NEURAL RESPONSES TO FEEDBACK IN INDIVIDUALS WITH TRAIT NEGATIVE AFFECT

by

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ABSTRACT

An individual's actions, typically motivated to maximize rewards and minimize losses, govern the outcomes s/he receives. Accordingly, the mesolimbic circuit of the brain has evolved specialized structures to assess rewarding and aversive feedback in an effort to guide subsequent behavior. Although a substantial body of research indicates that a central feature of negative affect (NA) is increased sensitivity to negative outcomes, supporting brain mechanisms have not been fully identified. The present study therefore explored the relationship between trait NA and neural responses to feedback. Individuals high in trait NA or low in both trait NA and trait positive affect underwent functional magnetic resonance imaging as they completed a modified incentive delay task. Results indicated that participants with high trait NA had enhanced activation to both rewards and losses in the caudate, suggesting that both outcomes are arousing and that negative outcomes are reinforced much like rewarding ones. Trait NA was also associated with enhanced striatal activation to losses relative to missing rewards. Collectively, the data provide evidence that trait NA is associated with hyperresponsivity to valenced outcomes. Moreover, such individuals have particularly deviant processing in the reinforcement of losses, suggesting a mechanism by which negative cognitive bias develops and is maintained. Clinical implications are discussed.

Chapter 1

INTRODUCTION

It is evolutionarily adaptive for humans to seek rewards and avoid losses. Accordingly, cognitive mechanisms have evolved to determine the values of rewarding and aversive stimuli, establish when they occur, and use that information to guide behavior (Delgado, 2007). A growing imaging literature has explored normal human reward circuitry and has revealed brain structures implicated in such processing of rewards and losses (e.g., Knutson, Westdorp, Kaiser, & Hommer, 2000; O'Doherty, 2004). Moreover, this body of work has laid a foundation for determining how deviations could give rise to psychopathology. Because trait negative affect (NA), reflecting a distressed disposition, is associated with a broad range of psychopathology, an examination of the relationship between trait NA and neural responses to rewards and losses allows researchers to better understand common and distinct biological mechanisms in numerous psychopathological disorders.

Trait NA is a stable disposition (Watson & Walker, 1996) characterized by the tendency to experience negative mood states, such as worry, nervousness, anger, fear, guilt, and sadness (Watson, Clark, & Tellegen, 1988). In the literature, trait NA has been discussed as both a dimension of temperament (negative affectivity, negative temperament) and of personality (neuroticism, negative emotionality). Although marked by such negative mood states, it is associated with features that persist outside

of these states like poor self-esteem and mood-regulation skills, as well as the tendency to make health complaints. Individuals with trait NA also tend to react catastrophically and cope poorly in stressful situations (Clark & Watson, 1991). Moreover, they are generally pessimistic, ruminate on failures, mistakes, and disappointments, report less satisfaction with themselves, and describe themselves more negatively than those low in NA (Watson & Clark, 1984).

Accordingly, trait NA has been associated with a range of psychopathology. Its stress feature is linked to internalizing disorders like anxiety and depression, to the extent that an individual's level of NA can predict both the onset and outcome of affective disorders (Ormel, Rosmalen, & Farmer, 2004). In contrast, the emotion-regulation and aggression facets of trait NA are associated with externalizing disorders like substance abuse and conduct disorder (Krueger, Caspi, Moffit, Silva, & McGee, 1996; Ormel et al., 2004). Across these disorders, trait NA is theorized to play a critical role in both the development and maintenance of the psychopathology (Clark, Watson, & Mineka, 1994; Krueger et al., 1996).

Not surprisingly, trait NA is associated with dysfunction of several cognitive processes, including attentional control, perception, and memory. Regarding deficits in attentional control, individuals with trait NA have an attentional bias towards negative cues (Derryberry & Reed, 1994). They display difficulty in shifting attention (Derryberry & Rothbart, 1988), such that they orient earlier towards negative or threatening information and have difficulty disengaging from it once their attention has been captured (Cisler, Bacon, & Williams, 2009). They also have heightened

difficulty ignoring salient, distracting information (Bishop, 2008). In addition, individuals with trait NA have altered perceptions and memory biases. They appraise situations as more threatening and stressful (Hemenover & Dienstbier, 1996; Oliver & Brough, 2002) and interpret ambiguous information more negatively than their counterparts (Haney, 1973). They also more easily recognize and more readily recall negative information than do individuals with low NA (Larsen, 1992; Watson & Clark, 1984). With such judgments and attributions, it is not surprising that individuals with trait NA form dysfunctional beliefs about themselves, others, and the world (Luten, Ralph, & Mineka, 1997; Clark & Watson, 1991; Watson & Clark, 1984).

Because individuals with trait NA maintain such biases, researchers have been interested in exploring their neural processing of externally-driven feedback. An increasing body of work has examined neural processing of incentives (e.g., Knutson, Bhanji, Cooney, Atlas, & Gotlib, 2008; Smoski et al., 2009) and feedback (e.g., McCabe, Wollindale, Harmer, & Cowen, 2012; Pizzagalli et al., 2009) in disorders of which NA is a characteristic. However, no known studies have explicitly examined the relationship between brain activations to feedback and negative affect itself.

Feedback from the environment functions to help individuals determine the success of their actions. Consequently, feedback must be evaluated to determine its valence (good or bad) and its magnitude. Evaluations of feedback appear to play a crucial role to sustaining motivation, as behavioral adjustments are made to maximize future rewards and minimize future losses (Ponchon et al., 2002). These outcomes are not just seen in processing decisions at the gross behavioral level, but in simple motor

processes like movement and coordination (Wrase et al., 2007). To better understand the role of outcomes, a growing literature has explored how rewards and punishments affect typical neural processes. Animal research has implicated mesolimbic dopamine projections in appetitive motivation (Olds & Milner, 1954), and human research has found evidence for the specialization of structures within this circuit (e.g., Knutson, Fong, Adams, Varner, & Hommer, 2001; O'Doherty, 2004). Critical structures in this reward circuitry include the striatum, ventromedial prefrontal cortex (vmPFC), orbitofrontal cortex (OFC), and anterior cingulate cortex (ACC).

The striatum is activated by a variety of rewards, including drugs of abuse (e.g., Breiter et al., 1997), attractive faces (Aharon et al., 2001), humor (Mobbs, Greicius, Abdel-Azim, Menon, & Reiss, 2003), and monetary incentives (Dillon et al., 2008; Knutson, Adams, Fong, & Hommer, 2001). It can be parsed into two functionally distinct subunits, the ventral and dorsal striatum. The ventral striatum, comprised mainly of the nucleus accumbens (NAc), supports signal integration for the prefrontal cortex, amygdala, and hippocampus (Wagar & Thagard, 2004). It appears to function primarily in reward anticipation in ways that contribute to learning (Berns, McClure, Pagnoni, & Montague, 2001; Robbins & Everitt, 1992), but several studies have found it to become activated in receipt of rewards as well (e.g., Breiter et al., 2001). The dorsal striatum, primarily consisting of the caudate, putamen, and pallidum, receives input from the prefrontal cortex and appears to be implicated in the receipt of feedback when it the feedback is contingent on a relevant action (Tricomi, Delgado, & Fiez, 2004; Wagar & Thagard, 2004). The caudate and putamen appear to

play critical roles in learning and updating actions that lead to rewards (O'Doherty, 2004; Delgado, 2007), and the pallidum signals motor pathways to adjust their functioning (Smith, Tindell, Aldridge, & Berridge, 2009). In support, Wrase and colleagues (2007) found that activity in the dorsal striatum predicts behavioral adaptation after delivered rewards.

