbox, *Spatial Vision 10*:433-436.

Calder, A. J., Beaver, J. D., Davis, M. H., van Ditzhuijzen, J., Keane, J., & Lawrence, A. D. (2007). Disgust sensitivity predicts the insula and pallidal response to pictures of disgusting foods. *European Journal of Neuroscience, 25,* 3422-3428

Caseras, X. ,Garner, M,. Bradley, B., Mogg, K. (2007). Biases in visual orienting to negative and positive scenes in dysphoria: A eye movement study. *Journal of Abnormal Psychology, 116,*491-497

Clark, L. A., & Watson, D. (1991). Tripartite model of anxiety and depression: Psychometric evidence and taxonomic implications. *Journal of Abnormal Psychology, 100,* 316-336

Clark, L. A., Watson, D., & Mineka, S. (1994). Temperament, personality, and the mood and anxiety disorders. *Journal of Abnormal Psychology, 103*(1), 103-116.

Compton, R. J., Banich, M. T., Mohanty, A., Milham, M. P., Herrington, J., Miller, G. A., … Heller, W. (2003). Paying attention to emotion: An fMRI investigation of cognitive and emotional Stroop tasks. *Cognitive Affective and Behavioral Neuroscience, 3*, 81-96.

Compton, R. J., Heller, W., Banich, M. T., Palmieri, P. A., & Miller, G. A. (2000). Responding to threat: Hemispheric asymmetries and interhemispheric division of input. Neuropsychology, 14, 254–264.

Cowen, S. L., Davis, G. A., & Nitz, D. A. (2012). Anterior cingulate neurons in the rat

map anticipated effort and reward to their associated action sequences. *Journal of Neurophysiology, 107*, 2393-2407.

Crocker, L. D., Heller, W., Speilberg, J. M., Warren, S. L., Bredemeier, K., Sutton, B. P., … Miller, G. A. (2012). Neural mechanisms of attentional control differentiate trait and state negative affect. *Frontiers in Psychology, 3*, 1-13.

Cuthbert, B. & Insel, T. (2010). The data of diagnosis: New approaches to psychiatric classification. *Psychiatry, 73*(4), 311-314.

Delgado, M. R. (2007). Reward-related responses in the human striatum. *Annals of the New York Academy of Sciences, 1104*, 70-88.

Der-Avakian, A. & Markou, A. (2011). The neurobiology of anhedonia and other reward-related deficits. *Trends in Neurosciences, 35*(1), 68-77.

Dichter, G. S., Kozink, R. V., McClernon, F. J., & Smoski, M. J. (2012). Remitted major depression is characterized by reward network hyperactivation during reward anticipation and hypoactivation during reward outcomes. *Journal of Affective Disorders, 136*, 1126-1134.

Dillon, D. G., Holmes, A. J., Jahn, A. L., Bogdan, R., Wald, L. L., Pizzagalli, D. A. (2008).Dissociation of neural regions associated with anticipatory versus consummatory phases of incentive processing. *Psychophysiology, 45*, 36-49.

Eizenman, M., Yu, L. H., Grupp, L., Eizenman, E., Ellenbogen, M., Gemar, M., & Levitan, R. D. (2003). A naturalistic visual scanning approach to assess selective attention in major depressive disorder. *Psychiatry Research, 118*(2), 117-128.

Engels, A. S., Heller, W., Mohanty, A., Herrington, J. D., Banich, M. T., Webb, A. G., Miller, G. A. (2007). Specificity of regional brain activity in anxiety types during emotion processing. *Psychophysiology, 44,* 352-363.

Engels, A. S., Heller, W., Spielberg, J. M., Warren, S. L., Sutton, B. P., Banich, M. T., & Miller, G. A. (2010). Co-occuring anxiety influences patterns of brain activity in depression. *Cognitive, Affective & Behavioral Neuroscience, 10*(1), 141-156.

Eysenck, M. W. (1997). Anxiety and cognition: A unified theory hove. United Kingdom: Psychology Press.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*(2), 336-353.

Figee, M., Vink, M., de Geus, R., Vulink, N., Veltman, D. J., Westenberg, H., & Denys, D. (2011). Dysfunctional reward circuitry in obsessive-compulsive disorder. *Biological Psychiatry, 69*, 867-874.

Grabenhorst & Rolls. (2011). Value, pleasure and choice in the ventral prefrontal cortex. *Trends in Cognitive Sciences, 15*(2), 56-67.

Grillon, C. (2008). Models and mechanisms of anxiety: Evidence from startle studies. *Psychopharmacology, 199,* 421–437.

Heller, W., Nitschke, J.B., Etienne, M.A., & Miller, G.A. (1997). Patterns of regional brain activity differentiate types of anxiety. *Journal of Abnormal Psychology, 106,* 376-385.

Joormann, J. & Gotlib, I. H. (2007). Selective attention to emotional faces following

recovery from depression. *Journal of Abnormal Psychology, 116,* 80-85.

Joorman, J., Talbot, L., & Gotlib, I. H. (2007). Biased processing of emotional information in girls at risk for depression. *Journal of Abnormal Psychology, 118,* 412-417.

Kennerley, S. W., Walton, M. E., Behrens, T. E. J., Buckley, M. J., & Rushworth, M. F. S. (2006). Optimal decision making and the anterior cingulate cortex. *Nature Neuroscience, 9*(7), 940-947.

Knutson, B., Adams, C. M., Fong, G. W., & Hommer, D. (2001). Anticipation of increasing monetary reward selectively recruits nucleus accumbens. *The Journal of Neuroscience, 21*, 1-5.

Knutson, B., Bhanji, J. P., Cooney, R. E., Atlas, L. Y., & Gotlib, I. H. (2008). Neural responses to monetary incentives in major depression. *Biological Psychiatry, 63*(7), 686-692.

