EFFECT OF MOOD INDUCTION AND NEGATIVE URGENCY ON DELAY DISCOUNTING PERFORMANCE IN FMRI

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ABSTRACT

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Doctor of Philosophy

Impulsivity research has most commonly address reward-focused behaviors, often overlooking facets of impulsivity related to negative affect and punishment avoidance. Though viewed as distinct characteristics, common psychological and physiological vulnerabilities exist for impulsivity and negative mood. The diminished ability to delay immediate rewards to achieve long-term goals is a hallmark of impulsive behavior that frequently co-occurs with negative mood and results in many maladaptive health behaviors, such as anxiety, depression, and addiction. Using a delayed discounting paradigm paired with mood induction, we examined how Negative Urgency, a type of impulsivity related to negative affect, was associated with delay discounting behaviors and shared neural substrates.

Participants (N = 66) completed self-report measures of impulsivity and performed a delayed discounting task following negative and neutral mood induction. Additionally, a subset of participants (N = 18) performed the delay discounting task and mood induction while undergoing an fMRI scan. The mood induction involved participants reading a series of neutral statements and negatively-valenced statements while listening to mood-congruent music. Following the mood induction, participants were shown a series of two monetary choices, each varying in magnitude in terms of value and time delay, and selected one of the choices.

Results of the study showed that negative urgency was not significantly related to the rate at which participants discounted the value of future rewards behaviorally. Exploratory analyses did show possible relationships between other personality factors and delay discounting rates. fMRI results showed no main effect for negative mood fMRI results with Negative Urgency were non-significant, though right ventrolateral prefrontal cortex activation correlated with a measure of trait anxiety. Implications of these findings, limitations, and future directions are also discussed.

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Introduction

Many short-term rewarding behaviors can be deleterious when aggregated over time, and so selecting behaviors that service long-term goals at the expense of immediate reward can be a highly adaptive strategy (Bickel & Marsch, 2000). This ability to select more distal, advantageous behaviors is a powerful predictor of many health behaviors. Those who are less able to make these advantageous choices are more likely to engage in a number of risky behavior patterns, such as chronic smoking (Bickel, Odum, & Madden, 1999), substance abuse (Coffey, Gudleski, Saladin, & Brady, 2003; Perry & Carroll, 2008), and overeating (Guerrieri et al., 2007). Additionally, reduced ability to delay reward is associated with psychiatric conditions like bipolar disorder, major depressive disorder, and generalized anxiety disorder (Bellani et al., 2012; Pawluk & Koerner, 2013).

Because many health decisions are driven by the receipt of reward (and the activation of concomitant dopamine pathways), individuals experience an emotional component in the decision-making process. Most often the positively-valenced emotions related to reward sensitivity are the focus of impulsivity research, and indeed the positive sensations of reward are powerful motivations. In addition to reward sensitivity, however, sensitivity to punishment can also provide motivation in decision-making. A construct that addresses motivation arising from sensitivity to punishment is *negative urgency*, which is an emotion-based disposition that is "a tendency to commit rash or regrettable actions as a result of intense negative affect" (Whiteside & Lynam, 2001). This is a type of impulsivity that differs from other, more traditional flavors of impulsivity, as it describes impulsive behaviors as an "active avoidance" strategy rather than approach to reward. Because the hypothesized motivational factors of negative urgency are unique among impulsivity constructs, research thus far has been limited and has required

modifications to existing theories of impulsivity to account for new findings. Negative urgency is compatible with these constructs insofar as it is correlated with other types of impulsivity, but also uniquely contributes to impulsive behavior in ways that are not yet understood. In particular, the neurological characteristics of negative urgency are not well known. Understanding the relationship between impulsive personality traits and mood will provide insight into how these characteristics may influence many psychiatric conditions like depression, anxiety, and substance abuse, as well as other health behaviors.

Impulsivity

Impulsivity is a multidimensional personality characteristic associated with acting without thinking and enhanced sensitivity to reward. The sub-constructs of impulsivity share common features that broadly include behavioral disinhibition and executive under-regulation. Various sub-constructs of impulsivity include different aspects of disinhibition, such as sensation seeking, lack of persistence, impatience, harm avoidance, inattention, and novelty seeking (Evenden, 1999; Kirby & Finch, 2010). For the sake of convenience, impulsivity will be referred to in this paper as a single construct, though we recognize that impulsivity may more accurately be viewed as a category of these more specific, distinct-but-related sub-constructs.

Models of Impulsivity

Reinforcement Sensitivity Theory. Perhaps the most influential and studied formulation of impulsivity proposed is the Reinforcement Sensitivity Theory (RST; Gray, 1970). This theory posits two systems that govern behavior: the *behavioral activation system* (BAS) and the *behavior inhibition system* (BIS). These systems are hypothesized to be two dimensions of behavior that drive an organism either to approach a novel stimulus or situation (BAS) or to withdraw and avoid a stimulus or situation (BIS). An individual with a high BAS is

hypothesized to be driven by the potential for rewards and is thought of as being "activated" (i.e., approach-driven) toward reward and less sensitive to punishment. This person would more readily detect cues of reward in the environment. In cases where the BAS is relatively more active than the BIS (which constrains approach behaviors) the individual would engage more freely in approach behaviors that were immediately rewarding. In contrast, an individual with a relatively more active BIS is more likely to be sensitive to punishment and prone to anxiety. In this state of cognitive and physiological arousal, a person appraises an environmental stimulus as threatening or dangerous and typically engages in avoidance of that stimulus (Elwood, Wolitzky-Taylor, & Olatunji, 2011). This increased sensitivity to punishment would cause avoidance of stimuli and decrease the likelihood of acting impulsively to seek reward. These two systems are hypothesized to influence one another but activate relatively independently, resulting in behavior patterns as described above (relatively high BAS = more impulsive, relatively high BIS = more restrained).

This two-part model has been refined over the years, incorporating the concept of the *flight-fight-freeze system* (FFFS; Gray, 1982; Gray & MacNaughton, 2000). The FFFS monitors potentially aversive stimuli in the environment and evaluates these stimuli for potential harm or threat. When potential harm is detected, the FFFS would attempt to engage avoidance behaviors. In this updated model, the BIS moderates competition between the FFFS and BAS and selects the course of action that an individual takes (Carver, Johnson, & Joormann, 2009; Gray, 1987; McClure, Laibson, Loewenstein, & Cohen, 2004; Reuter et al., 2004). The BIS is only activated as a response to BAS-FFFS conflict rather than by a stimulus directly. A rewarding stimulus with no detected drawbacks would engage the BAS without any moderation from the BIS.

Should the FFFS detect an aversive quality to a potentially rewarding stimulus, then the BIS would engage and attempt to resolve the conflict and select the most advantageous behavior.

Another modern alteration to the traditional RST is that the BIS and BAS are not necessarily viewed as orthogonally-related, fully-independent systems. The joint-subsystems version of the RST views the BIS and BAS as systems capable of mutual influence that can give differential levels of activation depending on the combination and intensities of BIS and BAS (Corr, 2002). An individual with an active BIS (i.e., high anxiety) and active BAS (i.e., high impulsivity) may then be acting impulsively as a way to protect the person through rash, thoughtless action motivated by punishment avoidance (Corr, 2002). The BIS's punishment detection function has been allocated to the FFFS and its regulatory role means it is frequently being activated by BAS and FFFS as well as inhibiting those systems, often simultaneously.

Eysenck's PEN Model. Other theories of impulsivity have proposed similar mechanisms to the RST that drive impulsive behaviors. One such theory of impulsivity proposes introversion/extraversion and neuroticism/emotional stability as the primary dimensions that govern behavior (a normal/psychoticism dimension is also proposed but does not relate directly to impulsive behavior) (PEN; Eysenck, 1981). In this system, impulsive behaviors would come from those high in neuroticism and high in extraversion, essentially being highly activated and likely to respond to negative stimuli. One could also be low in neuroticism and high in extraversion and exhibit low-anxiety, impulsive behaviors similar to behaviors driven by BAS. Anxiety would result from low extraversion and high neuroticism paralleling high BIS. Low impulsivity would be a combination of low neuroticism and introversion, resembling a moderate BIS and moderate BAS. The RST and PEN's two dimensions map onto each other in a rotated fashion – approximately 30° according to Gray (1994). The PEN therefore accounts for similar

aspects of behavior as the RST, though the rotation means it does not describe the behaviors of interest as effectively for the present study's conception of impulsivity. The psychoticism scale also does not equate well with the FFFS. Additionally, the proposed physiological underpinnings for the PEN are not as robust as those for the RST (Dawe, Gullo, & Loxton, 2004; Evenden, 1999).

Psychobiological Model of Temperament and Character. Cloninger posited a model of impulsivity describing harm avoidance, novelty seeking, and reward dependence as the primary dimensions of personality governing approach and avoidance behaviors (Cloninger, 1987; Cloninger, Svrakic, & Przybeck, 1993). In this model, the harm avoidance dimension engages in behavioral inhibition and is sensitive to environmental signals of punishment and non-reward. Cloninger suggests that these behaviors are governed by serotonin pathways in the brain and cause passive avoidance and extinction behaviors. Novelty seeking is a system of behavioral activation that is primarily modulated by the neurotransmitter dopamine. Novelty seeking is similar to the BAS and accounts for behaviors like exploratory pursuit, approach, and active avoidance. The active avoidance aspect shares features with the FFFS and illustrates how Cloninger's constructs do not fully overlap with the RST. Reward dependence is resistance to extinction and behavioral maintenance of already learned behaviors. How this dimension compares to the RST is unclear, though its description is consistent with current research on the behavioral mechanisms for addiction, which are frequently tied to dopamine receptors and not norepinephrine as Cloninger proposed, though the question of whether both are involved remains open (Volkow, Wang, Fowler, & Tomasi, 2012).

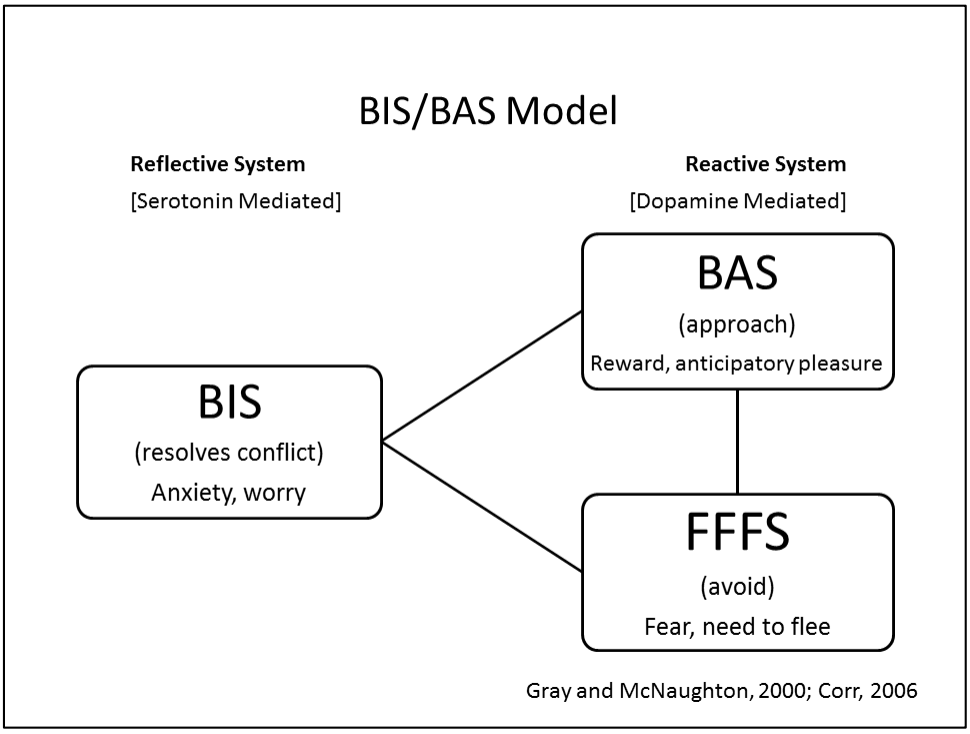
Carver's Model. A model of impulsivity by Carver et al. (2008; Carver et al., 2009) suggests a more prominent role for serotonin in the evaluative systems rather than the dopamine

system implicated in impulsive decision-making and addiction (Cyders & Smith, 2008; Rothemund et al., 2007; Winstanley, 2007). The *reactive system* is an evolutionarily more primitive system that guides action based on efficient, quick, and emotional appraisal of stimuli while the *reflective system* is a more advanced system of self-regulation and executive function. The reactive system parallels the idea of an active BAS and FFFS where one would act "without thinking" (i.e., without strong executive processing). This system would employ more cytoarchitecturally primitive areas based on quick, unrefined appraisal of environmental stimuli. The reactive system acts on available information in response to situations of urgency. The reflective system parallels the BIS, where restraint would be employed by an active executive/inhibitory response. The reflective system would function as a way to evaluate conflicting or complicated signals from the reactive system (BAS/FFFS) and select the choice deemed most adaptive to the situation. Impulsive behavior occurs when the reactive system is more effective in governing behavior than the reflective system (i.e., either the reactive system is hyperactive and overpowers the reflective system or the reflective system is hypoactive and is unable to inhibit the reactive system). A diminished capability of the reflective system to regulate impulsive behavior is a common feature for both impulsivity and mood disorders (Apter et al., 1990; Carver et al., 2008, 2009; Cyders & Smith, 2008).