Other brain regions implicated in reward processing circuitry are vmPFC, OFC, and ACC. vmPFC in particular appears to update and encode the value of the stimulus (Kringelbach, 2005) with receipt of rewards (Knutson, Adams, Fong, & Hommer, 2001; Knutson, Fong, Bennett, Adams, & Hommer, 2003) and desirable stimuli (McClure et al., 2004) activating this region. OFC appears to code the reward value of the stimulus, activating to rewarding stimuli but showing decreased activation once the individual is satiated or the stimulus is no longer rewarding (for review, O'Doherty, 2004). ACC is implicated in conflict monitoring and activates under conditions of increased risk or conflict when behavioral errors are more likely or when the desired outcome is not achieved (Gehring & Willoughby, 2002; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004). Wrase and colleagues (2007) followed up these data and found that ACC activation also predicts adjustment after delivered punishments.

Such research examining how rewards and punishments affect neural structures in a typical individual has laid a foundation for exploring how psychopathology may be associated with deviant feedback processing. Research from a variety of methodologies have provided reason to postulate that negative affect may

have maladaptive reward circuitry. Behavioral studies have found trait NA to predict distress following negative emotional imagery (Larsen & Ketelar, 1991), negative film clips (Gross, Sutton, & Ketelaar, 1998), and negative emotional slides (Zelenski & Larsen, 1999). Further, an event-related potential component that reflects intrinsic feedback after making an error, error-related negativity (ERN), is heightened in individuals with NA, suggesting that individuals with high NA have increased sensitivity to their own mistakes (Hajcak, McDonald, & Simons, 2004). Considering these sensitivities, it is not surprising that when confronted with negative feedback, individuals with trait NA show increased sensitivity to the outcome, as well as avoidant behaviors (Larsen & Ketelaar, 1989). Further support for the relationship between negative affect and abnormal responses to negative feedback comes from psychopathological disorders linked to negative affect that also demonstrated heightened responsivity to negative stimuli and feedback (for review, see Eshel & Roiser, 2010).

Although research has demonstrated negative affect (NA) is characterized by increased sensitivity to negative outcomes, relevant brain mechanisms have not been fully identified. The present study therefore explored the relationship between trait NA and neural responses to feedback. Individuals with varying levels of trait affect were recruited to complete a monetary incentive delay (MID) task. There were three types of monetary outcomes for each trial: gain, no change in balance, and loss. Of these, participants were cued to two potential monetary outcomes that could be received for each trial, and they received the better or worse outcome depending on the speed of

their response in a simple task. In addition to allowing for the investigation of rewards and losses in general, this paradigm permitted the examination of relationships between more specific types of incentive-related feedback. In other words, how did receiving a reward differ from missing a loss? How did losing differ from missing a reward? Between-group examination of neural responses to these questions allowed for a more in-depth examination of potential differences in their reward circuitries.

The specific goals of the present study were twofold. As the current task was newly implemented in this laboratory, the first goal was to demonstrate that the task captures individuals' responses to feedback as intended. It was hypothesized that, consistent with previous literature, the vmPFC, OFC, and striatal structures would activate to rewards and that the ACC would activate to losses. In addition, it was hypothesized that feedback indicating no change would be more rewarding than punishment feedback but less rewarding than reward feedback. The second, and central, goal was to determine whether individuals high in trait NA exhibit abnormalities in processing incentive-related feedback by examining how trait NA modulates neural responses to feedback. Due to heightened sensitivity to negative stimuli and feedback, it was hypothesized that individuals with trait NA would demonstrate hyperresponsivity to loss feedback, such that trait NA may be associated with hyperactivation of the striatum in this condition. No differences were expected between the NA and control groups in response to rewards. In addition, due to mood incongruent conflict, it was hypothesized that the trait NA group would show increased activation of the ACC to rewards. Determining the ways in which NA

modulates responses to feedback at a neural level provides insight into the structures supporting maladaptive cognitions, as well as potential mechanisms for their maintenance, and has important clinical implications.

Chapter 2

METHOD

Participants

The sample was comprised of 90 undergraduate students over the course of several semesters. All were enrolled in an introductory psychology course and were selected for the experiment by their responses to the Positive Affect Negative Affect Schedule (PANAS; Watson, Clark, & Tellegan, 1988). The PANAS had been administered to all introductory psychology students, and students were invited to participate in the study if their scores on its Trait Negative Affect and Trait Positive Affect (PA) subscales met one of three criteria relative to all students' scores collected in the first semester of data collection: (1) at least the 80th percentile (≥29) on Trait Negative Affect and no more than the 50th percentile (≤34) on Trait Positive Affect; (2) at least the 80th percentile (≥41) on Trait Positive Affect and no more than the 50th percentile (≤22) on Trait Negative Affect; (3) no more than the 50th percentile for both Trait Negative Affect (≤22) or Trait Positive Affect (≤34). Participants were excluded for a history of serious brain injury, abnormal hearing or vision, claustrophobia, left-handedness, or metal in their body, or if pregnant or a nonnative English speaker.

For their participation in the laboratory sessions, students were paid for the number of sessions completed and received a bonus if they completed all sessions. No

participants discontinued once informed consent was obtained and the procedures had begun. The data from 12 participants were excluded from analyses for movement of over 2.13 mm between adjacent volumes, error rates exceeding 13% of trials, or incomplete questionnaire data. In total, the data from 78 participants were analyzed (49% female; 81% Caucasian; 4% African American; 9% Asian; 3% more than one race; 4% chose not to answer the race question). These participants were split among groups as follows: 24 high PA (38% female; 79% Caucasian); 25 high NA (60% female; 84% Caucasian); 29 low PA/low NA (48% female; 79% Caucasian). The present study examined only the high NA and control (low PA/low NA) groups.

Procedure

The laboratory procedure was divided into three parts. Two parts involved participating in a monetary incentive delay task (MID) task (modified from Knutson, Westdorp, Kaiser, & Hommer, 2000) during separate fMRI and EEG sessions. The third part involved the completion of a neuropsychiatric battery. Participants always completed the neuropsychiatric battery second, with the order of the EEG and fMRI sessions first or third, counterbalanced across participants. For the present paper, only MRI data from the MID task will be reported.

Experimental Paradigm

Participants first completed 24 practice trials of the MID task to orient themselves with the task. During functional imaging, participants completed 144 experimental trials of the MID task, which were divided into 3 blocks of 48 trials. Figure 1 diagrams the trial structure. Each trial began with a 1.5 s visual cue that

signaled which two of three potential outcomes (monetary gain, no change, monetary loss) participants could receive for the trial. A fixation dot then appeared for a variable offset-to-onset interstimulus interval (ISI; 3.0, 4.5, 6.0, or 7.5 s), followed by a target emotion word for 1.5 s. During the 1.5 s word presentation, the participant pressed a button to respond to the word presentation, and the emotion word changed color after a variable amount of time. A second fixation dot appeared during a variable offset-to-onset ISI (3.0, 4.5, 6.0, 7.5 s) and was followed by the presentation of visual feedback for 1.5 s. The feedback indicated whether the participant won or lost money, whether there was no money change, or whether there was an error. Pressing a button before the emotion word appeared, pressing a button other than the one designated under the dominant-hand index finger during the target period, or failing to press a button in response to the target constituted errors.