Knutson, B., Fong, G. W., Adams, C. M., Varner, J. L., & Hommer, D. (2001). Dissociation of reward anticipation and outcome with event-related fMRI. *Brain Imaging, 17*(4), 3683-3687.

Knutson, B., Westdrop, A., Kaiser, E., & Hommer, D. (2000). FMRI visualization of brain activity during a monetary incentive delay task. *NeuroImage, 12*, 20-27.

MacLeod, A. K. & Byrne, A. (1996). Anxiety, depression, and the anticipation of future positive and negative experiences. *Journal of Abnormal Psychology, 105,* 286-289

Maddock, R. J. (1999). The retrosplenial cortex and emotion: New insights from

functional neuroimaging of the human brain. *Trends in Neurosciences, 22,* 310-316.

Maddock, R. J., Garrett, A. S., & Buonocore, M. H. (2003). Posterior cingulate cortex activation by emotional words: fMRI evidence from a valence decision task. *Human Brain Mapping, 18,* 30-41.

Mathews, A. & MacLeod, C. (1994). Cognitive approaches to emotion and emotional disorders. *Annual Review of Psychology, 45,* 25-50.

Milham, M. P., & Banich, M. T. (2005). Anterior cingulated cortex: An fMRI analysis of conflict specificity and functional differentiation. *Human Brain Mapping, 25,* 328-335.

Milham, M. P., Banich, M. T., & Barad, V. (2003). Competition for priority in processing increases prefrontal cortex's involvement in top-down control: An event-related fMRI study of the Stroop task. *Cognitive Brain Research, 17,* 212-222.

Mineka, S. & Sutton, S. (1992). Cognitive biases and the emotional disorders. *Psychological Science, 3,* 65-69.

Mineka, S. & Zinbarg, R. (2006). A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. *American Psychologist, 61,* 10–26.

Moser, J. S., Moran, T. P., & Jendrusina, A. A. (2012). Parsing relationships between dimensions of anxiety and action monitoring brain potentials in female undergraduates. *Psychophysiology, 49,* 3-10.

Nitschke, J. B., & Heller, W. (2002). The neuropsychology of anxiety disorders: Affect, cognition, and neural circuitry. In H. D'haenen, J. A. den Boer, H. Westenberg, & P. Willner (Eds.), Textbook of bio- logical psychiatry (pp. 975–988). Chichester, UK:Wiley.

Nitschke, J. B., Heller, W., & Miller, G. A. (2000). Anxiety, stress, and cortical brain function. In J. C. Borod (Ed.), The neuropsychology of emotion (pp. 298–319). New York: Oxford University Press.

Nitschke, J.B., Heller, W., Imig, J.C., McDonald, R.P., & Miller, G.A. (2001). Distinguishing dimensions of anxiety and depression. *Cognitive Therapy and Research, 25*, 1-22.

Nitschke, J. B., Heller, W., Palmieri, P. A., & Miller, G. A. (1999). Contrasting patterns of brain activity in anxious apprehension and anxious arousal. *Psychophysiology, 36*, 628–637.

O'Doherty, J. (2007). Reward representations and reward-related learning in the human brain: Insights from neuroimaging. *Current Opinion In Neurobiology, 14*, 769-776.

Pelli, D. G. (1997) The VideoToolbox software for visual psychophysics: Transforming numbers into movies, *Spatial Vision 10*:437-442.

Pizzagalli, D. A., Holmes, A. J., Dillon, D. G., Goetz, E. L., Birk, J. L., Bogdan, R., . . . Fava, M. (2009). Reduced caudate and nucleus accumbens response to rewards in unmedicated individuals with major depressive disorder. *American Journal of Psychiatry, 166,*702-710.

Rinck, M. & Becker, E. S. (2005). A comparison of attentional biases and memory biases in women with social phobia and major depression. *Journal of Abnormal Psychology, 114*,62-75.

Silton, R. L., Heller, W., Engels, A. S., Towers, D. N., Spielberg, J. M., Edgar, J. C., … Miller, G. A. (2011). Depression and anxious apprehension distinguish frontocingulate cortical activity during top-down attentional control. *Journal of Abnormal Psychology, 120*(2), 272-285.

Smoski, M. J., Felder, J., Bizzell, J., Green, S. R., Ernst, M., Lynch, T. R., & Dichter, G. S. (2009). fMRI of alterations in reward selection, anticipation, and feedback in major depressive disorder. *Journal of Affective Disorders, 118*,69-78.

Sylvester, C. M., Corbetta, M., Raichle, M. E., Rodebaugh, T. L., Schlaggar, B. L., Sheline, Y. I., … Lenze, E. J. (2012). Functional network dysfunction in anxiety and anxiety disorders. *Trends in Neurosciences, 35*(9), 527-535.

Tricomi, E. M., Delgado, M. R., & Fiez, J. A. (2004). Modulation of caudate activity by action contingency. *Neuron, 41*, 281-292.

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 and Social Psychology, 54*(6), 1063-1070.

Watson, D., Weber, K., Assenheimer, J. S., Clark, L. A., Strauss, M. E., &

McCormick, R. A. (1995). Testing a tripartite model: I. Evaluating the convergent and discriminant validity of anxiety and depression symptom scales. *Journal of Abnormal Psychology, 104,* 3-14.

Appendix

IRB APPROVAL LETTER

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Office of the Vice Chancellor for Research

Institutional Review Board
528 East Green Street
Suite 203
Champaign, IL 61820

November 19, 2012

Wendy Heller
715 Psychology Bldg
603 E Daniel St
M/C 716

RE: *Effects of Emotion on Executive Function*
IRB Protocol Number: 08297

Dear Wendy:

This letter authorizes the use of human subjects in your continuing project entitled *Effects of Emotion on Executive Function*. The University of Illinois at Urbana-Champaign Institutional Review Board (IRB) approved the protocol as described in your IRB-1 application, by expedited continuing review. The expiration date for this protocol, UIUC number 08297, is 11/15/2013. The risk designation applied to your project is *no more than minimal risk*. Certification of approval is available upon request.