Summary of models. Models described so far have been derived primarily from questionnaire data and the development of theoretical constructs. How well each was tied to underlying physical substrates that give rise to impulsive behaviors has varied from model to model, though the research for the RST in particular has yielded many results as it has been refined over the years (Evenden, 1999).

Across all of these models there is considerable theoretical and experimental overlap and a great deal of research examines what brain circuitry might be involved with both approach and avoidance behaviors (and any number of complex combinations of the two). The model used in the present paper is the RST and is illustrated in Figure 1. This model provides a framework for the hypotheses about negative urgency that will be addressed by this research study. Additionally, the RST is able to accommodate other aspects of theories that are theoretically useful in describing how negative urgency may operate at a neurobiological level (e.g., including aspects of the reflective and reactive system's serotonin system explanation).

Figure 1 *BIS/BAS Model*



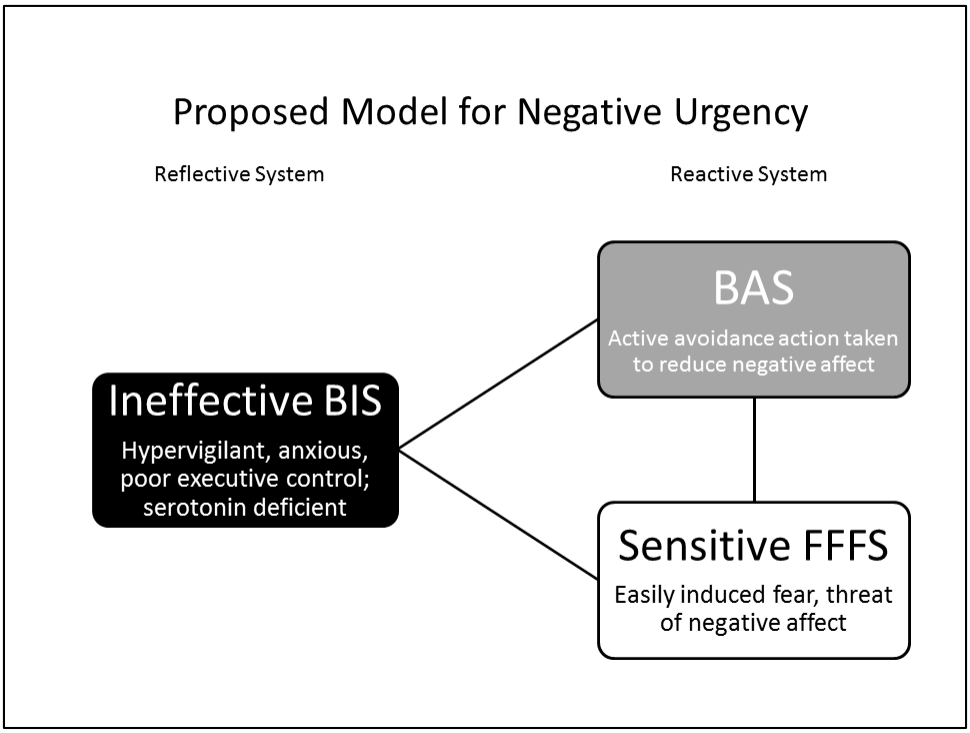
Negative Urgency

Negative urgency, the tendency to act impulsively to actively avoid negative affect, is not yet fully integrated with existing theories of impulsivity in the literature. The RST, particularly the joint-subsystems theory that views the BIS and BAS as systems capable of mutual influence as opposed to completely orthogonal systems (Corr, 2002), is able to accommodate the model proposed in the present study. The RST model and the Reactive/Reflective model both include a role for specific neurotransmitters as primary moderators of expressed behaviors. Dopamine systems have been in the forefront of reward processing research. The focus on dopamine systems is congruent with the reward-focus of many types of impulsivity but it does not fully account for the emotional regulation systems that are responsible for internal emotional states that may motivate certain types of actions, such as avoidance of harm or the actions associated with the FFFS.

A proposed physiological mechanism for vulnerability to negative urgency is suboptimal regulation of the serotonin system. Gray (1987) notes that the BIS is mediated by serotonin, with deficiencies resulting in less executive controls over impulsive drives as do Carver et al. (2008, 2009) for the reflective system. The majority of serotonin within the brain is synthesized in the raphe nucleus, a structure in the brainstem that has projections primarily to the forebrain, amygdala, thalamus, and hypothalamus (Jacobs & Azmitia, 1992). When this system is impaired or otherwise under-functioning, individuals express emotional dysregulation (Canli & Lesch, 2007; Davidson, Putnam, & Larson, 2000) and behavioral learning deficits (Crockett, Clark, & Robbins, 2009). Reduced overall levels of serotonin in individuals has been shown to predict increased impulsivity and mood disorders, which are all subsequently related to the development of negative health behaviors (Carver et al., 2009; Siever & Trestman, 1993).

Figure 2 describes the present study's proposed model for how negative urgency relates to the BIS/BAS model described in Figure 1. In this case individuals with high trait negative urgency would have a more easily activated FFFS – they are temperamentally more likely to find threatening stimuli in the environment. The BIS, for a number of possible reasons – low serotonin levels, insufficient cognitive resources, conditioned hypervigilance – is then unable to moderate the FFFS and the BAS effectively. Even if an individual under normal circumstances would not have an "overactive" BAS (i.e., be prone to impulsivity), the potential for negative affect would be sufficiently threatening to the individual and the person would lack the cognitive resources to properly select an adaptive behavior. Instead, the person engages the BAS as a means for active avoidance and makes an impulsive action.

Figure 2 *Proposed Model for Negative Urgency*



To illustrate this process, imagine a person who is being asked by a friend to work all weekend helping the friend move to a new home. The person in that instance is faced with the choice of helping (and doing something he or she does not desire to do) or refusing (the person's preferred choice). However, in the moment of choosing the person feels a great deal of anxiety and social pressure to say yes. In the moment when the person chooses to agree or not, the person is in an activated, anxious state and is lacking the cognitive resources to regulate the emotional response and select the long-term desired choice. As a way to avoid this punishing negative affect the person selects the choice for short-term relief. The immediate situation is ended, successfully avoiding current negative affect by impulsively selecting a choice with a net negative outcome for the individual. This person under neutral or positively appraised situations may behave relatively non-impulsively and yet when stimuli evoke negative affect, the reaction may resemble other types of impulsivity – "acting without thinking." The impulsive behavior is motivated through avoidance rather than approach.

Self-Report Measures of Impulsivity

A number of instruments have been developed to measure various facets of impulsivity and are divided essentially into two categories: self-report questionnaires and behavioral measures (Patton, Stanford, & Barratt, 1995; Whiteside, Lynam, Miller, & Reynolds, 2005). Self-report measures are questionnaires that typically use Likert-type items to assess various subtypes of impulsivity. A widely-used impulsivity scale, the Barratt Impulsivity Scale (BIS-11; Patton et al., 1995), has a main total score of "impulsivity" that is the sum of scores from all items. Three second-order factors exist which combine six lower subtypes of impulsivity: Attentional (Attention, Cognitive Instability), Motor (Motor, Perseverance), and Nonplanning (Self-Control, Cognitive Complexity). To compare, the UPPS+P Impulsive Behaviour scale

(Whiteside et al., 2005) is a five-dimensional measure of impulsivity with no higher-order measures of impulsivity. The scales measured in the UPPS+P are Negative Urgency, (lack of) Premeditation, (lack of) Perseverance, Sensation Seeking, and Positive Urgency. The scales for these two instruments are measuring multiple facets of impulsivity in different ways; though overlap exists, no two scales between them are directly measuring the same construct. For instance, Premeditation, Perseverance, and Negative Urgency all share overlap with the second-order factors from the BIS-11. From preliminary research by this author, it appears that Negative Urgency is not significantly correlated with the BIS-11 Sensation Seeking subscale and the UPPS+P Sensation Seeking scale is only significantly related to the second-order Motor scale. Scales from different instruments have varying degrees of overlap but no one scale is comprehensive. Even though these two measures both are targeting the same phenomenon, impulsivity, they are each capturing different facets that exist in that classification. These questionnaires also have the same limitations of most self-report measures in that the items are face-valid, enabling respondents to appear a certain way if they wish; rely on self-perceptions, which may not reflect actual behavior; and do not capture actual behaviors of impulsivity, which limits their ability to predict behavior.

Kirby and Finch (2010) conducted a principle components analysis of many impulsivity questions from impulsivity questionnaires and other self-report measures of personality. Seven meaningful components of impulsivity were found in this analysis that could not be statistically decomposed further; however, at different points in their analysis different numbers of factors existed that reflected common terms for impulsivity subtypes. For instance, "sensation seeking" quickly emerged and was separated from "unprepared/spontaneous." Neither of these terms survived the process, being further broken down into other factors such as "impetuous,"

"divertible," "thrill and risk," and "impatience," among others. This analysis highlights further the diversity of impulsivity types, the multiple "levels" that a construct may exist at (i.e., it may be composed of other sub-constructs), and the difficulty of using a common vocabulary for describing impulsive features.

Behavioral measures of impulsivity are measures that directly assess impulsive behavior, eliminating self-report bias and other weaknesses of the self-report measures. These measures assess cognitive processes that are believed to be related to impulsivity (i.e., specific patterns of performance may indicate the degree to which an individual is more impulsive relative to a normal population of peers). These measures have included the Color Word Stroop (Stroop, 1935) for inhibition, Digit Span (Weiss et al., 2010) for working memory and attention, Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994) for planning and decision-making, and Delay Discounting tasks (Bickel & Marsch, 2001) for reward inhibition and executive control, among others. While these measures have strengths that questionnaires do not, they include their own drawbacks. Many experimental variations exist making standardization difficult across studies, they are more time-intensive for participants, and they similarly are only addressing certain sub-constructs of impulsivity. To further complicate measurement, behavioral and self-report measures are only weakly correlated with one another (Reynolds, Ortengren, Richards, & de Wit, 2006; Stanford et al., 2009).

To account for these difficulties of measurement, the present study will include common self-report measures and a standardized behavior paradigm for analyzing the construct of negative urgency. This will allow multiple areas of impulsivity to be captured and compared within the study and with extant studies in the mood and impulsivity literature. Additionally,

isolating a single construct of impulsivity to study will remove the problems of measurement that come from treating impulsivity as a unitary construct.

Delay Discounting

Delay Discounting is a paradigm that measures behavioral impulsivity in terms of how successful an individual is at obtaining the greatest amount of value from the task when choosing from smaller, nearer reward values versus relatively larger, delayed values (e.g., electing to have $5 today versus $25 in four weeks). How much one is willing to delay the reward is a non-linear function of how much they value the delayed reward relative to the delay amount and this discounting curve differs for each individual. These curves describe the degree to which each person will prefer what reward value at different delay lengths. These curves are calculated with the equation $\mathrm{V} = \frac{\mathrm{A}}{1+k\mathrm{D}}$, where the value (V) of a choice is equal to that amount (A) divided by one plus the value of the delayed reinforcer (D) at the given rate (*k*). Brain activation in executive control areas when the delayed conditions are selected showed increased activation concordant with length of delay being selected (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012; McClure et al., 2004; Wittmann, Leland, & Paulus, 2007).

An important element of delay discounting as it relates to *k* calculations is the switchpoint (or indifference point). Switchpoints are the value at which an individual is equally likely to select an immediate, lesser value as he or she is to select a delayed, greater value. For instance, at a 2 week delay, an individual with a switchpoint if $60 would be just as likely to select the $60 today versus waiting 2 weeks for $100. For all values below that switchpoint (e.g., $55) we would predict that individual chooses to select the larger, delayed option. For all values above that switchpoint (e.g., $75) we would predict that the individual would choose the smaller, immediate option. For each different time delay an individual will have a different switchpoint.

Typically as the length of delay for the delayed choice is increased, the switchpoint will become lower. These switchpoints are used when calculating *k* to determine D, the value of the delayed reinforcer that is idiosyncratic for each individual. By calculating several switchpoints for several time delays, the curve for *k* can be calculated and the individual's rate of discounting can be determined.

Similar to impulsivity, researchers have identified several brain activation patterns that are characteristic of mood-related dysfunction. Networks of emotional regulation include a prominent role for the medial prefrontal cortex (mPFC) and connected areas, including the anterior cingulate cortex (ACC), lateral orbitofrontal cortex (OFC), amygdala, ventral striatum, ventral pallidum, and medial thalamic nuclei (Drevets, Price, & Furey, 2008; Öngür, Ferry, & Price, 2003). Individuals at high-risk for depression have shown diminished functioning in these emotional regulatory brain regions in fMRI studies (Joormann, Cooney, Henry, & Gotlib, 2012) suggesting similar areas that under-function in impulsivity may be under-functioning for negative affect regulation. Patients with Post-Traumatic Stress Disorder have shown hypoactivations in ventral mPFC and ACC while other anxiety disorders result in hyperactivation of the amygdala and insular cortex (Etkin & Wager, 2007). While mood disorders are collectively heterogeneous in their exact patterns of activation, areas associated with the evaluation and expression of emotions are repeatedly found across studies indicating that a common system of emotion regulation, when impaired, can lead to dysfunctional negative affect. This emotional regulation system also appears to be intertwined with the regulation of impulsive behavior so that the dysfunction of this system may manifest in a behaviorally distinct way.