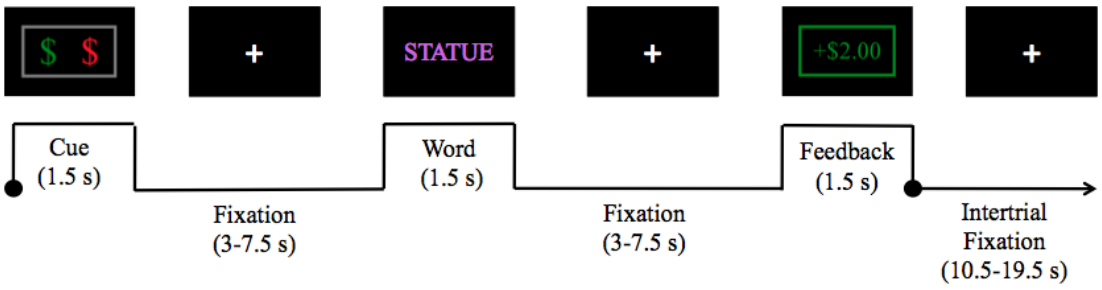

Figure 1 **Trial structure**. Each trial includes a cue, word that changes color during its presentation, and feedback. Participants are instructed to press a button as quickly as possible after the word presentation to obtain the more favorable cued feedback.

Accordingly, trial length varied from 10.5 to 19.5 s, with trials separated by an additional variable offset-to-onset intertrial interval (ITI; 10.5, 12.0, 13.5, 15.0, 16.5, 18.0, 19.5). These timings were determined by a locally modified version of a genetic algorithm (Wager & Nichols, 2003) designed to optimize event-related fMRI designs. Matlab (the MathWorks, Natick, MA) with Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997) was used to control the presentation of stimuli and measure the reaction times.

Cues, each signaling two of the three potential monetary outcomes, are presented in Figure 2. Each cue was depicted as two dollar-sign symbols ("$") indicating the two potential outcomes for a trial: green dollar signs represented monetary gain; gray represented no change in balance; red represented monetary loss. Combinations of three outcomes yielded four possible dichotomous cue types: either a rewarding or aversive outcome (monetary loss or gain); potentially rewarding outcome (monetary gain or no change in balance); potentially aversive outcome (monetary loss or no change in balance); no incentive (no change in balance). In all but the no incentive cue type, one cued outcome was considered rewarding, and the other punishing. Depending on cue type, the more rewarding cue could be either the monetary gain or no change, and the more aversive cue could be either no change or monetary loss. Of significance, the cue indicated only outcome valence and did not convey magnitude.

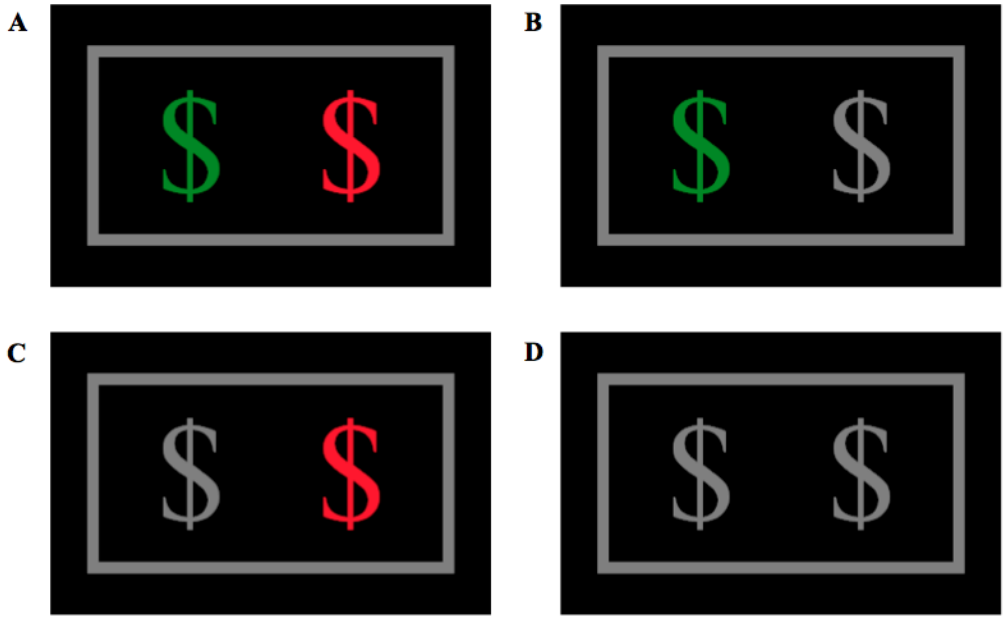

Figure 2 **Four possible incentive cues**. A green dollar sign represent the possibility of a monetary reward. A red dollar sign represents the possibility of a monetary loss. A gray dollar sign represents the possibility of no gain or loss. Accordingly, the following cues are depicted: reward/loss (A), reward/no change (B), loss/no change (C), and no incentive (D).

Participants were instructed that their outcome would be based on how quickly they pressed the button after the emotion word appeared on the screen. In actuality, whether or not the participant pressed the button before the emotion word changed color determined the participant's success on that trial. Therefore, of the dichotomously cued outcomes, fast, successful performance on a trial yielded the rewarding outcome, and slow, unsuccessful performance yielded the aversive outcome. To equalize the proportion of successes and failures for each participant, the time points marking the 15th and 85th percentiles in the participant's reaction time

distribution from the previous block (or the practice block for the first experimental block) were used as the duration of the word presentation before the color change for the current block. Because of this adjusted performance criterion, participants were successful on approximately 50% of trials.

Successful performance on trials in which a monetary gain was possible yielded participants a gain of $1.80 to $2.35 (*M*=$2.08). Unsuccessful performance on trials in which a monetary loss was possible yielded participants a loss of equal magnitude. The color of the feedback (green, gray, or red) indicated whether the participant's performance was successful or unsuccessful by providing either the better or worse cued outcome. While the color of the feedback indicated the valence of the outcome, a dollar amount notified participants of the change in their balance, as participants were instructed they would be able to keep their cumulative earnings. Throughout the experiment, participants did not receive information about their cumulative earnings. Therefore, in order to maintain motivation to perform, participants were told that their overall performance would qualify them for a bonus block at the end of the experiment, in which they could earn and not lose additional money. While "overall performance" was not clearly defined and may have been interpreted by participants to reflect their accuracy, it was determined by general behavior during the task. By this definition, all participants demonstrated good performance and were provided the bonus block.