The IRB has also reviewed the request for major modifications. I will officially note for the record that these major modifications to the original project, as noted in your correspondence received 09/070/2012, supplying details for a 3 year follow-up study involving completion of questionnaires and an interview using the SCID; adding questionnaires to the study that measure different aspects of emotion, personality and relevant life experiences; supplying recruitment message for follow-up study; and supplying consent letters for follow-up study as well as the debriefing form, have been approved.

Copies of the attached date-stamped consent form(s) must be used in obtaining informed consent. If there is a need to revise or alter the consent form(s), please submit the revised form(s) for IRB review, approval, and date-stamping prior to use.

Please note that additional modifications to your project need to be submitted to the IRB for review and approval before the modifications are initiated. To submit modifications to your protocol, please complete the IRB Research Amendment Form (see http://irb.illinois.edu/?q=forms-and-instructions/research-amendments.html). Unless modifications are made to this project, no further submittals are required to the IRB.

We appreciate your conscientious adherence to the requirements of human subject's research. If you have any questions about the IRB process, or if you need assistance at any time, please feel free to contact the IRB Office or me or visit our Web site at http://www.irb.illinois.edu.

Sincerely,

Anita Balgopal, Director, Institutional Review Board

c: Brad Sutton
Gregory Miller
Juyoen Hur

Biomedical Imaging Center
Beckman Institute for Advanced Science and Technology
University of Illinois at Urbana-Champaign

Functional Imaging Consent Form

Investigators directing MRI research: Arthur Kramer, Ph.D., Tracey Wszalek, Ph.D., University of Illinois at Urbana-Champaign; Joseph Barkmeier, M.D., and Associates, Carle Clinic, Urbana.

Title of study: Effects of Emotion on Executive Function

Principal investigator/s: Wendy Heller, Ph.D.
Contact information is listed on p. 3.

Department/s: Psychology, University of Illinois at Urbana-Champaign

Research project:

We would like to understand how particular regions of the brain help us perform different tasks (such as remembering faces, listening to words, speaking aloud, or paying attention to certain information while ignoring other information). You are being asked to participate in a research study that will help us better understand how the brain functions. If you agree to participate in the study, magnetic resonance imaging (MRI) scans of your brain will be taken. There are two types of brain scans that may be done. Brain anatomy scans are used to determine the structure of the brain. Scans of brain function are used to determine which parts of your brain are active when you perform these different tasks.

Non-clinical scans:

NONE of the scans done during this study are appropriate for clinical interpretation. This means that they are not designed to assess any medical condition you may have. They are not designed to reveal all clinically relevant neurological problems. Rather, they are intended solely for research purposes.

Description of the MRI procedure:

You will be asked to lie on a bed that slides into the long tube of the scanner. The scanner is a small enclosed space. Radio waves and strong, changing magnetic fields are used to make images of your brain. You will be given earplugs and earphones to protect your ears since these changing magnetic fields cause loud knocking, thumping, or pinging noises. You will be asked to remain very still at these times. A scan typically lasts about 12 minutes and will never exceed 20 minutes. A number of scans will be performed with the entire procedure lasting less than 2 hours. To help you keep your head perfectly still, we will put cushions around your head or you may be asked to bite on a bar that has a dental impression of your mouth.

For some of the scans, you will look at images on a video screen. You may see letters, words, shapes, mazes, faces, color forms, etc. You will be instructed about a specific task and asked to push a button when certain conditions are met. An example of this would be to push a button every time green rectangles appear on the screen or every time you hear a particular sound.

Potential Risks:

More than a million MRI studies have been performed around the world. We will be following standard MRI procedures. You must understand that magnetic resonance imaging can be hazardous in the presence of some metallic devices, specifically: strong magnetic fields may dislodge metallic implants, causing bleeding and disruption of adjacent tissues. These fields may also cause erratic function of electrical pacemakers and stimulators. Radio waves may heat the body and metallic objects within or on the body, possibly resulting in burns. Certain metallic objects may move toward the magnet at very fast speeds if attracted by the magnetic field.

Thus, by consenting, you agree to:

Answer the Participant History Safety and Screening accurately,
Tell the investigators about all metallic devices in/on your body, and
Not bring any metal devices (e.g., pens, coins, keys, credit cards) into the scanning room without staff approval.

Although highly unlikely, you may experience dizziness, nausea, headache, flashing lights, unusual tastes, numbness, or tingling while in the magnet, or possible momentary loss of balance after leaving the magnet. These sensations are mostly due to movement while inside the magnet and can be minimized by holding still. All of these sensations should stop shortly after you leave the magnet. Additionally, because of the small space in the magnet, and the duration of the study, some people find the experiment to be uncomfortable or unpleasant. However, since you will have a visual screen to look at, you are unlikely to experience such feelings. Nonetheless, the investigator and the MR technician will check with you frequently to determine if you are experiencing any such negative sensations. You can discontinue the study at any time without penalty.

Remuneration:

You will receive $15 per hour of participation with a minimum of $15 per session. If you withdraw from the study before completion you will be compensated for the time you participated at the rate of $15 per hour, prorated to the ½ hour (i.e., ½ hour = $7.50).

Benefits:

There is no direct personal benefit to participating in this study. However, your participation provides the investigator with a greater understanding of brain structure, function and connectivity which may be useful in the development of beneficial clinical treatments.