We believe delay discounting will address negative urgency because it recreates a situation likely to elicit an impulsive response in those high in Negative Urgency. The ability to delay discount requires cognitive resources and self-control to select a choice with no immediately rewarding qualities, but likely positive long-term outcomes. Negative urgency is postulated to result from ineffective regulation of the self, emotional response, or insufficient cognitive resources and so the person chooses an immediate choice (active avoidance of negative affect) at the expense of a future positive consequence. Since delay discounting offers selection between two choices based on immediate versus delayed rewards it should be sensitive to those with differences in their abilities to regulate impulses under different mood conditions.

Negative Urgency and Mood

The most important aspect to consider in the model of negative urgency is how that construct relates to negative mood, which is unique from other impulsivity types. Impulsivity constructs can be sorted into three different categories: emotion-based actions, deficits of conscientiousness, and sensation seeking (Dick et al., 2010). Negative urgency is in the category of emotion-based actions. The hallmark of negative urgency is its ties to negative affect and how impulsivity to avoid negative affect leads to long-term negative outcomes in the favor of immediate emotional relief. Such patterns are observed in current research that identifies areas where negative urgency and mood are related to negative outcomes including alcohol use, eating disorders, and depressive interpersonal relationships (Anestis, Selby, & Joiner, 2007; Karyadi & King, 2011; Van der Linden et al., 2006). Generalized anxiety disorder (GAD) is also related to the rash behaviors of those scoring high on negative urgency (Pawluk & Koerner, 2013); the reason hypothesized by the authors for those with likely GAD is that the “intolerance of negative emotions prompts impulsive behavior” (p. 736). By itself negative mood also predicts behaviors

of substance dependence and predicts the onset and maintenance of addictive behaviors (Conner, Pinquart, & Gamble, 2009; Strine et al., 2008; Weinberger, George, & McKee, 2011; White, Grilo, O'Malley, & Potenza, 2010).

Another predictor of engaging in negative health behaviors is current and past instances of psychiatric mood disorder symptoms. Several studies have shown major depressive disorder, anxiety disorders, and bipolar disorder are frequent predictors of smoking addiction, alcohol abuse, obesity, and other substance abuse (Arnow, Kenardy, & Agras, 1995; Dilleen et al., 2012; Finzi-Dottan & Zubery, 2009; Strine et al., 2008; Sulkowski et al., 2009; Swann, Steinberg, Lijffijt, & Moeller, 2008; Weinberger et al., 2011). One theory asserts that the psychological pain and dysregulation associated with these mood disorders motivates individuals to use risky methods of coping, which leads to individuals initiating negative health behaviors that provide immediate pain reduction (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004). The psychophysiological dysregulation creates a drive for immediate relief and diminishes the individual's natural ability to act towards long-term goals.

Overall, the evidence supports conditions where impulsive behaviors are made because of sensitivity to punishment and not necessarily for seeking reward. In these situations, individuals are acting impulsively to escape negative affect and seek respite via immediately rewarding behaviors. While there is a "reward" of sorts (feeling better by avoiding negative affect), the reward aspect is not derived from approaching some valued reward but from avoiding a situation. It is the anxiety of being punished that instigates the impulsive action.

Mood induction and negative urgency. Negative urgency is associated not only with acting rashly in response to a negative stimulus, but also failing to regulate emotion effectively. In situations of heightened emotionality (e.g., fear, anxiety, threat of negative affect generally)

the characteristics of negative urgency are activated and result in impulsive choices. In the absence of negative affect an individual with high negative urgency may appear no more impulsive than any other person. It is the combination of personality traits plus environmental interaction that gives rise to the impulsive choice.

Mood induction is an experimental procedure in which individuals are exposed to stimuli that elicit some form of affect, positive or negative. Mood induction is used to examine how an individual's performance on any task may be changed by manipulating their emotional state. Positive mood induction can increase performance (i.e., decrease discounting rates) on a delay discounting task (Hirsh, Guindon, Morisano, & Peterson, 2010), while negative mood induction can impair a person's ability to negotiate for better long-term rewards (Brooks & Schweitzer, 2011). Neuroimaging studies of mood induction show that negative mood induction has a pervasive effect on areas of the brain that aid in emotion regulation, including areas of the dorsolateral prefrontal cortex (DLPFC), ACC, and mPFC (Drevets et al., 2008; Joormann et al., 2012).

Methods for inducing mood include using stimuli with emotional valence such as guided imagery, imaginal prompts, reading sentences/stories, music, and performance feedback (Mayer, Allen, & Beauregard, 1995; Richell & Anderson, 2004; Westermann, Spies, Stahl, & Hesse, 1996). Combinations of various methods are also often used, with one being a primary mood inducer and the other as a secondary inducer of the mood, usually for maintenance of the effect during the other experimental task. A common combination is to use emotionally-valenced sentences, known as Velten or Velten-type statements (Velten, 1968), and mood-congruent music. Reviews of mood induction methods have found all these methods equally effective, with films perhaps having a slightly stronger effect (Westermann et al., 1996). Robinson, Grillon, and

Sahakian (2012) recommend a combination of Velten-type statements and mood-congruent music since they are shown to have repeatable effects, are useful for many neurocognitive paradigms, and are more easily standardized for comparison to other studies.

Neuroimaging, Reward, and Decision-Making

Experimental designs using neuroimaging techniques have found dopamine-sensitive brain regions to be the regions that underlie impulsive and reward-seeking behaviors. fMRI experiments where individuals respond to the value of an immediate reward in tasks such as delay discounting (Hinvest, Elliott, McKie, & Anderson, 2011), monetary incentive delay (Beck et al., 2009), and stimulus-response-reward contingencies (Diekhof et al., 2011) show activations in major components of the dopamine reward system, including the medial OFC, ventral striatum, insula, and amygdala. These brain regions are primarily limbic structures that correspond with the reactive BAS and are involved with appetitive responses to environmental stimuli.

Regions associated with the BIS are reflective brain areas that are implicated in executive control and emotional regulation. Right DLPFC was found to be inversely related to impulsive responses on a Go/No-Go task (Adinoff, 2004). Right lateral OFC, posterior OFC, and superior temporal gyrus were found also found to be active in participants who were able to inhibit impulsive behaviors (Horn, Dolan, Elliott, Deakin, & Woodruff, 2003). A delay discounting task by McClure et al. (2004) demonstrated that those able to inhibit immediately rewarding stimuli and select long-term, more valuable rewards activated DLPFC and posterior cingulate cortex (PCC). Prefrontal cortex (PFC) and other reflective regions are also associated with areas sensitive to serotonin (Crockett et al., 2009; Verdejo-García & Bechara, 2009).

Behaviorally, high-impulsive individuals show an increased sensitivity to the perceived value of a reward and show relatively higher activation in dopamine reward areas when contrasted with low-impulsive controls. Among groups associated with high impulsivity, such as those with food addiction, high-impulsive individuals show increased sensitivity to the potential for rewards with relatively diminished sensitivity to the reward itself (Bechara, Tranel, & Damasio, 2000; Davis, Strachan, & Berkson, 2004). High-impulsive individuals showed decreased activation in BIS areas, such as lateral OFC, DLPFC, and PCC, when making decisions favoring immediate reward. Low-impulsive individuals conversely showed greater activation in similar areas of impulse control indicating active processing of long-term reward value and the ability to act toward that goal. In addition to their high reward sensitivity, high-impulsive individuals in this study showed decreased sensitivity to punishment, which further increased the likelihood of under-restrained impulsive action (Gearhardt et al., 2011; Noël et al., 2011).

Summary of Review

A traditional view of impulsivity is that those who are impulsive are less sensitive to punishment and more sensitive to reward. However current research indicates that sensitivity to reward may not be the only motivation of impulsive approach-behaviors. Emotional salience and reactivity is a central premise for the somatic marker theory of addiction (Verdejo-García & Bechara, 2009; Verdejo-García, Pérez-García, & Bechara, 2006), the reactive/reflective model, and the most modern conceptualization of the RST. Research by Martin, Cox, Brooks, and Savage (2014) has shown that in the case of cigarette smokers are *more* sensitive to punishment, a finding not in line with traditional views but more consistent with emerging research. A theory of impulsivity must account for both trait and state tendencies of an individual and facilitate a

multi-faceted view of impulsivity. Viewing impulsivity in a more fine-grained way does not preclude the idea that more general systems underlie general impulsivity (it appears that generally speaking, they do) but suggests that these general systems give rise to specific impulsivity sub-constructs and that certain patterns of interacting brain systems can predict specific tendencies in behavior related to reward and impulsivity.

The aims of this study were to explore the relationship between negative urgency and mood through behavioral and neuroimaging methods. Specifically the study experimentally evaluated how negative urgency relates to delay discounting when an induced negative mood may put additional demands on brain areas hypothesized to regulate this type of impulsive behavior. Exploring both mood and impulsivity simultaneously provided a unique perspective for how these functions interact in common neurobiological pathways and behavioral outcomes. A delay discounting task was used to measure impulsivity behaviorally and within the brain. Delay discounting is a task that measures a person's preference for smaller, immediate rewards versus larger, delayed rewards. Concurrent with the delay discounting task was a negative and neutral mood induction task so participants performed the delay discounting task two different mood states.

Research Aims/Hypotheses

Aim 1: To explore how negative mood induction influences impulsive decision-making.

Hypothesis 1: Negative mood induction will result in the diminished ability of individuals to choose larger delayed rewards compared to their performance in neutral mood conditions.

Hypothesis 2: Individuals scoring higher on negative urgency will have diminished ability to choose larger delayed rewards during the negative mood induction condition compared to individuals with lower negative urgency.

Aim 2: To understand how mood and decision-making interact in terms of shared neurocircuitry.

Hypothesis 1: Areas associated with inhibitory control to reward cues will be attenuated in conditions of increased negative affect compared to neutral affect (DLPFC, lateral OFC, PCC).

Hypothesis 2: Areas associated with increased emotionality and sensitivity to rewards will be more highly activated in the negative affect condition compared to the neutral affect condition (medial OFC, amygdala, ventral striatum).

Aim 3: To determine brain region differences of decision-making as a function of negative urgency under negative mood induction.

Hypothesis 1: Individuals with high urgency impulsivity will show attenuated activation in areas of executive control areas (DLPFC, lateral OFC, PCC) when selecting immediate rewards versus delayed rewards.

Hypothesis 2: Individuals with high urgency impulsivity will show relatively higher activation in areas related to immediate reward valuation (medial OFC, mPFC, ventrolateral PFC (VLPFC), ventral striatum) when making immediate rewards versus delayed rewards.

Methods

Participants and Procedures

Involvement in the study consisted of approximately 1.5 hours of participation for participants completing behavioral-only protocol of the study and 2.5 - 3 total hours for participants recruited for the fMRI portion. The study recruited 60 adults to complete the mood induction and delay discounting protocol. Of that group, 12 participants completed the mood induction and delay discounting tasks within the fMRI scanner. Participants were between the ages of 18-31, undergraduates from The University of Kansas who were fluent in English as a primary language.

Participants for the study were recruited through the online University of Kansas (KU) Psychology Research Participation System (SONA). Sixty participants were recruited, with one fMRI participant being excluded from the final analysis because of alterations in the scanning protocol following their participation. This cohort was chosen because of the proposed study's exploratory nature, to ensure a relatively homogenous population, and to be comparable to prior impulsivity research. Research credits required for completion of their psychology coursework were offered as compensation for their time and participation. Participation in the study was voluntary and participants were free to withdraw at any time.

All participants for the fMRI study were English-speaking, right-handed, and able to be scanned in an fMRI (e.g., no metal medical implants that would prohibit use of an MRI scanner). Right-handed participants were selected to minimize the possibility of unpredictable brain function lateralization that can occur with left-handed or ambidextrous persons. For the behavioral study, participation was not restricted on handedness or being able to use the MRI scanner.

Recruitment and Informed Consent. Participants were recruited from The University of Kansas Lawrence campus via the SONA online subject recruitment pool. Online screening occurred prior to consent to ensure participants qualified for inclusion in the present study. Written explanation for the study rationale and participant requirements was given. All subjects participating in the study consented to participate as evidenced by signing a paper informed consent form. Subjects were informed that they were free to withdraw their consent at any time with no penalty. When consent is withdrawn, participation in the study will be terminated and no additional data will be collected or used for analysis.