Emotion words used in the task were selected from the Affective Norms for English Words (ANEW) database (Bradley & Lang, 1999) on the basis of published

norms for valence, arousal, word length, and frequency of use in the English language. Of the 148 words chosen, 48 were positive (e.g., joy, fun), 48 were neutral (e.g., glass, statue), and 48 were negative (e.g., war, cancer). Positive and negative words were chosen for high arousal (*M*=6.57 and 6.53, respectively), and neutral words were chosen for low arousal (*M*=3.82).

fMRI Data Acquisition

Data were acquired using a Siemens Magnetom Trio 3 Tesla scanner. Two MPRAGE sequences to image the structure of the participant's brain (192 axial slices; slice thickness: 0.9000 mm; in-plane voxel size: 0.4492 mm x 0.4492 mm) were acquired as the participant completed the practice block. These structural sequences were used in analysis to register each participant's functional data to standard space. Gradient field maps were also collected prior to trial presentation to correct for geometric distortions in the functional data caused by magnetic field inhomogeneity (Jezzard and Balaban, 1995).

As participants completed the three blocks of the experimental paradigm, 993 3D functional images were acquired using a Siemens gradient echo-planar imaging sequence (repetition time [TR]: 3000 ms; echo time [TE]: 50 ms; flip angle: 90°; field of view [FOV]: 23 cm). Each functional image was comprised of 50 oblique axial slices (slice thickness: 2.4 mm; in-plane resolution: 2.133 mm x 2.133 mm) that were collected parallel to the anterior and posterior commissures. Three volumes at the beginning of each block were omitted as the scanner achieved steady state.

fMRI Processing, Data Reduction, and Analysis

Software tools from FSL's analysis package (e.g., MCFLIRT, FEAT, FILM, FNIRT, FLAME; http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/) were used for image processing, reduction, and analysis. Preprocessing included motion correction using rigid-body registration, which allowed for only *xyz* translations and rotations. This was implemented with MCFLIRT, FSL's linear registration tool (Jenkinson, Bannister, Brady, & Smith, 2002). Data were also high-pass filtered to attenuate frequencies below 1/180 Hz, spatially smoothed with a 3D Gaussian kernel (5 mm full width at half-maximum), and slice-time corrected using FSL's fMRI Expert Analysis Tool version 5.98 (FEAT; http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FEAT). Gradient field maps were then used to correct geometric distortions.

Regression analyses were performed by block on each participant's processed functional data with autocorrelation correction using FMRIB's Improved Linear Model (FILM; Woolrich, Ripley, Brady, & Smith, 2001). Statistical maps were generated with multiple computations for each intracerebral voxel. An explanatory variable (EV) was created for each of the 4 cue types, 3 emotion-word types, and 8 feedback outcome conditions (2 feedback possibilities per cue type). Three additional predictors were included to account for errors occurring in each period of the trial – cue, word, and feedback. To better approximate the temporal course of the blood-oxygen-level-dependent (BOLD) hemodynamic response, EVs were convolved with a gamma function (mean lag=6 s, SD=3 s; phase=0 s). Each yielded a per-voxel effect

size parameter estimate (β) map depicting the magnitude of the activation associated with that EV.

β values were contrasted for the relevant parameters to create comparisons of interest. Seven contrasts were created for the feedback period, five of which are presented in this report: (1) a reward comparison (Reward – No Change) contrasted feedback following a successful response that yielded a monetary gain rather than no change; (2) a loss comparison (Loss – No Change) contrasted feedback following an unsuccessful response that yielded a monetary loss rather than no change; (3) a valence comparison (Reward - Loss) contrasted feedback containing a monetary reward with that of a monetary loss; (4) a reward versus avoiding loss comparison ($\text{Reward}_{\text{No Change}} - \text{No Change}_{\text{Loss}}$) contrasted feedback indicating a monetary gain, rather than no change, when responding successfully; (5) a loss versus missing reward comparison ($\text{Loss}_{\text{No Change}} - \text{No Change}_{\text{Reward}}$) contrasted feedback indicating a monetary loss, rather than no change, when answering unsuccessfully.

These five contrasts, computed and analyzed separately for each voxel, represented the dependent variables in the model. First-level predictors of brain activation were the three blocks, embedded within individuals, which formed second-level predictors. For each contrast for each individual, a weighted average of the three task blocks was calculated in a fixed-effects model using the inverses of within-block standard deviations as weights. Because only within-block variance was used in the model without estimating a new variance term, inferences from these first-level analyses are applicable only to particular blocks for the specific subject.

For each participant, functional activation maps were morphed into a common stereotaxic space (the 2009 Montreal Neurological Institute [MNI] template; 152 symmetrical 1 mm x 1 mm x 1 mm). This common template was resampled to a 2 mm x 2 mm x 2 mm template (Fonov, Janke, Collins, Caramanos, & Arnold, 2009) using FMRIB's Non-Linear Image Registration, FNIRT (Andersson, Smith, & Jenkins, 2008) to more closely resemble the functional data resolution and help in data visualization. However, there was not enough resolution to register the functional data directly to the template, so an intermediary step involving the individual's structural data was employed.

Specifically, of the two structural sequences recorded during each participant's practice block, the first was aligned to the second using rigid-body registration, which allowed only for *xyz* translation and rotation. The aligned images were then averaged together to create one structural image with an increased signal-to-noise ratio. To then register the functional data to this structural image, the middle volume of functional data from each block was aligned to the structural image, again using rigid-body registration. Although the middle volume was used for this alignment, the entirety of the functional data was registered to the structural image.

The average structural image was registered to the resampled standard MNI template through two steps. The first step required linear registration, allowing only for *xyz* translation, rotation, zoom, and shear of the structural image onto the MNI template. Using the results of the linear registration, the second step required non-linear registration using cubic b-spline functions and a morph resolution of 10 mm.

Finally, the numeric combinations of the parameters determined by these three registration steps (rigid-body functional to average structural, linear structural to MNI, and non-linear structural to MNI) were concatenated. This created a morph procedure ("warp") mapping the functional data to MNI space, and this warp was applied to the β maps.

Statistical analyses of brain activation were first conducted across all subjects using FMRIB's Local Analysis of Mixed Effects (FLAME). Main effects of feedback period were examined separately through *t*-tests of the means across all participants for each of the [Reward – No Change], [Loss – No Change], [Reward – Loss], [Reward $_{\text{No Change}}$ – No Change $_{\text{Loss}}$], and [Loss $_{\text{No Change}}$ – No Change $_{\text{Reward}}$] contrasts. Group differences were then examined by entering these contrasts as dependent variables in a multiple-regression model with group identification used as third-level predictors. In addition, an a priori comparison was conducted based on group in which trait negative affect comparison that contrasted the high negative affect group with the low negative affect/low positive affect group. Each group-based regression analyses created a β map.

Based on a priori hypotheses, masks were based on the Harvard-Oxford probabilistic atlas provided in FSL to limit the number of voxels under consideration and control familywise error rate. Regions of interest (ROI) were all bilateral, in that each comprised a noncontiguous pair of sets of contiguous voxels that incorporated the ROI in both hemispheres. In other words, a mask for a particular ROI was composed of that region in both hemispheres. ROIs included (1) caudate, (2) putamen,

(3) nucleus accumbens, (4) pallidum, (5) striatum, (6) orbitofrontal cortex, and (7) anterior cingulate and paracingulate gray matter.