Confidentiality:

All possible steps have been taken to assure your privacy. The experimenter will assign you an arbitrary code number which will be used throughout the scan. Only this code (and never your name) will be used when analyzing or reporting the data. Any identifying information will be kept in a locked location in the Biomedical Imaging Center. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research

information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

Voluntary participation and withdrawal:

Participation in the research is voluntary. You are free to stop participating at any time. If you choose not to volunteer or if the research is ended for any reason by you or the researchers, this will have no effect on any other benefits to which you are entitled. If you are a student at the University of Illinois, your decision to participate, decline, or withdraw from participation will have no effect on your grades at, status at, or future relations with the university.

Before you agree to participate in this study, you must provide informed consent indicating that you: 1. Are informed about the MRI procedure; 2. Are participating because you want to participate; and 3. Know that you can withdraw from the study at any time without penalty.

Dissemination of findings:

The results of the research, including but not limited to your images, may be published, and presented at lectures and professional meetings, but you will not be identified in any such publication or presentation.

What you will do in this experiment:

In this MRI study, " Effects of Emotion on Executive Function ", you will be asked to look at a series of visual stimuli, e.g. words, and asked to make a decision about those stimuli by pressing a particular button. Some of the slides may include emotional content, but nothing intended to be upsetting. No scan duration will exceed 20 minutes. The entire procedure will last no longer than 2 hours.

Contact Information:

You will be given a copy of this consent form for your records. If at any time, either now or later, you have a question, please feel free to ask it. If you have questions or concerns regarding your rights as a participant in this study, please contact the University of Illinois Institutional Review Board office at (217) 333-2670 or irb@uiuc.edu. You may, if you so choose, call the University of Illinois Institutional Review Board collect. If you have any questions about this particular study, you may contact Professor Heller (217) 333-2670 or w-heller@illinois.edu. You may, if you so choose, call this office collect.

Agreement:

By signing this document, I am stating that the nature of the MRI scan has been explained to me, and I understand that the data obtained from this scan are to be used for research purposes only, not for the evaluation or diagnosis of any disorder. I am also stating that I have had the opportunity to ask questions concerning any and all aspects of the procedures involved. I understand that I must be 18 or older to participate in this study. I am also aware that participation is voluntary, that I may withdraw my consent at any time, and that if I decide not to participate or decide to withdraw my participation, I will not be penalized in any way.

I, the undersigned, hereby consent to be a participant in the portion of the project described above conducted at the Biomedical Imaging Center, Beckman Institute.

Signature of investigator: _____

Signature of participant: _____

Signature of witness: _____

Date: _____

CONSENT TO EXPERIMENT PARTICIPATION

(Study1)

Department of Psychology
University of Illinois at Urbana-Champaign

This research project, conducted by Dr. Heller, studies the relationship between various emotions and physiological responses during visual and cognitive tasks. The project consists of two sessions which can be completed at the participant's scheduling convenience. You must be at least 18 years old to participate.

Session one involves an explanation of physiological recording procedure, a laboratory tour, some paper and pencil tests and/or computerized measures. These tests and measures ask about various behaviors, feelings, memories, or thoughts you might have, as well as assessing some basic skills and abilities such as vocabulary and memory. We will also ask you to give a questionnaire to a friend or family member to mail back to us. The second session involves the recording of regional brain activity using magnetic resonance imaging (MRI) and is covered in more detail in a separate consent form for those participants who are asked to participate in it. You will be given a task to do while you are in the magnet. The task involves viewing slides of letters, words, faces, geometric patterns, or other visual stimuli. Some of the slides include emotional content, but nothing intended to be upsetting. You may also be asked to recall certain memories and feelings before and during the task. This is not intended to be upsetting but to generate a general mood state. Each session will last between 60 and 180 minutes.

Though these types of procedures are typically interesting and educational, they are not intended to benefit the participant directly. The goal of this research is to increase basic psychological knowledge. Participants will be paid $10 for the lab tour and $15 an hour for the MRI session. Participants may make up to $40 for completing the study.

Results of the project are completely confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

Participation in the project is strictly voluntary. Participants may choose to withdraw at any time, without penalty. The investigator may also terminate participation if there is a difficulty with performing the tasks. If a session is not completed, the participant will be paid depending on how much of the study they completed. The decision to participate will have no effect on the participants'

grades or on their relationship to the University. Each procedure is explained in advance, and the participant is encouraged to ask questions at any point during the project.

I have read and understood the above, and I agree to participate in this research project. I have been informed of the procedure, discomforts, and value of the research. I am aware that I may choose to withdraw from participation at any time, without penalty. I have been told that I will be given a copy of this consent form.

Signature of Participant	Local Phone #	Age	Date

Signature of Experimenter

For any further information about the research contact: Dr. Wendy Heller, 333-6312 (w-heller@illinois.edu). If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.

CONSENT TO EXPERIMENT PARTICIPATION

(Study1)

Department of Psychology
University of Illinois at Urbana-Champaign

This research project, conducted by Dr. Heller, studies the relationship between various emotions and physiological responses during visual and cognitive tasks. The project consists of up to two sessions which can be completed at the participant's scheduling convenience. You must be at least 18 years old to participate.

Session one involves an explanation of physiological recording procedure, a laboratory tour, some paper and pencil tests and/or computerized measures. These tests and measures ask about various behaviors, feelings, memories, or thoughts you might have, as well as assessing some basic skills and abilities such as vocabulary and memory. We may also ask you to give a questionnaire to a friend or family member to mail back to us. Providing the questionnaire to your friend or family member is entirely voluntary, and will in no way affect the credit you receive in this study. Their response, or lack of response, will have no bearing on the course credit you receive for completing this experiment. You will not receive additional credit if they complete the survey. Session one will last 50 minutes. There are no anticipated risks beyond those encountered in daily life for participating in this session. The second session involves the recording of regional brain activity using magnetic resonance imaging (MRI) and is covered in more detail in a separate consent form for those participants who are asked to participate in it. You will be given a task to do while you are in the magnet. The task involves viewing slides of letters, words, faces, geometric patterns, or other visual stimuli. Some of the slides may include emotional content, but nothing intended to be upsetting. You may also be asked to recall certain memories and feelings before and during the task. This is not intended to be upsetting but to generate a general mood state. Session two will last 110 minutes.