Written informed consent for fMRI participants was obtained prior to beginning assessment. A verbal explanation of the study was provided in addition to the written explanation included in the consent form. Participants were encouraged to ask questions concerning the study. After reading the consent form, participants were given the opportunity to ask any questions and to provide a verbal summary of the study to assess participant's understanding of the study. For the purposes of consent, participants were expected to verbalize an understanding of the following study aspects: 1) administration of behavioral measures during initial assessment, 2) imaging of their brain activity by MRI, requiring their body to be within an enclosed space for approximately an hour, and 3) administration of mood induction and a delay discounting task during MRI. The consent process took approximately 10 – 15 minutes for behavioral and fMRI participants. An additional 10 minutes of explanation of what to expect in the MRI scanner and a detailed outline of the response procedure was given specifically to fMRI participants.

All behavioral and cognitive assessments were completed in a private room with only the examiner present. The MRI control room and scanner were located in a private area set apart

from the front area of Hoglund Brain Imaging Center (HBIC). The door to the control room was locked during scanning to prevent individuals not involved in the study from entering. Only research personnel and MRI technicians were allowed within the scanning room when the participant is being scanned.

Access to participant information and research data was limited to authorized research personnel. All participants were assigned a unique identification number and all study materials and research data were associated exclusively with this number. All testing materials and questionnaires were stored within a locked cabinet inside the locked lab facility at the HBIC. A log was kept of all data collection and analysis steps completed for each subject. For the MRI scans a research log was kept by the lab technicians regarding steps completed and any errors detected. MRI data was saved on a CD kept by the lab technicians, as well as a CD kept by research personnel and was de-identified. De-identified MRI data was saved on secure server (XNAT), which is firewall-protected and requires PI authorization to access. All data were processed locally on computers within the HBIC. All collected data was stored on hard drives within the HBIC computer lab and archived to the XNAT secure database system.

Protection Against Risk

Those who elected to participate were explicitly told that they may withdraw from the study at any time without negative consequence. The consent form was reviewed with each participant and a copy of the consent form was given to the participant and as well as kept on file within the HBIC. Ethical standards were monitored by the KUMC Institutional Review Board. All records were kept in locked filing cabinets in offices that accessible only to authorized staff and are kept locked when unoccupied. Subject files were kept in a secure area, with access limited to designated staff members (PI and Co-Investigators).

All participants were briefed before the fMRI and completed an MRI safety checklist prior to entering the scanner. Individuals with conditions contraindicated for MRI scanning were excluded from the study (i.e., pacemaker, surgical implants, claustrophobia, metal plates, pregnancy, etc.). Participants in need of corrective eyewear will be fitted with plastic, scanner-safe glasses. Although participants typically remain alone in the MRI suite during scanning, research personnel were available to stay if requested by the participant. No participants requested this option. The scanner technicians and researchers were in audio contact with the participants in the scanner and will be able to respond immediately to participant requests.

The negative mood induction for fMRI participants causing temporary discomfort was a concern. Previous research has demonstrated that negative mood induction has effects that are short-lived and non-severe. The sentences and music to which the participants were exposed did not include any extreme, violent, or disturbing features. Participants were informed that some discomfort related to negative mood is to be expected and that they could halt the study at any time should they feel inclined to do so. Post-induction debriefing included informal questions about the effectiveness of the induction, questions about the patients' comfort during scans, and inquiries about anything that participants would like to ask the investigators. Participants reported no major adverse effects from the scan or mood induction. No participants indicated that they remained substantially affected by the mood induction and that they were relatively near their mood to baseline following debriefing.

Measures

The objective of this research project was to explore the relationship between impulsivity and mood, particularly brain activations associated with impulsivity and mood. To achieve this objective we examined delay discounting behaviors and brain activations following a negative

mood induction and a neutral mood induction. Multiple measures were used to evaluate impulsivity, including self-report, behavioral, and neuroimaging.

Self-Report Measures. Several behavioral measures were collected during prior to participants completing the mood induction and delay discounting tasks. Questionnaires were collected online via secure internet connection to the REDCap survey and database service from a computer in research space on KU campus or Hoglund Brain Imaging Center. REDCap is a system of data collection and storage developed by Vanderbilt University and housed within secure, HIPAA compliant servers within The University of Kansas. In-person study procedures, including consent, additional questionnaires, and fMRI scanning, took place at HBIC on the KUMC campus. All participants not completing the fMRI version of the protocol completed the study in confidential lab space on the University of Kansas campus. Questionnaires completed online were done so in accordance with APA guidelines for online data collection.

Though the primary measure of interest for the proposed hypotheses is negative urgency, additional behavioral measures were collected to explore other characteristics related to negative urgency and impulsivity relevant for this and possible future studies. This information included demographic information, symptoms of anxiety and depression, sensitivity to reward and punishment, coping strategies, and other measures of impulsivity. Collecting these measures also allows for comparison of some results to other studies that rely on the same measures. Measures used in the study are listed in the following subsection.

Demographics questionnaire. A short demographic questionnaire designed for this study was completed by the participants. Information collected included age, gender, ethnicity, and brief psychiatric history.

The UPPS Impulsive Behavior Scale (UPPS+P; Whiteside & Lynam, 2001). This 45-item self-report questionnaire measured 5 personality scales related to impulsivity personality traits: Negative Urgency, (lack of) Premeditation, (lack of) Perseverance, and Sensation-Seeking, and Positive Urgency.

The Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995). This 30-item self-report questionnaire measured impulsiveness. Total score measures overall levels of general impulsivity. Subscales include Attention, Motor, Self-Control, Cognitive Complexity, Perseverance, and Cognitive Instability. Additionally, second-order factors of Attentional, Motor, and Non-planning are measured.

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia, Ávila, Moltó, & Caseras, 2001). This is a 48-item measure of Gray's impulsivity (BAS) and anxiety (BIS) dimensions. Participants selected "yes" or "no" to questions assessing an individual's relative activation and restraint in a variety of ways. Examples of questions included "Are you easily discouraged in difficult situations?" and "Do you sometimes do things for quick gains?"

BIS/BAS Scale (BIS-BAS; Carver & White, 1994). This is a 24-item Likert-type self-report questionnaire that measures preferences for impulsive and inhibition preferences. Participants responded to questions like "Criticism or scolding hurts me quite a bit," and "I go out of my way to get things I want,"

The Beck Anxiety Inventory – Trait (BAI-T; Kohn, Kantor, DeCicco, & Beck, 2008). This is a 21-item self-report measure of trait anxiety. Participants rated how much they generally feel they have been bothered by a particular symptom (from 0 = "not at all" to 3 = "severely, it

bothered me a lot"). The BAI-T is a measure created specifically to discriminate from situational anxiety and from depressive symptoms.

Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977). This is a 20-item self-report measure of depressive symptoms that the participant has experienced during the past week. Participants rate how they felt or behaved as prompted by each question (1 = "Rarely or none of the time (less than 1 day)" to 4 = "Most or all of the time (5 – 7 days)").

MR Screener (for fMRI participants only). This is a short screener designed to assess eligibility for the fMRI section of the study and to ensure safety of participants by identifying potentially dangerous conditions (e.g., metal in the body).

Mood Induction Measure. This self-report questionnaire using adapted from a visual analog scale to a Likert-type scale with 4 choices ascertained the participant's mood valence and intensity at 6 points during the study for the emotions of happy, calm, sad, bored, depressed, and anxious.

Delay Discounting. The delay discounting paradigm is a task that measures an individual's preference for reward values of various magnitudes to be received at various lengths of delay. The present study was modeled after the design used by McClure and colleagues (2004) for use in an fMRI. During the task participants selected between two options: 1) a fixed reward ($100) given after a delay of some number of weeks, or 2) a smaller reward (less than $100) offered today. All monetary "rewards" used for choices were hypothetical; participants received study credit for their time participating in the study and were instructed to make choices they were prefer if the money were real. The two options were presented on either side of the screen and participants were given as much time as needed to make their selection by pressing "1" or "2" on the response pad. An example trial is presented in Figure 2.

Participants completed 1 block of delay discounting before the first mood induction to obtain baseline *k* values The entire interval of available choices is divided into thirds (in this case, $0 - $100) and the initial choices were chosen as the one-third and two-third cut points. Based on the participants' responses, choices were dynamically generated by offering values based on previous answers that would "narrow in" on each switchpoint for a given time delay by calculating new one-third and two-third cut points. A complete description of the calculations to determine switchpoints in this way can be found in Wittmann et al. (2007). The 8 trials for each delay were administered sequentially since the current values were determined by previous responses; the sets for each delay length were administered in random order. For fMRI participants, pauses of 30 seconds between sets of trials were added to aid imaging data analysis. Total time for this block was approximately 3 minutes for behavioral participants and 5 minutes for fMRI participants. For fMRI participants, this administration was also to ensure that the task was understood prior to their participation in the scanner.

Two blocks of delay discounting trials following each mood induction block were administered. The initial and first post-induction delay discounting blocks were approximately 5 minutes in total length. There were 40 total trials, 8 for each delay: 2-week, 4-week, 6-week, 12-week, and no-delay (control trials). The second post-induction delay discounting blocks comprised 60 total trials, 12 trials each for the 2-week, 4-week, 6-week, 12-week, and no-delay trials. The number of trials were equal for both mood conditions. Trials within blocks were presented in a randomized order. Between-trial fixations points were on screen for between 1.5 and 11.5 seconds. Intervals between trials for fMRI participants were longer on average (4.5 seconds) to accommodate the staggering of samples by the scanner needed to correctly account for the time course of the hemodynamic response. The average interval between trials for the

behavioral-only participants was 1.75 seconds. The total time for the second block of trials was approximately 4 minutes for the behavioral participants and 8 minutes for fMRI participants. The *early* choice for each trial was "today" and the *delayed* choice was 2 weeks, 4weeks, 6 weeks or 12 weeks from today.

Measure of Mood. Before the first mood induction, between all blocks, and following the last delay discounting task, participants completed a brief subjective mood rating question set to establish current mood and evaluate the effectiveness of the mood induction. Mood will be measured at six points throughout the study: 1. pre-negative induction, 2. post-negative induction, 3. post-negative induction delay discounting, 4. pre-neutral induction, 5. post-neutral induction, 6. post-neutral induction delay discounting. This 6-item measure included questions for 6 emotional states: happy, calm, sad, bored, depressed, and anxious. Moods of "anxious" and "calm" were added to the 4 mood induction protocol questions found in Robinson et al. (2012). Anxiety was added because of its relation to negative urgency. Calm was added to include a measure of positive-valence, low arousal mood. Because of the constraints of responding in the scanner, the visual analog scale recommended in the Robinson protocol was adapted to work with a 4-key response pad. Responses to the question, "How [mood] are you?" were "Not at all," "Somewhat," "A lot," and "Very much."

Mood Induction Protocol

The mood induction procedure in this study was similar to research from Berna et al. (2010), who used Velten-type (Velten, 1968) statements and mood-congruent music (Mayer et al., 1995; Wagner, Koschke, Leuf, Schlösser, & Bär, 2009). This study's protocol for mood induction for psychological research was also adapted from a published and validated protocol with special emphasis and guidance on neurophysiological research (Robinson et al., 2012). The

delay discounting task was computerized version that has been established in previous Hoglund Brain Imaging Center (HBIC) fMRI studies. Participants read a series of 58 Velten-type statements for 12 seconds each preceding a delay discounting task. Each participant experienced one neutral mood induction followed by a block of delay discounting task and one negative mood induction block followed by a block of delay discounting task, with order of presentation balanced across participants. Velten-type statements included "It often seems that no matter how hard I try, things still go wrong" for the negative mood condition and "The doorkeeper was dressed in red" for the neutral mood condition. Mood-congruent lyricless music for each block was played during the induction to magnify the intensity of the emotion during the mood induction procedure. Additionally, music from the immediately preceding mood induction block was played throughout the following delay discounting task to help maintain the induced mood. For the neutral mood induction *The Planets, Op. 32: VII. Neptune, the Mystic* by Gustav Holst was played. For the negative mood condition the piece *Russia under the Mongolian Yoke* in C Minor by Sergei Sergeyevich Prokofiev was played at half speed. These pieces have been used previously in musical mood induction tasks to evoke the congruent mood in participants successfully (Berna et al., 2010; Robinson et al., 2012). The length of effect for Velten-type mood induction tasks can be relatively short (several minutes) unless somehow maintained through the cognitive task as well (Clark, 1983; Guerrieri et al., 2007). Additionally, music is recommended by Robinson et al. (2012) as a way to maintain induced mood during follow-up cognitive tasks.