Two-tailed *t*-tests were performed on the group βs and converted to *z* scores, which were used to determine the significance of the βs. Monte Carlo simulations were then conducted using AFNI's AlphaSim (Ward, 2000) to correct for multiple comparisons by estimating the appropriate cluster size for each mask at a family-wise error rate of .05. With an individual voxel threshold of 2.17, these estimates indicate required minimum cluster sizes of 36 (caudate), 46 (putamen), 25 (nucleus accumbens), 28 (pallidum), 60 (striatum), 97 (orbitofrontal cortex), and 85 (anterior cingulate and paracingulate gray matter) to achieve familywise error-rate control.

Behavioral Data Analysis

Average reaction times (RTs) were computed for each cue type and word type and statistically evaluated in SPSS version 19 using the General Linear Model module's repeated measures analysis of variance (ANOVA) with either cue type or word type as the within-subjects factor and with group as the between-subjects factor. Huynh-Feldt corrections were applied to address violations of sphericity. Post hoc paired-samples t-tests were then performed to compare RTs based on cue-types across groups, and independent samples t-tests were used to compare RTs based on cue-types within groups.

Chapter 3

RESULTS

Behavioral Performance

There was an effect of cue type on reaction time to words, $F(3, 137)=22.05$, $p<.001$, $\eta^2_p=.30$, such that no incentive cues (M = 296 ms, SD=48 ms) yielded longer reaction times than reward/loss (M=278 ms, SD=44 ms), reward/no change (M = 276 ms, SD = 45 ms), and loss/no change (M=279 ms, SD=50 ms) cues. Although there was no main effect of group ($F(1, 52)=0.12$, $p=.911$, $\eta^2_p<.01$), the cue type by group interaction approached significance ($F(3, 137)=2.76$, $p=.052$, $\eta^2_p=.052$). The largest between-group differential on reaction time was to the reward/loss cue; however, post-hoc t-tests indicated no significant between-group differences for any of cue types.

In addition, there were no differences in reaction time depending on the type of emotion words, $F(2, 100)=0.14$, $p=.87$, $\eta^2_p<.01$. There was also no main effect of group ($F(1, 52) = 0.01$, $p=.92$, $\eta^2_p<.01$), nor a word type by group interaction ($F(2, 100)=0.51$, $p=.60$, $\eta^2_p=.01$).

Neuroimaging of Main Effects

Table 1 presents the main effects of the five contrasts, across all participants. Statistical comparisons of BOLD activations for each contrast were based on random effects with a statistic threshold at $p<.05$ after corrections for multiple comparisons. It

is important to note that, although the hemispheres in which significant activation occurs are noted, no inferences were drawn about lateralization. Reported results reflect simple-effects tests within hemisphere, without having examined interactions with hemisphere.

Table 1 Main effects of feedback period for each within-subject contrast

Region	Cluster Size mm^3	Direction of Relationship	Mean z-value	Location		
				X	Y	Z
Reward vs. no change feedback						
R Paracingulate gyrus [a]	11792	Positive	2.72	9	27	27
R Caudate [b]	592	Positive	2.58	13	17	-3
R Putamen [c]	424	Positive	2.68	17	15	-7
L Frontal pole/Frontal orbital cortex [e]	1096	Negative	-2.46	-47	43	-15
Loss vs. no change feedback						
Paracingulate gyrus/Anterior cingulate gyrus [a]	9216	Positive	2.59	1	33	11
L frontal pole/Frontal orbital cortex [e]	1376	Negative	-2.51	-39	43	-13
Reward vs. loss feedback						
Subcallosal cortex [a]	8008	Positive	2.82	-5	15	-7
Anterior cingulate gyrus [a]	944	Positive	2.72	-3	5	27
Paracingulate gyrus [a]	1232	Positive	2.77	-5	31	37
R Caudate [b]	2496	Positive	3.25	11	19	1
L Caudate [b]	2008	Positive	3.10	-11	17	3
R Putamen/R Accumbens [c]	1736	Positive	4.13	13	11	-11
R Putamen/R Accumbens [f]	728	Positive	5.33	13	11	-11
L Putamen [c]	1320	Positive	3.53	-15	9	-11
L Accumbens [d]	4304	Positive	3.55	-11	9	-11
L Accumbens [f]	696	Positive	4.79	-11	9	-11
Frontal orbital cortex [e]	17616	Positive	2.93	15	7	-17
Frontal orbital cortex/Frontal pole [e]	1960	Positive	2.49	29	33	-13
Frontal orbital cortex/Frontal operculum cortex [e]	1000	Negative	-2.58	47	25	-5

Table 1 Continued

Reward feedback vs. avoiding a loss						
Anterior cingulate gyrus/Paracingulate gyrus [a]	19504	Positive	2.70	9	27	27
R Caudate [b]	784	Positive	2.84	13	17	-5
R Accumbens [f]	344	Positive	2.77	13	17	-7
R Pallidum [g]	224	Positive	2.67	21	1	-1
R Putamen [c]	1128	Positive	2.75	17	15	-7
L Putamen [c]	632	Positive	2.47	-21	13	-1
Frontal Pole/Frontal orbital cortex [e]	1432	Negative	2.57	-47	41	-17
Frontal Pole/Paracingulate gyrus [e]	1024	Positive	2.51	1	57	3
Loss feedback vs. missing a reward						
Subcallosal Cortex/Anterior cingulate gyrus [a]	3648	Positive	2.52	1	31	-1
Anterior cingulate gyrus [a]	928	Positive	2.60	-1	31	11

Note. L = Left. R = Right. Positive reflects enhanced activation of the first variable in each contrast relative to the second. Negative reflects deactivation of the first variable in each contrast relative to the second. Location refers to coordinates for the maximum *z*-stat in MNI152 2009 symmetrical space. [a] Correction for only cingulate cortex and paracingulate cortex voxels. [b] Correction for only caudate voxels. [c] Correction for only putamen voxels. [d] Correction for only striatal voxels [e] Correction for only occipitofrontal gray matter voxels. [f] Correction for only nucleus accumbens voxels. [g] Correction for only pallidum voxels.

Reward vs. No Change

The [Reward – No Change] contrast yielded significant activations to monetary gains in several regions, including right paracingulate cortex (vmPFC) and right regions of dorsal striatum, specifically the caudate and putamen. There was also deactivation of left OFC during reward processing.

Loss vs. No Change

The [Loss – No Change] contrast identified activation to losses in ACC. Losses in this context were also characterized by a deactivation in the left frontal pole of OFC.

Reward vs. Loss

Depicted in Figure 3, when the [Reward – Loss] contrast was applied to compare responses rewards and losses against each other, the caudate, putamen, and paracingulate activations remained significant. In fact, the striatal activation extended to the bilateral accumbens and reached threshold for significance in both hemispheric locations of the caudate and putamen. Activation to rewards also extended into OFC, with two larger regions activating, and a third, small region deactivating to rewards.