Though these types of procedures are typically interesting and educational, they are not intended to benefit the participant directly. The goal of this research is to increase basic psychological knowledge. At the end of the study you will be given an explanation of the goals of the research. Participants will receive one hour of Psychology course credit for each hour of participation. Your participation in this study is voluntary, and you may withdraw from the study at any time. If you withdraw before the completion of the study, you will receive pro-rated credit for the amount of time you participated (e.g. 1 credit for 50-110 minutes, 2 credits for greater than 110 minutes, and 3 credits for completion of the study). If you withdraw from the study before completing in at least 50 minutes, you will not receive credit. If you decide to stop participation in the study before finishing, we will provide you with an Early Withdrawal form which you must complete in order to receive your pro-rated credit.

Results of the project are completely confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of

Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

Participation in the project is strictly voluntary. The investigator may also terminate participation if there is a difficulty with performing the tasks. The decision to participate or stop participation will have no effect on your grades or on your relationship to the University. Each procedure is explained in advance, and the participant is encouraged to ask questions at any point during the project.

I have read and understood the above, and I agree to participate in this research project. I have been informed of the procedure, discomforts, and value of the research. I am aware that I may choose to withdraw from participation at any time, without penalty. I have been told that I will be given a copy of this consent form.

Signature of Participant	Local Phone #	Age	Date

Signature of Experimenter

For any further information about the research contact: Dr. Wendy Heller, 333-6312 (w-heller@illinois.edu). If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.

CONSENT TO EXPERIMENT PARTICIPATION
(Study 2)

Department of Psychology
University of Illinois at Urbana-Champaign

This research project, conducted by Dr. Heller, studies the relationship between various emotions and physiological responses during visual and cognitive tasks. The project consists of up to four sessions which can be completed at the participant's scheduling convenience. You must be at least 18 years old to participate.

Session one and session two involve an explanation of physiological recording procedures, a laboratory tour, some paper and pencil tests, and/or some computerized tests. These tests and measures ask about various behaviors, feelings, or thoughts you might have, as well as assessing some basic skills and abilities such as vocabulary and memory. We will also ask you to give a questionnaire to a friend or family member to mail back to us. The third session involves the attachment of painless physiological sensors to the surface of the skin using routine procedures, and the recording of physiological responses during visual and cognitive tasks. The fourth session, using similar visual and cognitive tasks, involves recording of regional brain activity using magnetic resonance imaging and is covered in more detail in a separate consent form. The visual task involves viewing slides of letters, words, faces, geometric patterns, or other visual stimuli. Some of the slides include emotional content, but nothing intended to be upsetting. The cognitive tasks are standard paper and computerized measures. Only minor discomfort is involved in these procedures (e.g. having the skin rubbed). Each session will last between 60 and 180 minutes.

Though these types of procedures are typically interesting and educational, they are not intended to benefit the participant directly. The goal of this research is to increase basic psychological knowledge. Participants will be paid $10 for the lab tour, $25 for the paper and pencil/computerized tests, and $15 an hour for each lab session. Participants will receive a $10 bonus for completing all sessions and may be eligible to receive up to a $20 bonus during both lab sessions. Participants may make up to $160 in this experiment.

Results of the project are completely confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

Participation in the project is strictly voluntary and entails no foreseeable risks beyond those experienced in ordinary, everyday life. Participants may choose to withdraw at any time, without penalty. The investigator may also terminate participation if there is a difficulty with performing the tasks. If a session is not completed, the participant will be paid depending on how much of the study they completed. The decision to participate will have no effect on the participants' grades or on their relationship to the University. Each procedure is explained in advance, and the participant is encouraged to ask questions at any point during the project.

I have read and understood the above, I certify that I am at least 18 years old, and I agree to participate in this research project. I have been informed of the procedure, discomforts, and value of the research. I am

aware that I may choose to withdraw from participation at any time, without penalty. I have been told that I will be given a copy of this consent form.

Signature of Participant	Local Phone #	Age	Date

Signature of Experimenter

For any further information about the research contact: Dr. Wendy Heller, 333-6312 (w-heller@illinois.edu). If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.

CONSENT TO PROVIDE ADDITIONAL INFORMATION

Department of Psychology
University of Illinois at Urbana-Champaign

You recently participated in a research project conducted by Dr. Heller. We thank you for participating in this study, and for providing us with valuable information for our research. We would like to request that you provide some additional information for use in our study. This is strictly voluntary – you are not required to provide us with this information, and it does not change the compensation you received (or will receive) for participating in the study. Although you will not receive additional payment for providing us with this information, it will take just a moment of your time, and it will greatly help us in our research.

If you would like to provide this information, you may sign this consent form, answer the enclosed questions, and return both the signed consent form and the questions to us. There is no need to write your name on the questionnaire pages. We have enclosed an additional copy of this consent form for you to keep for your own records. If you would prefer to not participate any further, you may simply ignore this request.

While participating will not benefit you directly, you will be providing information that will advance research that may benefit society as a whole. There are no risks to participating beyond what one would encounter in everyday life. Some of these answers you will provide may be of a personal nature, but your answers to these questions are confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others. Your decision to participate, decline, or withdraw from participation will have no effect on your grades at, status at, or future relations with the University of Illinois.