Imaging Protocol

FMRI scanning was performed at the University of Kansas HBIC, using a 3-Tesla Siemens Skyra Scanner (Siemens, Erlangen, Germany). Structural scanning included T1-

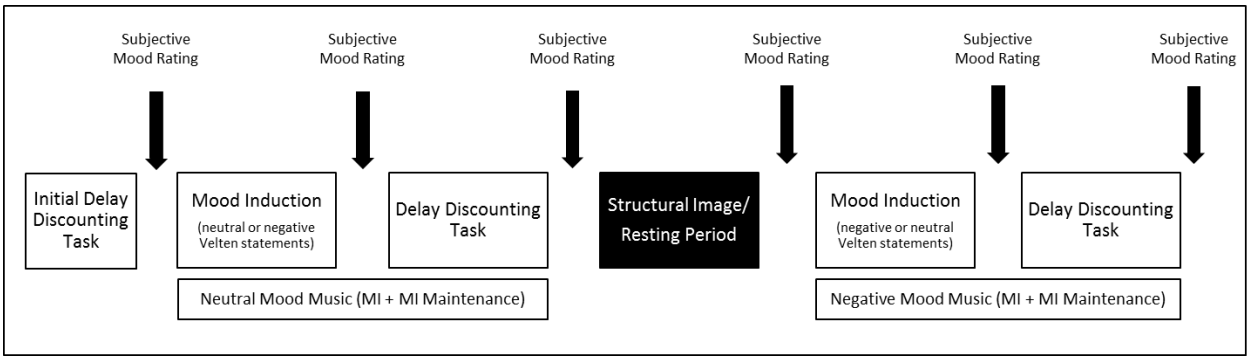
weighted anatomical images will with 3D MPRAGE sequence (TR/TE= 23/2ms, flip angle =9°, FOV=256 mm, matrix=256x176, slice thickness=1 x 1 x 1.2 mm). This scan is used for slice localization for the functional scans, Talairach transformation, and coregistration with fMRI data. Gradient echo blood oxygen level dependent (BOLD) scans are acquired in 35 contiguous oblique axial 3 mm slices at a 40º angle (TR= 2000 ms, TE= 25, flip angle = 90°, in-plane resolution=2.9mm). Visual stimuli were back-projected to a screen from a shielded LCD projector. To optimize signal in ventromedial prefrontal regions by minimizing susceptibility artifact, all participants were positioned in the scanner so that the angle of the AC-PC plane is between 17° and 22° in scanner coordinate space. The angle was verified with a localization scan. This careful positioning ensures that the 40° slice acquisition angle will be applied in the same way for all subjects. These procedures were developed in collaboration with the HBIC MR physicist, Dr. Phil Lee.

Summary of Study Design

The research project included a behavioral study and a neuroimaging study. The experimental protocol for both studies was as similar as possible given constraints necessitated by using the fMRI equipment. The primary differences in design between the two studies was the extra time required to complete the tasks in the scanner, different study location, additional instructions and preparation for fMRI participants, and overall longer study time for fMRI participants. Participants performed a mood induction task of either neutral or negative mood followed by a delay discounting task. Following an approximately 10 minute break to return to an emotional baseline, participants again completed a mood induction task followed immediately by a set of delay discounting choices. Several brief "mood probes" were given between blocks of tasks to measure subjective mood changes in participants. Presentation order of negative and

neutral mood conditions were counterbalanced among participants. The time to complete the full protocol was approximately 50 minutes for behavioral participants and approximately 70-75 minutes for fMRI participants. Figure 1 illustrates the layout of the delay discounting and mood induction tasks.

Figure 3 *Behavioral and fMRI study design.*



Data Analysis and Interpretation

Behavioral data were analyzed with IBM SPSS (version 22) and a p-value of <0.05 was used to indicate statistical significance unless otherwise specified. The data were analyzed in the following steps: 1) Determine if groups by location were significantly different on demographic variables or mood induction effectiveness, 2) Determine if mood induction was successful for the mood states of interest (Sad, Depressed, Anxious), 3) Evaluate changes in impulsivity as measured by *k* as a function of changes in mood induction condition (Negative vs. Neutral) (**Aim 1 H1**) and in terms of how *k* covaries with negative urgency (**Aim 1 H2**), 4) Examine functional differences in brain activation between mood conditions when choosing between immediate and delayed rewards (**Aim 2 H1, H2**), and Examine role of negative urgency when making immediate and delayed reward choices for negative and neutral mood conditions (**Aim 3 H1, H2**). Because participants completed all surveys during their time participating, the number

of missing values was very low (<.002%); since missing data represented an extremely small proportion of total responses and missing values did not appear to be systematically related, series mean replacement was used for these values in statistical calculations.

Demographic Comparison

Demographic information was analyzed using multivariate analysis of variance (MANOVA) to detect possible differences between fMRI and behavioral participants prior to analyzing combined group data.

Differences between fMRI and behavioral groups on self-report measures, k-values, and mood ratings were analyzed using repeated measures analysis of covariance (ANCOVA). Self-report measures that were theoretically related to constructs being measured were evaluated using bivariate correlation to determine if between-group differences existed for location; scales evaluated included negative urgency, BIS-11 total score, CES-D total score, BAI-T total score, subscales from the Brief COPE measure, and subscales from the SPSRQ measure.

Mood Comparison. To determine whether the mood induction resulted in reported change in mood by participants, the effectiveness of the mood induction (neutral vs. negative) was assessed using a repeated measures MANOVA including all 6 six emotions measured (Happy, Calm, Sad, Bored, Depressed, Anxious). Greenhouse-Geisser corrections were used to adjust for non-sphericity of the data.

Main effect for mood induction on Delay Discounting Rates (Aim 1, H1 and H2). Effects of mood induction on delay discounting rates (*k*) were analyzed using repeated measures ANCOVA. For the predicted model, Negative Urgency was entered as a covariate for the model. Additionally, an exploratory, *post hoc* model using repeated measures ANCOVA with other personality scales as covariates was evaluated; covariates were determined by bivariate

correlation between collected *k* values at 3 time points and personality measures of impulsivity. All measures of impulsivity that were significantly ($p < .05$) correlated with a value of *k* at any time point were entered into the model as covariates.

FMRI data analysis (Aims 2, H1 and H2; Aim 3, H1 and H2). fMRI data were pre-processed and analyzed using Analysis of Functional NeuroImages (AFNI; http://afni.nimh.nih.gov) software. Pre-processing and statistical analyses were performed on each participant's data in AFNI. The fMRI images were realigned to the first slice collected in the first run to correct for motion. The images were spatially smoothed with a 4 mm FWHM Gaussian blur. Functional images were realigned to the anatomical images obtained within each session and normalized to Talairach and Tournoux's (1988) stereotaxic atlas. A region of interest (ROI) approach was used to address Aim 2. ROIs were defined based on coordinates from another delay discounting experiment by McClure et al. (2004). Spherical ROI mask were created using a 3.5 mm radius for the DLPFC, lateral OFC, medial OFC, mPFC, PCC, VLPFC, and ventral striatum. Locations of these ROIs are illustrated in Figure 4 and specific coordinates are shown in Table 1. Mean percent signal change was extracted for each spherical ROI and included in the analysis described below. In addition, a whole-brain exploratory analysis was run to identify activations in regions outside of these spheres. To account for multiple comparisons, and cluster thresholding were used, ($p_{voxelwise} < .01$, $p_{corrected} < .05$, cluster size > 53 voxels). Cluster size will be determined based on Monte Carlo simulations implemented by AFNI's 3dClustSim program.

To evaluate the effect of mood induction on decision-making (**Aim 2**), the negative affect condition was contrasted using a repeated measures analysis of variance (ANOVA) with the neutral affect condition and compared with participants' immediate choices versus delayed

choices in a Mood × Decision-Making design. To evaluate the relationship between negative urgency, mood induction, and decision-making (**Aim 3**), Mood × Decision-Making analyses were conducted using the same ROI masks and including negative urgency scores as a covariate with significant percent signal change in ROI-defined areas.

Figure 4 *Locations of 3.5 mm spherical ROIs.*

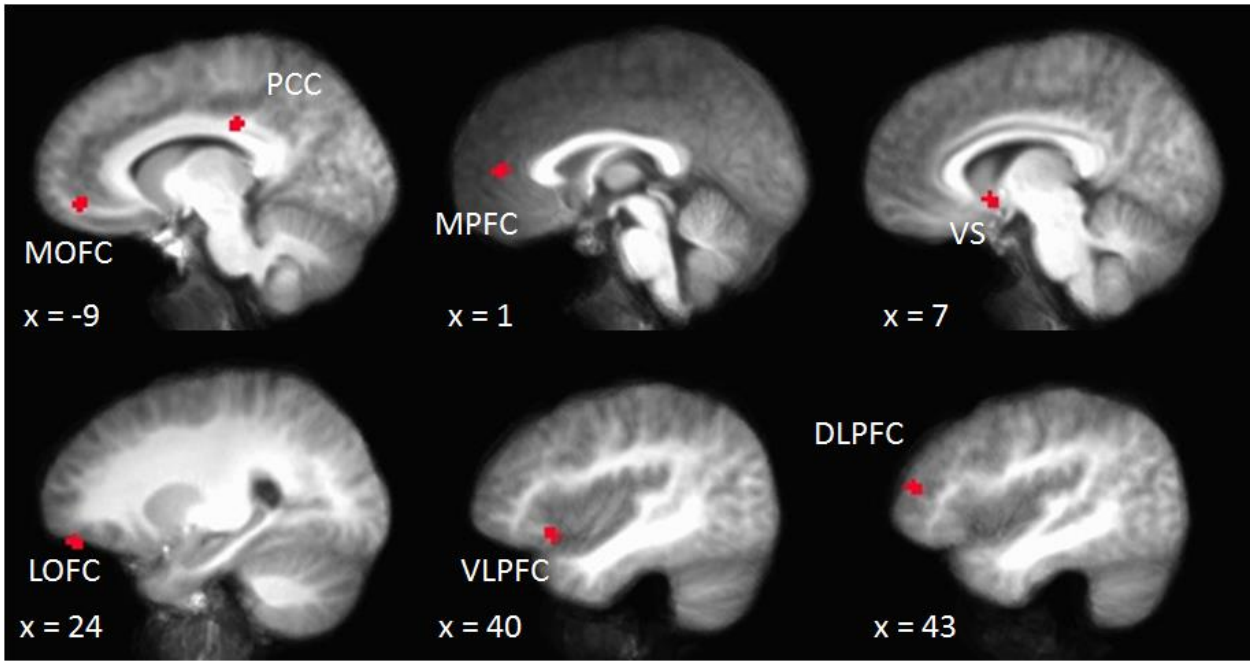


Table 1 *A priori regions of interest for fMRI analyses*

Region	*x*	*y*	*z*
DLPFC	44	43	13
Lateral OFC	24	48	-12
Medial OFC	-8	46	-6
mPFC	0	43	9
PCC	-8	-26	31
VLPFC	40	19	-8
Ventral Striatum	6	8	-4

Note. Coordinates are in Talairach space.
Coordinates for *a priori* ROIs taken from McClure at al. 2004.

Results

Demographics

The demographic breakdown of the sample were as follows. All participants: American Indian or Alaskan native 1.5%, Asian or Pacific Islander 6.2%, Black 3.1%, White 86.2%, Other 3.1%, not of Hispanic origin 89.2%, Hispanic origin 10.8%; behavioral participants: American Indian or Alaskan native 2.1%, Black 4.2%, White 89.6%, Other 4.2%, not of Hispanic origin 85.4%, Hispanic origin 14.6%; fMRI participants: Asian or Pacific Islander 23.5%, White 76.5%, not of Hispanic origin 100%. All demographic data for behavioral and fMRI participants are summarized in Table 2.

Table 2 *Participant Demographics*

	Sample distribution % (n): Behavioral	Sample distribution % (n): fMRI	Sample distribution % (n): Total
Sex			
Female	39.6 (19)	(9)	43.1 (28)
Male	60.4 (29)	(8)	56.9 (37)
Race			
American Indian	2.1 (1)	0.0 (0)	1.5 (1)
Asian or Pacific Islander	0.0 (0)	23.5 (4)	6.2 (4)
Black	4.2 (2)	0.0 (0)	3.1 (2)
White	89.6 (43)	76.5 (13)	86.2 (56)
Other	4.2 (2)	0.0 (0)	3.1 (2)
Ethnicity			
Not of Hispanic origin	85.4 (41)	100.0 (17)	89.2 (58)
Hispanic origin	14.6 (7)	0.0 (0)	10.8 (7)

Multivariate analysis of variance (MANOVA) for age, gender, race, and ethnicity showed a no significant multivariate effect for behavioral and fMRI groups, Wilks' $\lambda = .864$, $F(5, 59) = 1.856$, $p = .116$, $\eta_p^2 = .136$. All participants (N = 66; 37 males) were aged between 18 to 31 years (m = 19.74, SD = 2.56); behavioral participants (n = 48; 29 males) were aged between 18

to 31 years (m = 19.65, SD = 2.43); and fMRI participants (n = 18; 8 male) were aged between 18 to 31 years (m = 20, SD = 3.96). One fMRI participant was excluded from analyses because of unusable fMRI data.

Self-Report Variables

MANOVA tests on the behavioral and fMRI groups on all scales of the BIS-11, UPPS+P, BIS/BAS, SPSRQ, Brief COPE, CES-D, and BAI-T were not significant for group differences, Wilks $\lambda = .382$, ($F(33, 31) = 1.523$, $p = .121$, $\eta_p^2 = .618$). Because the omnibus test was non-significant, univariate results were not analyzed. Descriptive statistics combined across experimental setting (fMRI and behavioral) are presented in Table 3. Descriptive statistics for individual behavioral and fMRI groups are shown in Appendix A.