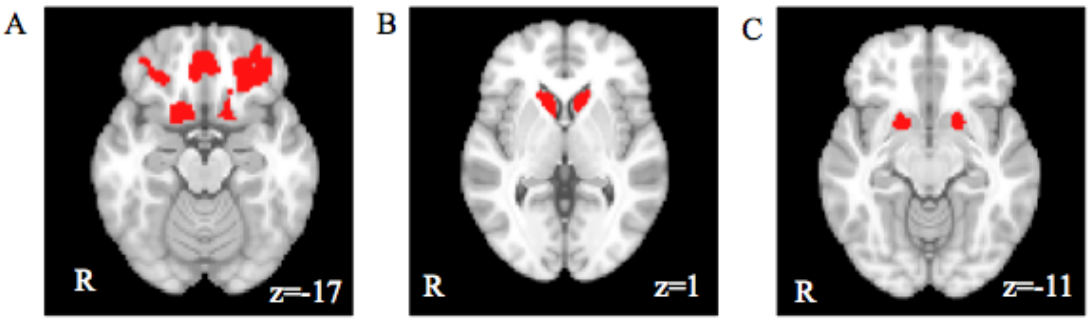

Figure 3 **Within-subjects activation for the [Reward-Loss] contrast.** Consistent with the literature, the monetary incentive delay task achieved the intended effects: activations were localized to the OFC and vmPFC (A), bilateral caudate (B), and bilateral nucleus accumbens and putamen. Activated regions in Figure 3A present activations from three clusters: one medial, comprising the three central clusters shown, and one in each hemisphere. Activations in Figures 3B and 3C represent distinct clusters. Images were selected at the voxel of maximal activation and from a direction allowing optimal viewing. R = Right.

Receiving a Reward vs. Avoiding a Loss

Two additional contrasts, nonorthogonal to those above but providing additional information, were performed. First, the [Reward $_{\text{No Change}}$ – No Change $_{\text{Loss}}$] contrast yielded activation to rewards in regions of the striatum, particularly the right accumbens, caudate, and pallidum, and the bilateral putamen. The OFC was also activated to rewards. In contrast, vmPFC was significantly deactivated during reward feedback.

Receiving a Loss vs. Missing a Reward

The experience of a loss rather than missing a reward, captured by the [Loss $_{\text{No Change}}$ – No Change $_{\text{Reward}}$] contrast, yielded activation of ACC.

Neuroimaging Group Differences

Table 2 presents the group differences, where activations for each contrast were based on random effects with a statistic threshold at $p<.05$ after corrections for multiple comparisons. The NA group differed from controls on three of the five contrasts: Reward vs. No Change, Loss vs. No Change, and Loss vs. Missing a Reward. Clusters of activation for each of these contrasts are depicted in Figures 4, 5, and 6, respectively. Regarding Reward vs. No Change, the high NA group had greater activation in ACC, vmPFC, caudate, and the temporal and frontal poles of OFC. In the Loss vs. No Change contrast, the NA group had greater activation in the left caudate and left supplementary motor cortex. In response to obtaining a loss rather than missing a reward, the NA group showed increased activation of the left caudate, bilateral accumbens, and the right putamen relative to control subjects.

Table 2 **Effects of the feedback period in the high NA group compared to low NA/PA group**

Region	Cluster Size mm^3	Direction of Relationship	Mean z-value	Location		
				X	Y	Z
Reward vs. no change feedback						
Anterior cingulate gyrus [a]	696	Positive	2.37	5	21	31
Paracingulate gyrus [a]	1232	Positive	2.44	-5	15	49
R caudate [b]	432	Positive	2.43	13	13	5
R Temporal pole/Frontal orbital cortex [c]	1776	Positive	2.50	47	23	-15
Frontal pole/R cerebral cortex [c]	896	Positive	2.51	27	57	-7
Loss vs. no change feedback						
L Supplementary motor cortex Cortex/Paracingulate gyrus [a]	712	Positive	2.48	-11	9	49
L Caudate [b]	528	Positive	2.37	-9	5	7
Loss feedback vs. missing a reward						
L Caudate [b]	400	Positive	2.46	-7	5	7
L Accumbens [e]	224	Positive	2.72	-7	11	-9
R Accumbens [e]	216	Positive	2.54	7	11	-11
R Putamen [f]	1048	Positive	2.46	25	-3	11

Note. L = Left. R = Right. Positive reflects enhanced activation of the first variable in each contrast relative to the second. Negative reflects deactivation of the first variable in each contrast relative to the second. Location refers to coordinates are for the maximum *z*-stat in MNI152 2009 symmetrical space. [a] Correction for only cingulate and paracingulate cortex voxels. [b] Correction for only caudate voxels. [c] Correction for only occipitofrontal gray matter voxels. [d] Correction for only striatal voxels. [e] Correction for only nucleus accumbens voxels. [f] Correction for only putamen voxels.

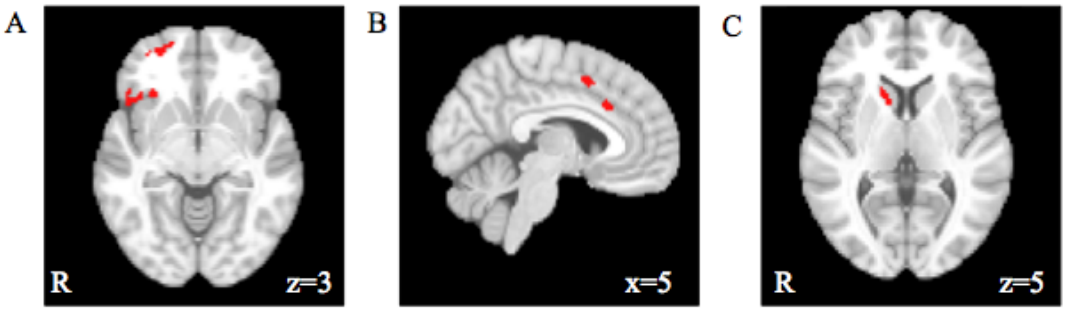

Figure 4 **Areas of greater activation in the NA group than in the control group for the [Reward – No Change] contrast.** Activations were localized to the right temporal and frontal poles of the OFC (A), anterior cingulate and paracingulate cortices (B), and right caudate (C). Activation in Figure 3A represents two clusters, one temporal/OFC and one frontal/OFC. Activations shown in Figures 3B and 3C represent distinct clusters. Images were selected at the voxel of maximal activation and from a direction allowing optimal viewing. R= Right.

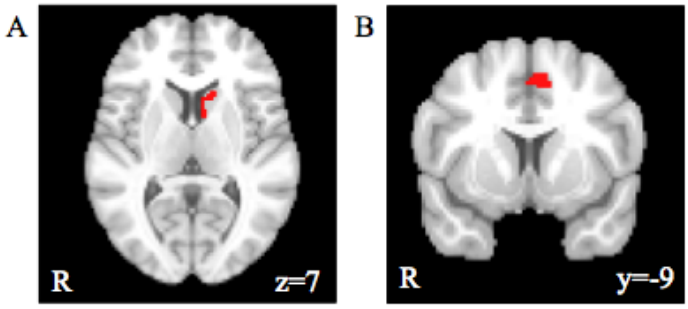

Figure 5 **Areas of greater activation in the NA group than in the control group for the [Loss – No Change] contrast.** Activations were localized to the left caudate (A) and supplementary motor/paracingulate cortex (B). Activations depict distinct clusters. Images were selected at the voxel of maximal activation and from a direction allowing optimal viewing. R = Right.