I have read and understood the above consent form, and I agree to voluntarily provide this additional information. I am 18 years of age or older. I have been informed of the procedure, risks, and value of the research. I am aware that I may choose to not provide this information, without penalty. I have been told that I may keep a copy of this consent form.

Signature of Participant	Local Phone #	Age	Date

For any further information about the research contact:
Dr. Wendy Heller, 333-6312 (w-heller@illinois.edu).
If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.

CONSENT TO EXPERIMENT PARTICIPATION

Department of Psychology
University of Illinois at Urbana-Champaign

1. Project Description:

This research project, conducted by Dr. Heller, studies the relationship between various emotions and physiological responses during visual and cognitive tasks. Genetic makeup might play a role in this relationship. Therefore, in addition to the physiological recording and magnetic resonance imaging procedures that we have already explained, we will collect a small amount of your saliva to obtain a sample of your DNA, which will be used to identify genes that might influence the relationship between emotions and physiological responses during visual and cognitive tasks. You must be at least 18 years old to participate.

You will be asked to provide a small saliva sample so that we can obtain a sample of your DNA from the cells inside your mouth. This can be done by having you spit into a collection tube or rinsing your mouth with a provided mouthwash and spitting into a collection tube. This will take about a minute. The researchers will keep some of the DNA that they get from these mouth samples.

After you provide the sample, it will be placed in a sterile container marked only with an identification number and sent by mail to the Core Genotyping Facility at the Institute for Behavioral Genetics at the University of Colorado, Boulder. We are working with researchers at the University of Colorado on a large multiple-site study of how emotions and cognitions are related. We send the samples to the University of Colorado facility because they are experts in the analysis of DNA. The sample mailed to the University of Colorado will be marked with the study identification number only, and your name will not be on the sample. After the sample is analyzed, information about your DNA will be stored in password-protected computer files by identification number only. If you do not wish to provide a DNA sample, you may still participate in the remainder of the study.

Results of the project are completely confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

2. Data sharing for multi-site studies:

As one part of our ongoing studies we are working with research groups around the world who are conducting similar research projects. There is no direct benefit to you from being in this study. However, your participation may help others in the future as a result of knowledge gained from the research. By combining data from these different projects we will be able to begin to answer important research questions that can only be addressed by analyzing an extremely large number of individuals. If your data are shared with investigators from other groups they will be identified by our study code number only, and your name will not be provided to the other investigators. In addition, the other researchers will keep all information regarding your data confidential, as stated in this consent form. If you do not wish for your data to be shared with other researchers for multi-site analyses, you can still participate in the remainder of the study. Below we ask you to indicate whether you are willing to allow us to use your DNA for a larger multi-site studies.

3. Procedures for storage and future use of your DNA sample:

In addition to the research for which you are consenting under this study, we are requesting your permission to save your DNA sample for future studies of other genes that influence emotion and cognition. If you consent to this procedure, researchers at the University of Colorado will store your DNA specimen indefinitely so they can use it for other studies in the future. Any new study would also be reviewed by an Institutional Review Board. Below we ask you to indicate whether you are willing to have your DNA used in future studies. However, at any time you may ask to have your DNA samples removed from any further studies by notifying the research team in writing.

Participation in this project is strictly voluntary and entails no foreseeable risks beyond those experienced in ordinary, everyday life. Participants may choose to withdraw at any time, without penalty. If a session is not completed, the participant will be paid on a prorated basis, meaning for the portion he/she completes. The decision to participate will have no effect on the participants' relationship to the University. Each procedure is explained in advance, and the participant is encouraged to ask questions at any point during the project. The investigator may terminate participation if the participant does not meet eligibility criteria in the first session, is experiencing negative sensations, or if he or she is non-responsive.

I have read and understood the above, I certify that I am at least 18 years old, and I agree to participate in this research project. I have been informed of the procedure, discomforts, and value of the research. I am aware that I may choose to withdraw from participation at any time, without penalty. I have been told that I will be given a copy of this consent form.

Permission to share my de-identified data with other researchers for multi-site studies

The researchers may share my data with other researchers for combined analyses as part of multi-site projects. The data sent to other laboratories will be identified by code number only, and my name will not be seen by researchers at other sites.

_____ I **consent** to have my data included in analyses that combine information from multiple sites.
_____ I **do not consent** to have my data included in multi-site analyses.

Permission to use my DNA specimen for future research

My DNA specimen may be saved and used for future research related to this study, even though the purpose of the future research is not known at this time.

_____ I **consent** to have my DNA specimen saved for future research studies.
_____ I **do not consent** to have my DNA specimen saved for future research studies.

_____	_____	____	_____
Signature of Participant	Local Phone #	Age	Date

_____
Signature of Experimenter

For any further information about the research call: Dr. Wendy Heller, 333-6312.
If you have any questions about your rights as a research participant call University of Illinois Institutional Review Board, at 217-333-2670 (call collect if outside local calling area)

UNIVERSITY OF ILLINOIS
APPROVED CONSENT
VALID UNTIL

NOV 15 2013

CONSENT TO EXPERIMENT PARTICIPATION

Department of Psychology
University of Illinois at Urbana-Champaign

This research project, conducted by Dr. Heller, studies the relationship between various emotions and physiological responses during visual and cognitive tasks. The attached questionnaire asks you to rate your friend or family member's everyday behavior. You must be at least 18 years old to participate. If you would like to participate, please follow the instructions on the questionnaire and return it along with this signed consent form using the pre-addressed, postage-paid envelope that we have provided.

Results of the project are completely confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

Participation in the project is strictly voluntary and entails no foreseeable risks beyond those experienced in ordinary, everyday life. Participants may choose to withdraw at any time, without penalty, and whether or not you choose to complete and return this questionnaire will <u>not</u> affect your friend or family member's further participation in the study or their relationship with the University of Illinois.