Table 3 *Combined Self-Report Impulsivity and Mood Measures*

Measure Name	Mean	SD	Min	Max	Range
BIS11 – Total	63.66	10.76	42	87	45
Attention	10.83	2.90	5	16	11
Cognitive Instability	6.61	1.69	3	11	8
Motor	15.11	2.91	11	24	13
Perseverance	6.68	1.62	4	11	7
Self-Control	12.63	3.67	6	22	16
Cognitive Complexity	11.80	2.83	6	17	11
UPPS+P					
Negative Urgency	27.58	5.24	15	41	26
Premeditation (lack of)	22.98	4.89	13	36	23
Perseverance (lack of)	20.03	4.57	10	32	22
Sensation Seeking	37.28	5.22	23	48	25
Positive Urgency	28.26	5.41	16	39	23
SPSRQ					
Sensitivity to Punishment	11.15	4.74	3	22	19
Sensitivity to Reinforcement	13.89	4.03	6	24	18
BIS/BAS					
BAS Drive	11.20	2.12	6	15	9
BAS Fun Seeking	12.57	2.02	7	16	9

Measure Name	Mean	SD	Min	Max	Range
BAS Reward Responsiveness	17.77	1.74	13	20	7
BIS	22.96	3.36	16	29	13
Brief COPE					
Self-Distraction	5.71	1.56	2	8	6
Active Coping	6.03	1.22	4	8	4
Denial	2.77	0.95	2	5	3
Substance Use	3.32	1.73	2	8	6
Emotional Sup	5.32	1.76	2	8	6
Instrumental Sup	5.05	1.80	2	8	6
Behavioral Disengagement	3.18	1.30	2	8	6
Venting	4.28	1.32	2	8	6
Positive Reframing	5.86	1.55	2	8	6
Planning	6.12	1.42	2	8	6
Humor	5.43	1.86	2	8	6
Acceptance	6.45	1.15	3	8	5
Religion	3.82	1.87	2	8	6
Self-Blame	5.44	1.73	2	8	6
CES-D – Total	12.37	7.83	2	31	29
BAI-T – Total	10.42	8.07	0	32.38	32.38

Mood Induction

Between Group Differences. Because of the difference in study environment between fMRI and behavioral participants, a repeated measures MANOVA was conducted to determine if experimental setting was related to self-report mood scores obtained during mood induction. Omnibus test of mood ratings between fMRI and behavioral groups showed significant interaction effect between groups overall, Wilks $\lambda = .747$, $F(6,58) = 3.266$, $p = .008$, $\eta_p^2 = .253$. Between-group univariate analyses (Bonferonni corrected $\alpha = .008$) indicated that mood ratings differed significantly between location (fMRI versus behavioral) for Happy, $F(1,63) = 15.304$, $p < .001$, $\eta_p^2 = .195$. All other mood ratings were the same between locations. Negatively valenced moods (Sad, Depressed, Anxious), of primary interest in this study, were not statistically different. Initial Happy ratings appeared to be different, with fMRI participants reporting higher baseline Happy ratings. The Happy rating pattern was similar for both mood

conditions at both locations, so both groups were analyzed together. These results are summarized in Table 5.

Table 4 *Mean Mood Ratings*

Mood	Pre-Neg	Post-Neg	Post-NegDD	Pre-Neu	Post-Neu	Post-NeuDD
Happy	2.88 (.76)	1.75 (.77)	2.08 (.89)	2.63 (.89)	2.35 (.89)	2.28 (.96)
Calm	3.15 (.78)	2.71 (.93)	2.86 (.88)	3.11 (.89)	3.03 (.90)	2.82 (.92)
Sad	1.23 (.52)	2.51 (1.03)	1.72 (.67)	1.35 (.57)	1.32 (.59)	1.37 (.65)
Bored	2.45 (1.02)	2.65 (1.02)	2.97 (.95)	2.54 (1.08)	3.05 (1.05)	3 (1.03)
Depressed	1.26 (.59)	2.17 (1.02)	1.48 (.69)	1.28 (.55)	1.28 (.55)	1.35 (.62)
Anxious	1.77 (.86)	2.15 (1.03)	1.95 (.96)	1.97 (.94)	2.26 (.99)	2.32 (1.06)

Table 5 *Differences in Mood Ratings Based on Location (fMRI vs. Behavioral groups)*

	Mood Condition	df	MS	F	Sig.	η_p^2
Location	Happy	1	5.874	15.304	<.001	0.195
	Calm	1	0.001	0.002	0.969	0.000
	Sad	1	0.129	0.583	0.448	0.009
	Bored	1	3.027	5.162	0.027	0.076
	Depressed	1	0.215	0.847	0.361	0.013
	Anxious	1	0.252	0.490	0.486	0.008
Error	Happy	63	0.384			
	Calm	63	0.370			
	Sad	63	0.221			
	Bored	63	0.586			
	Depressed	63	0.254			
	Anxious	63	0.514			

Computed using Bonferonni corrected alpha = .008, Huynh Feldt corrected for non-sphericity.

Mood Induction Effectiveness. To evaluate if subjective mood ratings changed as a function of mood induction, a repeated measures MANOVA was conducted for all mood ratings (Happy, Calm, Sad, Bored, Depressed, Anxious) across measurement points (1. pre-negative induction, 2. post-negative induction, 3. post-negative induction delay discounting, 4. pre-neutral induction, 5. post-neutral induction, 6. post-neutral induction delay discounting). Omnibus test

results showed significant changes in mood ratings occurred throughout the duration of the experiment, Wilks $\lambda = .160$, $F(30,35) = 6.129$, $p < .001$, $\eta_p^2 = .840$. For within-subjects effects, Mauchly's Test of Sphericity indicated assumptions of sphericity was violated for Happy, $\chi^2(14) = 40.125$, $p < .001$, $\varepsilon = .862$; Sad, $\chi^2(14) = 77.164$, $p < .001$, $\varepsilon = .649$; Bored, $\chi^2(14) = 35.855$, $p = .001$, $\varepsilon = .895$; Depressed, $\chi^2(14) = 127.138$, $p < .001$, $\varepsilon = .634$; and Anxious $\chi^2(14) = 38.607$, $p < .001$, $\varepsilon = .867$. Because of nonsphericity, Huynh-Feldt correction was used for estimates of sphericity in the following analyses. These results are summarized in Table 6.

Table 6 *Test of sphericity for mood ratings across conditions*

Measure	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon (Huynh-Feldt)
Happy	.524	40.125	14	<.001	.862
Calm	.786	14.952	14	.382	.997
Sad	.289	77.164	14	<.001	.649
Bored	.561	35.855	14	.001	.895
Depressed	.129	127.138	14	<.001	.634
Anxious	.537	38.607	14	<.001	.867

Table 7 *Univariate tests for mood induction mood ratings*

	Measure	SS	df	Mean Square	F	Sig.	η_p^2
Time	Happy	51.282	4.310	11.898	30.851	<.001	.325
	Calm	10.238	4.983	2.055	4.106	<.001	.060
	Sad	75.692	3.243	23.343	48.135	<.001	.429
	Bored	22.267	4.475	4.976	8.686	<.001	.119
	Depressed	40.331	3.171	12.720	30.188	<.001	.321
	Anxious	14.421	4.333	3.328	5.442	.004	.078
Error	Happy	106.385	275.843	.386			
	Calm	159.595	318.885	.500			
	Sad	100.641	207.526	.485			
	Bored	164.067	286.404	.573			
	Depressed	85.503	202.918	.421			
	Anxious	169.579	277.311	.612			

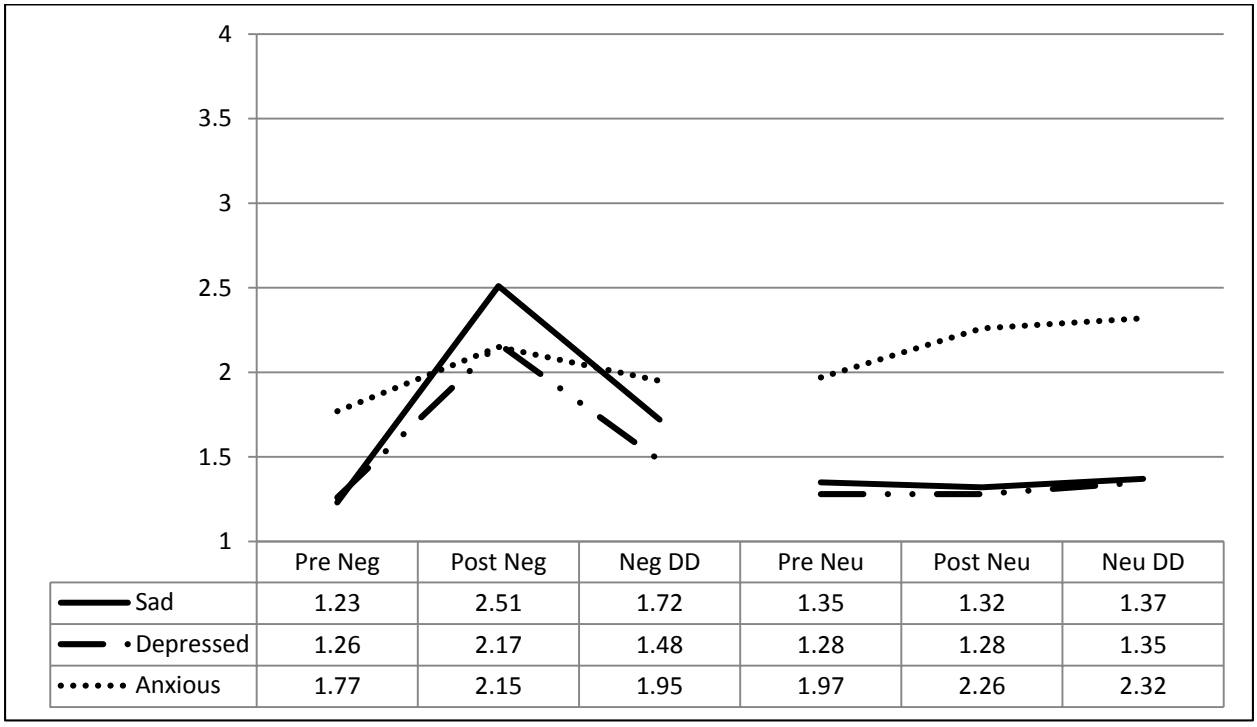
Computed using alpha = .05

Within-group univariate analyses of variance (Bonferonni corrected $\alpha = .008$) showed significant changes for all mood ratings during the experiment. These findings are summarized in Table 7. To more clearly illustrate mood changes in relation to stages of the experiment, mean mood rating changes for Sad, Depressed, and Anxious mood ratings are shown in Figure 5, and Happy, Calm, and Bored are shown in Figure 6. Figures showing the magnitude and degree of change across all measurement points for all six measured moods is included in Appendix B.

Pairwise comparisons for Sad mood ratings showed a significant increase (more sadness) following the negative mood induction procedure for the measurement immediately following negative mood induction, ($MD = 1.227$, $SD = .134$, $p < .001$) and for the subsequent negative mood condition delay discounting task ($MD = .492$, $SD = .085$, $p < .001$). Sad mood ratings at baseline levels (i.e., immediately preceding neutral and negative mood induction) were not significantly different ($MD = .123$, $SD = .071$, $p > .999$). For the neutral mood induction, Sad ratings were not significantly changed from baseline immediately following neutral mood induction ($MD = -.031$, $SD = .073$, $p > .999$) or neutral mood condition delayed discounting task ($MD = .015$, $SD = .083$, $p > .999$).