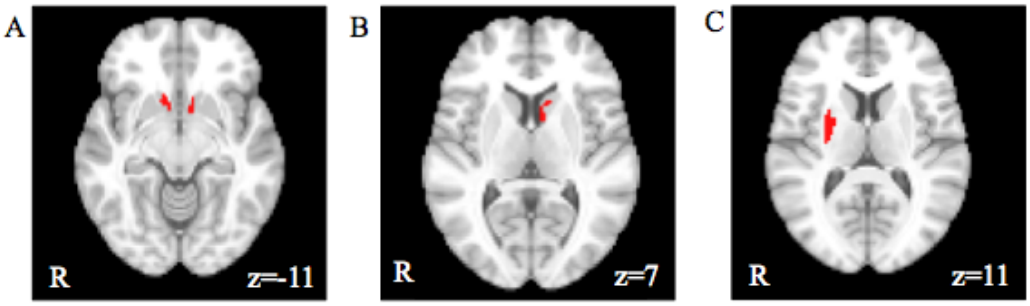

Figure 6 **Areas of greater activation in the NA group than in the control group for the [Loss $_{\text{No Change}}$ – No Change $_{\text{Reward}}$] contrast**. Activations were localized to the bilateral nucleus accumbens (A), left caudate (B), and right putamen (C). Activations depict distinct clusters. Images were selected at the voxel of maximal activation and from a direction allowing optimal viewing. R = Right.

Chapter 4

DISCUSSION

The primary goal of this study was to determine if individuals with trait NA exhibited neural abnormalities in processing incentive-related feedback. Despite a substantial body of research indicating that NA is associated with increased sensitivity to negative outcomes, supporting brain mechanisms had not yet been fully identified. Incorporating valence differentials between cued outcomes (monetary gain, no change in balance, monetary loss) allowed for the examination of general responses to rewards and losses, as well as more targeted questions, to better capture between-group distinctions in the processing of rewards and losses.

Before addressing whether individuals with trait NA exhibited neural distinctions from controls in feedback processing, the present study first evaluated whether participants completed the intended task. Because this is the first time that this laboratory has used a monetary incentive delay task, it was necessary to ensure that the task captured the intended effects. In both overt behavioral performance and regional brain activation patterns, results confirmed the hypotheses that the MID task assessed responses to both rewards and losses in ways that were convergent with previous literature. Behavioral data indicated that individuals responded more quickly to trials in which there was a monetary incentive. Findings from other studies (e.g., Knutson et al., 2008) corroborate these results and suggest that the possibility of

achieving a valenced outcome increases motivation to achieve the more desirable outcome.

Regarding brain activation patterns of the within-subject contrasts, trials delivering monetary gains prompted greater activation of vmPFC and dorsal striatum (caudate and putamen) than did trials with no change in balance. These data are consistent with previous research, indicating that vmPFC encodes desirable outcomes (McClure et al., 2004) and the dorsal striatal structures are involved in the learning and reinforcement of rewarding outcomes (Tricomi, Delgado, & Fiez, 2004). Monetary losses, relative to no changes in balance, were characterized by activation of ACC, signaling conflict between the desired and obtained outcome (Gehring & Willoughby, 2002), as well as deactivation of OFC, encoding the outcome as negative (O'Doherty, 2004). Comparing reward to punishments yielded activations of the vmPFC, dorsal (caudate, putamen, pallidum) and ventral (NAc) striatum, and OFC.

In addition, the present study assessed responses to obtaining a monetary gain and avoiding a loss, when the alternatives of both were losses. The contrast yielded activations of the ventral (NAc) and dorsal (caudate, putamen) striatum and ACC, indicating that monetary gains were perceived as more rewarding than avoiding losses, and reinforced as such. In addition, the difference between obtaining a loss and missing a reward was assessed. In this case, increased activation of the ACC signaled greater conflict between the desired and obtained outcome, suggesting that obtaining a loss is perceived more negatively than missing a reward. Overall, these data are

consistent with literature indicating that the MID task captures effects to rewards and losses consistent with previous tasks eliciting responses to feedback.

Some inconsistencies were found in relationship to previous literature and/or the hypotheses of the present study. These include a region of OFC negativity to monetary gains, compared to no change in balance, and deactivation of vmPFC to monetary gains, compared to avoiding a monetary loss. Regarding OFC deactivation, although OFC activation has been primarily been linked to appetitive outcomes (O'Doherty, 2004), some work has shown that different areas of the OFC respond differentially to rewarding and aversive outcomes (O'Doherty, Dayan, Eriston, Critchley, & Dolan, 2003). OFC appears to be involved in behavioral inhibition when task demands change (e.g., Prince, Carmichael, & Drevets, 1995), suggesting that it may identify when behavior should be altered (Spielberg, Stewart, Levin, Miller, & Heller, 2008). Regarding vmPFC deactivation to gains, interpretation would be purely speculative. Spielberg and colleagues (2008) noted that many inconsistent findings exist across fMRI literature, and further research is necessary to investigate these results. Apart from these two inconsistencies, however, the MID task used in the present study achieved the intended affects to reward and loss feedback.

Having confirmed that the MID task produced behavioral and neural responses to gains and losses as intended, the data were then evaluated to determine whether individuals high in trait NA exhibited abnormalities in their processing incentive-related feedback. Addressing this question bridges a gap in literature regarding the brain mechanisms responsible for supporting NA's documented sensitivity to negative

outcomes. Analyses produced two main findings. First, individuals with high trait NA show enhanced activation in the caudate, relative to controls, across both positive and negative feedback. Second, individuals with high trait NA reinforce negative outcomes.

The first main finding concerns enhanced activation of the striatum to both rewards and punishments, relative to no changes, in the trait NA group. We hypothesized that individuals with trait NA, relative to controls, would display similar striatal responses in the receipt of rewards but heightened activation to losses. Instead, the results yielded heightened activation of the caudate to both rewards and losses relative to controls. This finding warrants attention in two domains: first, that the activation across both types of feedback is enhanced *relative to controls*; and second, that the NA group experiences *similar activation* across reward and punishment feedback conditions.

The first consideration of this finding regards enhanced activation in these two contrasts relative to controls. At the surface, the results appear to conflict with the well-established theory that negative affect is associated with attentional bias towards negative information (Derryberry & Reed, 1994). However, arousal is another construct relevant to personality disposition that must be considered (Derryberry & Rothbart, 1988). In fact, individuals with high trait NA tend to have more reactive cortical pathways, resulting in higher arousal at lower levels of stimulation than is typical (Hebb, 1955). In support, groups thought to be high in NA reportedly experience generally higher levels of autonomic reactivity than controls (Rubin,

1964). Therefore, the data suggest that more arousing outcomes, represented by [Reward – No Change] and [Punishment – No Change] contrasts, are more salient in individuals with high trait NA and hence have a greater impact on the brain's reward circuitry. In support, there were no differences between groups in the [Reward – Punishment] contrast, indicating that it is the arousal of both emotionally salient outcomes, relative to no change, that differentiates the groups.