I have read and understood the above, I certify that I am at least 18 years old, and I agree to participate in this research project. I have been informed of the procedure, foreseeable risks, and value of the research. I am aware that I may choose to withdraw from participation at any time, without penalty. I understand that I will be given a copy of this consent form.

Signature of Participant	Local Phone #	Age	Date

Signature of Experimenter

For any further information about the research contact: Dr. Wendy Heller, 333-6312 (w-heller@illinois.edu).
If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.

CONSENT TO EXPERIMENT PARTICIPATION

Department of Psychology
University of Illinois at Urbana-Champaign

This research project, conducted by Dr. Heller, studies the relationship between various emotions and physiological responses during visual and cognitive tasks. Your friend is participating in a psychology experiment. The attached questionnaire asks you to rate your friend's everyday behavior. You must be at least 18 years old to participate. If you would like to participate, please follow the instructions on the questionnaire and return it along with this signed consent form using the pre-addressed envelope that we have provided. Once we have received your completed packet, we will send you an email informing you that you will receive compensation in the mail shortly. Compensation will be a $4 gift card to Espresso Royale Coffee Shop (http://www.espressoroyale.com/locations.php).

Results of the project are completely confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

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Participation in the project is strictly voluntary and entails no foreseeable risks beyond those experienced in ordinary, everyday life. Participants may choose to withdraw at any time, without penalty, and whether or not you choose to complete and return this questionnaire will <u>not</u> affect your friend's further participation in the study or their relationship with the University of Illinois.

I have read and understood the above, I certify that I am at least 18 years old, and I agree to participate in this research project. I have been informed of the procedure, foreseeable risks, and value of the research. I am aware that I may choose to withdraw from participation at any time, without penalty. I understand that I will be given a copy of this consent form.

Signature of Participant	Local Phone #	Age	Date

Signature of Experimenter

For any further information about the research contact: Dr. Wendy Heller, 217-333-6312 (w-heller@illinois.edu).
If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.

CONSENT TO EXPERIMENT PARTICIPATION

Department of Psychology
University of Illinois at Urbana-Champaign

This research project, conducted by Dr. Heller, studies the relationship between various emotions and physiological responses during visual and cognitive tasks. You must be at least 18 years old to participate.

You will be asked to participate in one, several, or all of the following parts of the research project. Your experimenter will let you know which parts you will be participating in. First, you will be given an explanation of procedures, a laboratory tour, paper and pencil questionnaires, and some standard cognitive tests. We may ask you to give a questionnaire to a friend or family member to mail back to us. You may also participate in an interview that screens for different feelings and experiences, including emotional and chemical substance use history, or be asked to recall different kinds of memories and feelings. You will be asked to perform a visual task that involves viewing slides of letters, words, faces, geometric patterns, or other visual stimuli. Some of the slides include emotional content, but nothing intended to be upsetting. The cognitive tasks are standard tests, some of which are computerized. If you participate in more than one session, each session will last between 60 and 210 minutes. Though these types of procedures are typically interesting and educational, the intention is not to benefit the participant but to increase basic psychological knowledge and to help us improve our experimental procedure.

Results of the project are completely confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

Participation in the project is strictly voluntary and entails no foreseeable risks beyond those experienced in ordinary, everyday life. Participants may choose to withdraw at any time, without penalty. Participation will <u>not</u> affect your relationship with the University of Illinois.

I have read and understood the above, I certify that I am at least 18 years old, and I agree to participate in this research project. I have been informed of the procedure, discomforts, and value of the research. I am aware that I may choose to withdraw from participation at any time, without penalty. I have been told that I will be given a copy of this consent form.

Signature of Participant	Local Phone #	Age	Date

UNIVERSITY OF ILLINOIS
APPROVED CONSENT
VALID UNTIL

NOV 15 2013

Signature of Experimenter

For any further information about the research contact: Dr. Wendy Heller, 333-6312 (w-heller@illinois.edu).
If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.

CONSENT TO RESEARCH PARTICIPATION

Department of Psychology

University of Illinois at Urbana-Champaign

I am invited to take part in a study on attitudes and behaviors. This study is being conducted by Dr. Heller and involves completing a set of questionnaires at home and returning them. Completing these questionnaires will take approximately 50 minutes and will entail no risks beyond those experienced in ordinary, everyday life. I will receive one course credit (one hour credit) for completing and returning the set of questionnaires. The decision to participate will have no effect on my grades or on my relationship to the University.

I understand that my responses on these take-home questionnaires may serve as a basis for an invitation to participate in a future psychology experiment. I may be contacted only if I have consented to future study participation by filling out a separate consent form. I am under no obligation to agree to any future procedures. Furthermore, I know that I can withdraw from participation in this study or any future procedures at any time, without penalty. However, if I withdraw from participation at this time, I will not receive course credit. I understand that results may be published in scholarly journals, but my confidentiality will be protected.

To help protect my privacy, I acknowledge that researchers have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify me, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify me, except as explained below.

I understand that the Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). I understand that a Certificate of Confidentiality does not prevent me or a member of my family from voluntarily releasing information about myself or my involvement in this research. If an insurer, employer, or other person obtains my written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, I understand that the Certificate of Confidentiality does not prevent researchers from reporting to local authorities if they believe that there is the possibility of harm to myself or others. I understand that it will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

I freely and voluntarily consent to take part in this research project. I will be given a copy of this form for my records.

Signature of Subject **Age (must be at least 18 years old to participate)** **Date**

Your name **Subject Pool Number**

For any further information about the research call:
Dr. Wendy Heller, 333-6312 (w-heller@illinois.edu)
If you have any questions about your rights as a research participant call
University of Illinois Institutional Review Board, at 217-333-2670 (irb@illinois.edu).
Collect calls are accepted if you identify yourself as a research participant.