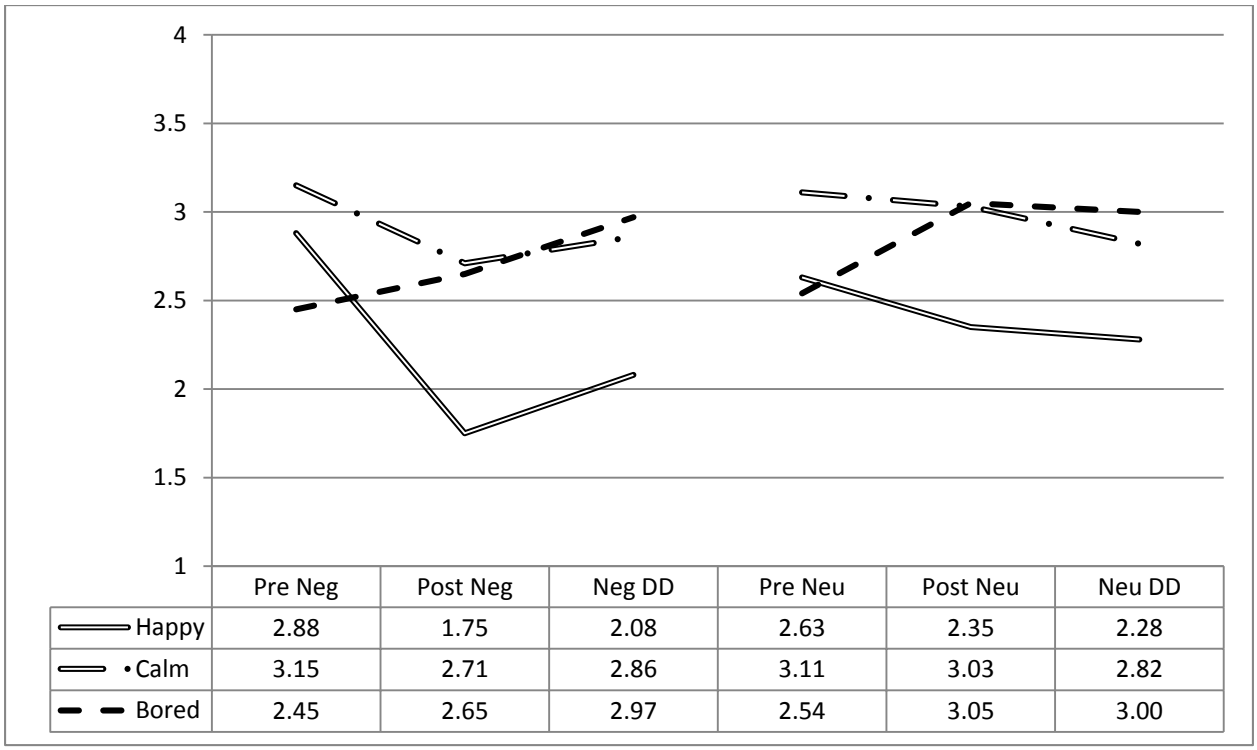
Pairwise comparisons for Depressed mood ratings also showed a significant increase immediately following the negative mood induction procedure, ($MD = .908$, $SD = .123$, $p < .001$) but the effect was not significantly different following the negative mood condition delay discounting task ($MD = .215$, $SD = .086$, $p = .227$). No other conditions were significantly different from each other, indicating that depressed mood ratings were only significantly elevated in the period following the negative mood induction. The neutral mood condition did not appear to significantly affect Depressed mood scores.

Figure 5 *Sad, Depressed, and Anxious Mood Ratings*



	Pre Neg	Post Neg	Neg DD	Pre Neu	Post Neu	Neu DD
Sad	1.23	2.51	1.72	1.35	1.32	1.37
Depressed	1.26	2.17	1.48	1.28	1.28	1.35
Anxious	1.77	2.15	1.95	1.97	2.26	2.32

Figure 6 *Happy, Calm, and Bored Mood Ratings*



	Pre Neg	Post Neg	Neg DD	Pre Neu	Post Neu	Neu DD
Happy	2.88	1.75	2.08	2.63	2.35	2.28
Calm	3.15	2.71	2.86	3.11	3.03	2.82
Bored	2.45	2.65	2.97	2.54	3.05	3.00

Anxious mood ratings following negative mood induction were not significantly different, indicating that the negative mood induction did not influence anxiety levels. The neutral mood induction also did not appear to significantly alter Anxious mood ratings from baseline. Complete pairwise comparison tables for all mood conditions are found in Appendix C.

Delay Discounting and Mood Condition Comparison (Aim 1, H1 and H2)

Predicted Model. The *a priori* hypothesis for change in *k* values across mood conditions (initial, negative mood, neutral mood) with Negative Urgency as a covariate was evaluated by conducting a repeated measures ANCOVA. Omnibus results showed no significant results for condition (i.e., baseline, post-mood induction, etc.), $F(2, 62) = .788$, $p = .459$, $\eta_p^2 = .025$, or for condition by Negative Urgency, $F(2, 63) = 1.026$, $p = .364$, $\eta_p^2 = .032$. Analysis of between-subjects and within-subjects showed no significant effects for condition or condition by Negative Urgency.

Exploratory Model. As a way to further understand the relationships between personality factors and possible effects that controlling for those factors would have on the ability to detect changes in *k*, a secondary model was evaluated from a data-driven approach. Covariates included in the repeated measures ANCOVA model for *k* values were determined by Pearson product-moment correlation coefficient to assess the relationship between *k* values and all scales of personality measures (UPPS+P, BIS11, BIS/BAS, SPSRQ, BAI-T, CES-D, Brief COPE). Scales significantly correlated with *k* values in any condition were included as covariates. Scales correlating with initial *k* values were Cognitive Complexity ($r = .29$, $p = .021$), Positive Urgency ($r = .27$, $p = .029$), Active Coping ($r = -.27$, $p = .028$), and Planning ($r = -.37$, $p = .002$). Scales correlating with negative mood *k* values were Motor ($r = .25$, $p = .048$), Cognitive Complexity ($r = .37$, $p = .003$), BIS11 Total Score ($r = .26$, $p = .040$), Positive

Urgency (r = .32, p = .009), and Substance Use (r = .27, p = .031). Scales correlating with neutral mood k values were Motor (r = .32, p = .009), Cognitive Complexity (r = .31, p = .013), and BIS11 Total Score (r = .28, p = .025). Because Cognitive Complexity and Motor scales were subscales from the BIS11, they were not included as covariates because information from those scales was already accounted for in the BIS11 Total Score.

A repeated measures MANCOVA was conducted for k values across conditions (initial, negative mood, neutral mood) with the following personality scales as covariates: Positive Urgency, BIS11 Total Score, Active Coping, Planning, and Substance Use. Omnibus results showed a significant interaction effect for Planning by mood condition, $F(2, 58) = 4.839$, p = .011, $\eta_p^2 = .143$. Univariate within-subjects results show that the interaction effect for Planning by condition was significant, $F(1.725, 101.770) = 3.842$, p = .030, $\eta_p^2 = .061$. There was no significant multivariate effect for k-value changes by mood induction or other interaction effects. When including this particular set of covariates, the effect of the Planning variable has a significant effect where participants scoring higher on the planning scale appeared to have lower delay discounting rates when subjected to mood induction (i.e., appear to be less reactive to the negative mood condition).

FMRI Results

Effect of Mood Condition during Decision-making Task (Aim 2 H1, H2). Contrasts for comparing negative mood and neutral mood conditions while engaged the delayed discounting task showed no significant activation differences for the spherical ROIs or the whole brain analysis. Based on these results, we conclude that there was no significant main effect of mood induction on the cognitive processes used when selecting immediate rewards versus

delayed rewards either in terms of increased limbic activation (Aim 2 H1) or decreased activation in frontal areas related to cognitive control (Aim 2 H2).

Negative Urgency, Mood Condition during Decision-making Task (Aim 3 H1, H2). Correlations between negative urgency and ROIs for areas of emotional activation (Aim 3 H1; medial OFC, mPFC, VLPFC, ventral striatum) and cognitive control (Aim 3 H2; DLPFC, lateral OFC, PCC) showed no significant relationship. These findings suggest the neurological patterns of activation observed during delay discounting task and mood induction task were not related to participant's self-reported levels of negative urgency.

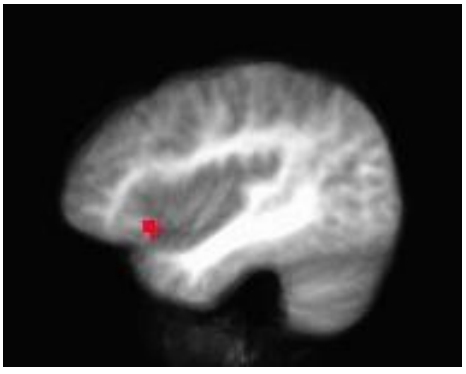
CES-D and BAI-T scores were evaluated because of their theoretical link to Negative Urgency and to more broadly explore the relation of long-term mood traits with mood state and decision making. We conducted a similar analysis as with negative urgency, correlating the percent signal change of activation for predicted ROIs (medial OFC, mPFC, VLPFC, ventral striatum, DLPFC, lateral OFC, PCC). Results were corrected for multiple comparisons using the False Discovery Rate (FDR) method as described in Benjamini and Hochberg (1995). BAI-T scores were significantly correlated with activity in the right VLPFC, with greater activation observed during the negative mood induction condition for delayed and immediate decision-making, $r = .648$, $p = .005$ (See Figure 7) . Despite not seeing a relationship between BAI-T scores and *k* values behaviorally, this finding suggests that individuals with a higher trait-level anxiety are engaging this area differently from those with lower trait anxiety. Despite participants not evidencing behavioral differences in their decision-making, the internal cognitive processes occurring while making delay discounting decisions do appear affected by negative mood state. CES-D scores were not significantly correlated with activation following FDR corrections. Full results of these correlations and corrected p-values are shown in Table 8.

Table 8 *Self-Report Scale Correlations with fMRI ROIs, FDR Corrected*

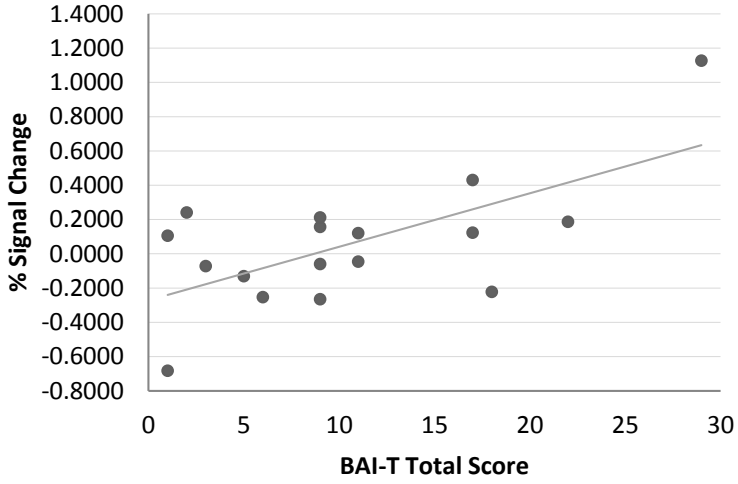
Scale	Region	*r*	p	i	q	crit	test
Negative Urgency	mPFC	-.21	.417	1	0.05	.007	0
	VS	-.14	.583	2	0.05	.014	0
	DLPFC	-.14	.598	3	0.05	.021	0
	vlPFC	.14	.605	4	0.05	.029	0
	LOFC	.08	.763	5	0.05	.036	0
	mOFC	.06	.818	6	0.05	.043	0
	PCC	-.02	.943	7	0.05	.050	0
BAI-T	vlPFC	**.65***	.005	1	0.05	.007	1
	mPFC	.40	.108	2	0.05	.014	0
	mOFC	.25	.343	3	0.05	.021	0
	PCC	.24	.362	4	0.05	.029	0
	DLPFC	.16	.551	5	0.05	.036	0
	LOFC	.05	.856	6	0.05	.043	0
	VS	.01	.964	7	0.05	.050	0
CES-D	DLPFC	-.40	.111	1	0.05	.007	0
	VS	-.37	.149	2	0.05	.014	0
	vlPFC	.21	.428	3	0.05	.021	0
	mPFC	-.17	.512	4	0.05	.029	0
	PCC	.15	.574	5	0.05	.036	0
	mOFC	.09	.734	6	0.05	.043	0
	LOFC	-.03	.896	7	0.05	.050	0

Note. False discovery rate value *q = .05. Individual critical values calculated for each correlation.

Figure 7 *Scatterplot of VLPFC % Signal Change and BAI-T Total Score.*



VLPFC, X = 40



Note. y = 0.0312x - 0.2714, R^2 = 0.42

Discussion

The goal of the current study explored a specific sub-construct of impulsivity, negative urgency, to further increase the understanding of impulsivity's increasingly integrated role in theories of personality and emotion regulation. The results demonstrated that successful mood induction occurred and, consequently, differences in behavioral impulsivity and neuronal activation patterns were observed in these conditions. However, the predicted role for Negative Urgency in these changes was not observed; instead, personality traits related to impulsivity had significant roles in the ways that discounting rates were changed behaviorally and the brain activation patterns indicating differential processing of the delay discounting task for those varying on different personality traits.

Mood induction effectiveness

The method used for negative mood induction was effective in influencing participants' self-reported mood ratings for two of the three primary emotions of interest. Immediately following the negative mood induction, participants rated their Sad and Depressed moods as greater than the baseline measurement. Sad mood remained elevated above baseline upon completion of the delay discounting task. The neutral task showed no significant changes in Sad or Depressed moods from baseline at any point in the task. Unexpectedly, anxious mood was effectively unchanged following negative mood and neutral mood induction, remaining relatively elevated for the duration of the experiment. The protocol from which the present study was adapted did not assess the "Anxious" mood state, and so no information about possible effects of this mood induction procedure on anxiety was available.

Overall, the mood ratings from participants indicate that the mood induction was successful for inducing negative mood for Sad and Depressed mood states. The lack of

differentiation of Anxious mood between conditions presents some concern as the construct of Negative Urgency is conceptually closely related to that mood state in particular. Happy, Calm, and Bored mood states appeared to be similar between conditions and did not represent major sources of variation for participants.

Behavioral Impulsivity, Mood induction, and Delay Discounting (Aim 1)

The behavioral impulsivity indexed by *k* values did not show any difference in the prediction that negative mood induction would alter discounting rates when including Negative Urgency as a covariate.