The second question pertains to the trait NA group alone, addressing the overlapping activation of the caudate to both rewards and losses. This pattern suggests that individuals with trait NA exhibit learning and reinforcement of positive and negative outcomes. Regions such as the vmPFC and OFC assess hedonic value and activate to pleasant or rewarding outcomes. Because these frontal regions innervate the striatum and modulate striatal responses (Haber, Kunishio, Mizobuchi, & Lynd-Balta, 1995), the exaggerated vmPFC and OFC activations to rewards in the high NA group likely contribute to the activation of the striatum in the rewarding feedback condition. However, this exaggerated vmPFC and OFC response was not present to drive the enhanced activation of the striatum to losses in the NA group. Consequently, the vmPFC and OFC activation to rewards only suggests that individuals with trait NA are able to differentiate between rewards and losses in the encoding process; however, they learn both outcomes.

Whereas numerous studies of typical populations indicate that the caudate is not typically activated to losses (e.g., Delgado, Miller, Inati, & Phelps, 2003; O'Doherty, 2004), present data indicating increased caudate activity in the trait NA

group are consistent with the hypothesis that the trait NA group would have hyperactivity in the striatum to losses. Analyses suggest that negative outcomes, similarly to positive outcomes, are learned and used to motivate future behavior. In addition, losses were associated with increased activity of the supplementary motor cortex, suggesting that planning of behavioral adjustments may accompany such learning. Because losses are reinforced similarly to rewards, the data may explain how individuals with NA develop and maintain automatic negative biases. In fact, reinforcement of negative processing may contribute to risk for psychopathology like depression. Several studies of related forms of psychopathology complement these results: remitted depressed patients had enhanced caudate responses to aversive stimuli (McCabe, Cowen, & Harmer, 2009); behaviorally inhibited individuals had similar vmPFC activations to gains and losses, but enhanced caudate activity to losses (Helfenstein et al., 2011).

In addition to vmPFC, OFC, and caudate, there was greater activation of ACC to rewards in individuals with trait NA. Consistent with the hypothesis that considers mood incongruence with receiving a monetary gain, the NA group exhibited greater ACC activation to gains than controls. As there were no group differences in reaction times or across conditions, it is unlikely that the present findings are the result of motor conflict. Instead, the results suggest that trait NA individuals experience more affective conflict in the context of monetary gains. While there is preliminary ERP evidence that ACC activates differently in individuals of negative affect compared to controls (Hajcak, McDonald, & Simons, 2004), there is a more substantial body of

evidence coming from psychological disorders associated with negative affect. For instance, cingulotomies of ACC are used to treat therapeutically unresponsive depression (Spangler et al., 1996), and positron emission tomography has found increased resting ACC activity in depressed patients and that inhibiting ACC activity can reduce depressive symptoms (Drevets, 1999; Mayberg et al., 2005). Further, the present data are consistent with the finding of individuals with depression who experience more ACC activation while anticipating attainable gains (Knutson et al., 2008).

The second general finding concerns the difference between responding unsuccessfully and losing money rather than missing a reward. Individuals with high trait NA did not differ from controls in their responses to receiving reward feedback rather than missing a punishment after a successful response. However, trait NA participants showed exaggerated activation of the striatum to losing rather than missing rewards. Although striatal activation is typically elicited by rewards, overtly negative events have also been found to elicit striatal activation, such as loss of money (Delgado, Locke, Stenger, & Fiez, 2003) or administration of a shock (Seymour, Daw, Dayan, Singer, & Dolan, 2004). In support, in an interaction of self vs. other and threatening vs. neutral contrasts, there was enhanced activity in the caudate when individuals attended to information deemed threatening to themselves (Blackwood et al., 2000). Considered collectively with past research, the present data support the [Loss – No Change] contrast findings in suggesting that negative outcomes are learned

and reinforced more heavily in individuals with trait NA than controls, likely encouraging the negative biases of individuals with trait NA.

In sum, the results of the present study demonstrate that individuals with high trait NA process negative information differently from typical individuals. Although previous experiments have indicated that increased sensitivity to negative outcomes is a central feature of NA, brain mechanisms of such biases have not been fully identified. Towards this goal, the present study determined supporting neural correlates of rewarding and aversive feedback. The enhanced striatal response to both negative and positive feedback suggests that individuals with trait NA reinforce negative outcomes similarly to positive outcomes. Further, the sensitivity of those with high trait NA to losing rather than missing rewards corroborates this heightened sensitivity to losses relative to typical individuals. Collectively, the data propose an explanation for the automaticity and continuation of negative biases. The activation of the ACC to rewards also appears to capture the effect of negative mood states of such individuals.

In pursuing an understanding of maladaptive reward circuitry in individuals with negative affect, this study has important implications for the assessment and treatment of psychopathology. Currently, many diagnoses related to negative affect are accomplished primarily through self-report. Although fMRI itself is not a feasible assessment tool, the biological differences in reward circuitries are notable and warrant research to develop behavioral measures that could target the neural

mechanisms related to hypersensitivity to valenced outcomes and reinforcement of losses.

In terms of therapy, these data first highlight the role that emotional arousal, both to pleasant and aversive feedback, may play a role in activating structures associated with negative mood states. If such structures contain information associated with high levels of arousal, exposure to these emotionally arousing states may help clients attenuate their responses to emotional feedback. For example, individuals with anxiety may have learned to fear interoceptive cues associated with positively arousing and negatively arousing stimuli and outcomes. Exposure to such situations may elicit the entirety of one's fear or distress response and help to more quickly extinguish the associations between arousal cues and negative mood states (Sass et al., 2009). Referencing the reinforcement of losses, the data also lend support to techniques like cognitive restructuring that aim to correct maladaptive cognitions in order to decrease negative biases.

The present study has several strengths, including a sample size several times that of typical fMRI experiments, which potentially gives the present dataset more statistical power than similar studies. It also extends the literature on feedback processing and psychopathology by explicitly examining regional brain activations associated with reward and loss feedback in negative affect. However, the study also has limitations. For one, the design is correlational, which does not permit researchers to determine whether trait NA leads to maladaptive reward circuitry or vice versa. In addition, fMRI methods do not have good temporal sensitivity and cannot provide

insight into sequence of activation among implicated structures. Further research using alternative methods like EEG or which target dopamine transmission could address this question in a group with trait NA to better understand the relationship among the implicated structures that were identified in this study. Research may also choose to explore the effect of outcome magnitude on responses to feedback in negative affect. Preliminary evidence from this study suggests that the greater the loss, the greater the learning. This effect can be further evaluated by providing different magnitudes of feedback (e.g., big gain, small gain, no change, small loss, big loss).

Overall, the present study provides preliminary insight into the distinctions of the reward circuitries between individuals with trait NA and typical individuals. Regional brain activations indicated that individuals with trait NA are hypersensitive to valenced outcomes, and they reinforce negative outcomes much like positive ones. This suggests a mechanism by which they develop and maintain negative biases, which, in turn, may contribute to psychopathology. In addition to having important clinical implications, this study can also assist in teasing apart cognitive effects attributable to characteristics of different disorders as researchers extend cognitive studies of feedback processing to specific disorders of which NA is a component.

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Appendix

IRB APPROVAL LETTER AND DOCUMENTATION

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

telephone (217) 333-2670 • *fax* (217) 333-0405 • *email* IRB@illinois.edu

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.

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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.

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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.

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. 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.

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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. 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.