CONSENT TO RESEARCH PARTICIPATION

Department of Psychology

University of Illinois at Urbana-Champaign

I am invited to participate in a research survey of interests and attitudes and possibly a brief computerized cognitive task conducted by Dr. Heller. The survey will take approximately 45 minutes and the computerized task if administered will take approximately 5 minutes. The survey combines questions from projects having various purposes, including development of surveys, determination of survey norms, and analysis of attitudinal patterns. This research entails no risks beyond those experienced in ordinary, everyday life. I will receive one course credit (one hour credit) for participating in this research now. I will also receive some questionnaires to take home. If I return them, I will receive a second course credit (one hour credit). In addition, I will also receive a questionnaire to give to a friend or roommate. If they return it, they will receive a gift certificate. The decision to participate will have no effect on my grades or on my relationship to the University.

I understand that survey responses may serve as a basis for an invitation to participate in a later psychology experiment (in addition to the take-home questionnaires that I can return for additional credit). I may consent to this future study by filling out a separate included consent form. I am under no obligation to agree to any future procedures. I am aware that if I do not complete and return the take-home questionnaires and/or if my friend does not complete and return their packet, I will still receive one credit for completing these questionnaires now. Furthermore, I know that I can withdraw from participation in the survey, the computer task, the take-home questionnaires or any later procedures at any time, without penalty. However, if I withdraw from this survey, I will not receive course credit. I understand that results may be published in scholarly journals, but my confidentiality will be protected.

To help protect my privacy, I acknowledge that researchers have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify me, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify me, except as explained below.

I understand that the Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). I understand that a Certificate of Confidentiality does not prevent me or a member of my family from voluntarily releasing information about myself or my involvement in this research. If an insurer, employer, or other person obtains my written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, I understand that the Certificate of Confidentiality does not prevent researchers from reporting to local authorities if they believe that there is the possibility of harm to myself or others. I understand that it will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

I freely and voluntarily consent to take part in this research project. I will be given a copy of this form for my records.

Signature of Subject **Age (must be at least 18 years old to participate)** **Date**

Your name **Subject Pool Number**

For any further information about the research call:
Dr. Wendy Heller, 333-6312 (w-heller@illinois.edu)
If you have any questions about your rights as a research participant call
University of Illinois Institutional Review Board, at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.

Consent to Future Contact and Contact Information Update

Dear ___(participant's name)____,

Within the last 2 years you completed a research study at the University of Illinois-Urbana Champaign with Dr. Miller and Dr. Heller's research lab. The study involved multiple study sessions and included an fMRI, EEG, and a battery of tests.

We are planning on a conducting a follow-up study to the one you previously completed approximately within the next year and will be offering financial compensation for your participation. The follow-up study involves considerably less time to complete than the previous study you participated in. We would like to be able to provide you the opportunity to earn some money by participating as a subject in this new study.

Please indicate if you are interested in the possibility of participating in this study.

Yes_____ No_____

If you are interested in participating in the study, please fill out updated contact information that would be applicable for at least the next year:

Your name

Campus/Local Address

Permanent Address (i.e. parent's address; relative's address)

Non-Illinois email

For any further information about the research call: Dr. Wendy Heller, 333-6312.
If you have any questions about your rights as a research participant call
University of Illinois Institutional Review Board, at 217-333-2670 (call collect if outside local calling area)

CONSENT TO EXPERIMENT PARTICIPATION

(Study 2 Follow-up)

Department of Psychology
University of Illinois at Urbana-Champaign

This research project, conducted by Dr. Heller, studies the relationship between various emotions and physiological responses during visual and cognitive tasks. The project consists of two sessions which can be completed at the participant's scheduling convenience. You must be at least 18 years old to participate.

Session one is a questionnaire session consisting of some paper and pencil tests and/or computerized measures. These tests and measures ask about various behaviors, feelings, memories, or thoughts you might have. The questionnaires will take approximately 2 hours to complete. We will also ask you to give a questionnaire to a friend or family member to mail back to us. The second involves an interview which screens for different feelings and experiences, including emotional and chemical substance use history. The interview session will take approximately 2 hours to complete. In total, the sessions will take approximately 4 hours to complete.

Though these types of procedures are typically interesting and educational, they are not intended to benefit the participant directly. The goal of this research is to increase basic psychological knowledge. Participants will be paid $15 for completing the questionnaire session and $15 for completing the interview session. Participants may make up to $30 for completing the study.

Results of the project are completely confidential. The results may be published in scholarly journals, but confidentiality will be protected and anonymity maintained. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Department of Health and Human Services (DHHS). You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information. Finally, The Certificate of Confidentiality does not prevent us from reporting to local authorities if we believe that there is the possibility of harm to self or others. It will not be used to prevent disclosure to local authorities of child abuse and neglect, or harm to self or others.

Participation in the project is strictly voluntary and entails no foreseeable risks beyond those experienced in ordinary life. Participants may choose to withdraw at any time, without penalty. The investigator may also terminate participation if there is a difficulty with performing the tasks. If a session is not completed, the participant will be paid depending on how much of the study they completed. The decision to participate will have no effect on the participants' grades or on their relationship to the University. Each procedure is explained in advance, and the participant is encouraged to ask questions at any point during the project.

I have read and understood the above, and I agree to participate in this research project. I have been informed of the procedure, discomforts, and value of the research. I am aware that I may choose to withdraw from participation at any time, without penalty. I have been told that I will be given a copy of this consent form.

Signature of Participant	Local Phone #	Age	Date

Signature of Experimenter

For further information about the research contact: Dr. Wendy Heller, 217-333-6312 (w-heller@illinois.edu). If you have any questions about your rights as a participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (irb@illinois.edu). Collect calls are accepted if you identify yourself as a research participant.