BIS/BAS/FFFS model the delay discounting task may not have sufficiently created "punishment" that participants would be trying to avoid. This model posits that the effectiveness of the inhibition system depends on its efficiency regulating incoming emotional and cognitive information and that those with higher Negative Urgency would be particularly susceptible to that system being overwhelmed and delay discounting performance would decrease. Delay discounting is by its nature a future-oriented, reward-focused mental process. Though Negative Urgency has been shown to have a significant relationship with anxiety—an affective reaction to possible negative future consequences— thus a punishment-focused delay discounting task may have been more effective for showing differences with Negative Urgency.

Lack of punishment in delay discounting paradigm may have insufficiently elicited negative affect in participants. An extant study of performance by patients with obsessive-compulsive disorder (OCD) on a Go/No-Go task found a significant increase in commission errors in conditions where direct punishment feedback was given (Morein-Zamir et al., 2013). The absence of overt punishing feedback in our delay discounting paradigm may have resulted in insufficient negative affect in participants with high Negative Urgency. Another consideration is

that participants may have been able to make decisions in a more cognitive or logic-based manner rather than a more emotional manner because the rewards were hypothetical. Though research has shown that hypothetical values result in similar patterns compared to real values (Johnson & Bickel, 2002; Madden et al., 2004), to our knowledge state-based mood changes have not been examined in terms of delay discounting. Our model of impulsivity relies on the emotional component of decision-making to overwhelm the BIS, resulting in poor choices. Although the mood induction was effective in altering self-report mood, without actual monetary loss there may have been reduced need for mental resources being dedicated to emotional regulation.

Additionally, while there is evidence for decreases in behavioral and cognitive performance as negative affect increases, examples include binge eating (Racine et al., 2013), aggression (Scott, DiLillo, Maldonado, & Watkins, 2015), self-report monetary discounting rates (Koff & Lucas, 2011), and memory encoding and recall (Potts, Camp, & Coyne, 1989), the degree of cognitive and emotional load may need to be sufficient to overload the BIS and this decrease in BIS performance may not be linear, requiring a threshold of cognitive load may be needed to overwhelm it. A study evidencing this pattern was seen in Vytal, Cornwell, Arkin, and Grillon (2012), where the cognitive load of an n-back task was parametrically increased and performance was measured by an anxiety response; they observed significantly increased anxiety responses occurring after a threshold of cognitive load was surpassed, from "medium" cognitive demand to "high" cognitive demand. A similar threshold of cognitive demand may be needed to result in the failure of the BIS.

Finally, the construct of Negative Urgency may be more relevant to a slightly different aspect of delay discounting—delay maintenance (related to delay of gratification). Delay

discounting is a highly cognitive task, involving weighing information, making idiopathic value judgments, and forecasting to the future (Bickel et al., 1999; Hirsh, Morisano, & Peterson, 2008). This decision-making task may be cognitively demanding by virtue of its complex, forward-looking nature, but these choices may not tie directly to the subjective emotional experience an individual is feeling when making that decision. Delay maintenance, conversely, requires individuals *sustain* a difficult choice over a period of time (Zayas, Mischel, & Pandey, 2014). The impulsive behaviors related to steeper delay discounting curves like gambling, alcohol use, and cigarette smoking are not necessarily perpetuated by a single choice about the future, but by continual choices supporting long-term goals (e.g., abstinence); when abstaining from these types of behaviors, an individual may revoke that choice at any time and choose the less optimal choice. This process of sustained effort may be more taxing to the BIS and address more directly the question of whether increased mental demands (cognitive and emotional) may predict impulsive choices mediated by Negative Urgency.

Exploratory Model. Discounting rates were influenced by the interaction between mood condition and the Planning subscale from the Brief COPE, when controlling for several other personality factors as covariates (Positive Urgency, BIS11 Total Score, Motor, Cognitive Complexity, and Substance Use). Specifically, negative mood induction increased discounting rates when accounting for participants' action strategies for coping with future events. Those with lower Planning scores showed higher *k* values (less impulsive) suggesting increased reactivity to the negative mood induction. The neutral condition was statistically no different from participants' baseline (pre-mood induction) *k* values. It is important to note that this effect was significant only in the multivariate tests, meaning that a larger combination of personality

factors may need to be accounted for when considering the effect of Planning on delay discounting rates.

Because the covariates for this model were determined *post hoc*, there is not a clear rationale for why controlling for these particular factors allowed for a change in *k* values to be detected. Notably, the effect of controlling for the covariates was significant at the multivariate level, but none of the covariates were significant as univariate predictors. This pattern suggests possible suppressor effects by the covariates, which may indicate that these factors are removing either a mediation or confounding effect between the mood condition and *k* values, similar to processes described by MacKinnon, Krull, and Lockwood (2000). In this case, the covariates may be related to the variances of independent and dependent variables. When including these factors in the model, we see an increase in the relationship between the conditions and *k* values, which is consistent with suppression. Future exploration of these variables would be needed to develop a theoretical framework to account for their relationship with delay discounting mood reactivity. The questions that form the Planning scale ("I've been trying to come up with a strategy about what to do" and "I've been thinking hard about what steps to take") suggest that a forward-looking focus on problem solving is a protective factor when coping with negative affect. Future-oriented attention has been posited in other research as one theory for the mechanism underlying discounting rate differences in delay discounting (Radu, Yi, Bickel, Gross, & McClure, 2011).

Despite finding no influence of negative urgency on delay discounting, impulsivity as measured by a delay discounting task is influenced by negative mood when accounting for other personality factors (i.e. planning). While discounting rates have been shown to be stable over time intervals as long as 1 year (Kirby, 2009), situational factors, such as drug craving or

positive mood, are also shown to affect discounting rates (Coffey et al., 2003; Hirsh et al., 2010; Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013); the present results indicate that experimental manipulation of negative mood can also be an environmental factor that changes how individuals make discounting decisions. Our hypothesized relationship between negative mood and negative urgency was not found, but there does appear to be a relationship between mood and discounting rates when accounting for personality. These findings support the general function of the predicted model regarding the change in impulsive behavior (i.e., discounting rates) when under emotional stress and as influenced by personality traits. Future studies examining mood and impulsive decision-making may also need to look into related personality factors, given the findings of the present study.

Mood Induction and Brain Activation (Aim 2)

The decision-making hypotheses that mood condition would have a significant main effect for decision-making and emotional regulation were not supported by the neuroimaging findings. Based in these results, we conclude that the negative mood induction by itself did not result in a significant change in how participants engaged in their decision-making process, either in terms of increased emotionality or reduced frontal activation. In terms of the predicted model, the neurological substrates of the BIS did not show systematic response to the presence of negative mood.

Role of Urgency in Delay Discounting in fMRI (Aim 3)

Negative Urgency. No relationship was found between Negative Urgency and mood induction in decision-making brain regions during delay discounting. This is consistent to what was found for the behavioral data (Aim 1). We believe that this lack of effect could be for similar reasons that behavioral *k* values were not related to negative urgency scores – that the task

presented may not have sufficiently elicited Negative Urgency. Because the construct of impulsivity is so diverse, differences in tasks may interact differently with different constructs, and, in this case, Negative Urgency may not have a strong relationship with delay discounting where the punishment aspect is more implied (e.g., that absence of reward) than direct (e.g., immediately losing money).

Trait Anxiety. The anxiety mood scale from the behavioral data showed that activation in the VLPFC was positively correlated with trait anxiety levels. In terms of the BIS/BAS Model, high trait anxiety is related to increased engagement of the BIS system, this increased engagement of the BIS system could lead to increased activation of the VLPFC in order to sustain non-impulsive decision-making when experiencing increased negative affect. VLPFC was shown in McClure et al. (2004) to have greater BOLD signal changes when participants were making relatively difficult decisions in a delay discounting task. Another study showed increased VLPFC activation for those with high motor impulsivity to maintain performance on a Go/No-go task (Goya-Maldonado et al., 2010). Other studies have found hypoactivation to be related to impulsive choices when the choices were difficult (de Ruiter et al., 2008; Hinvest et al., 2011). Unlike previous studies, we observed hyperactivation rather than hypoactivation of the right VLPFC. Since we did not see a behavioral change, we suggest that the right VLPFC hyperactivation solely reflects increased recruitment to maintain performance versus failure to recruit leading to impaired performance. We believe this increase in activation reflects additional cognitive demand required by those with high trait anxiety to make decisions in a way that is less cognitively taxing for those with lower trait anxiety.

Limitations

Several caveats exist that limit the interpretation of these results. Firstly, the population from which participants were selected represents a relatively small demographic slice of the overall population of adults in the United States. The way in which delay discounting occurs may be sensitive to culture, socioeconomic status, race/ethnicity, age, and other similar variables (Green, Myerson, & Ostaszewski, 1999; Reimers, Maylor, Stewart, & Chater, 2009). Additionally, emotion regulation has been shown to change over the lifespan (Larcom & Isaacowitz, 2009), and so the rates at which this sample delay discounted and the ability to regulate emotion may not necessarily be the same for other groups.

The inconsistent mood induction of anxiety presented another difficulty with ensuring that the BIS was sufficiently overwhelmed for those with his Negative Urgency. The implications are twofold. First, the theorized relationship between negative mood and Negative Urgency is primarily thought to be mediated through anxiety. While Sad and Depressed moods were substantially elevated by the negative mood induction, there was no significant effect on Anxious mood, meaning that reactivity to negative affect predicted by Negative Urgency would likely not exist at a detectable level if the primary negative mood state (anxiety) was not sufficiently elevated. Second, since both negative and neutral mood inductions resulted in similar levels of Anxious mood, if an effect occurred it would be undetectable because there was no difference between conditions. It is possible that participation in the experiment itself was anxiety provoking, increasing the baseline level of the anxiety for all participants. During study debriefing, some participants stated that the neutral condition was confusing or frustrating because they could not easily identify what mood they were meant to be feeling. The ambiguous nature of the task may have favored a slight bias toward Anxious mood from participants. Both

the negative and neutral mood conditions could have maintained anxiety levels in participants that may have been present upon initial participation in the study. In other words, instead of increasing anxiety, the mood induction may have prevented a natural decrease from baseline as participants became used to the study environment. Any combination of the nonspecific environmental characteristics (e.g., meeting new people, engaging in novel tasks, etc.), unanticipated negative affect increase/maintenance following neutral mood induction, or ineffectiveness of the mood induction procedure for anxiety may have caused the pattern observed.

Another limitation of this study is the experimental nature of mood induction tasks. Particularly, that mood induction in experimental settings seldom reflects the actual circumstances in which more typical negative mood states occur. Negative mood states in actual life represent a complex interplay of countless variables (e.g., existing relationships with others, significant real-world consequences of choices) that are impossible to capture completely in an experimental design. Additionally, there are ethical limitations to the degree that negative mood may be induced, which further limits the type of mood inductions used and the degree to which affect may be induced. If the rate of delay discounting is commensurate with the intensity of negative affect, then the ability to detect that change is limited by the ability to elicit intense, lasting negative mood.

Furthermore, in this study there we only had one behavioral measure of impulsivity used as the dependent measure (delay discounting). A complex construct such as impulsivity may better be explored by multiple behavioral measures that would capture different facets of the construct. Being able to measure decision-making using many tasks would be helpful to capture possible differences in how personality traits such as Negative Urgency and mood state might

interact with tasks requiring different cognitive and emotional demands, such as the Iowa Gambling Task or a Go/No-go task. Additionally, the use of an fMRI design restricted the number of tasks that could be done because of how long participants could remain in the scanner for a single session. Because the number of scans and times were limited, the number of tasks that could be adapted for fMRI and enacted in a short time was also limited.

General Discussion

Though we did not see the exact relationships between Negative Urgency, mood, and impulsivity as predicted, the results were nonetheless compelling and were consistent with the expected functions of the BIS/BAS/FFFS model and the role of negative affect influencing behavioral and neural differences. In particular, trait anxiety levels did predict differential cognitive process when making the delay discounting decisions, with high trait anxiety predicting greater VLPFC activation compared to low trait anxiety. Behaviorally, the results support the interaction between personality traits, state negative mood, and the mutability of discounting rates.

One of the main features of impulsive behaviors is that they by definition serve an immediate need. The ability to delay immediate reward in the service of long-term, more valuable reward is a powerful predictor of many health behaviors, including the development and maintenance of addictions. A high ability to delay rewards is associated with being less likely to engage in risky behavior patterns, such as chronic smoking (Balevich, Wein, & Flory, 2013), substance abuse (Coffey et al., 2003; Perry & Carroll, 2008), and overeating (Guerrieri et al., 2007). Addictive behaviors follow a pattern of selecting an immediate reward, such as smoking a cigarette to reduce anxiety, while neglecting the reward of a more valued but less immediate goal, such as longer life or better health. As addictive behaviors persist over time individuals'

ability to delay rewards decreases, which perpetuates the selection of an immediate reward with long-term negative effects (Bickel et al., 2007). This pattern results in a downward trajectory where individuals who may already demonstrate decreased ability to resist addictive behaviors are further impaired by the chronic behavior and therefore are even less equipped to cease the negative health behavior.

The research from this study is intended to further the understanding of reward, impulsivity, and mood as they relate to decision-making. We looked at Negative Urgency because of its relationship with negative mood states may be useful for understanding certain aspects of impulsive behaviors. For instance, the sensation-seeking type of impulsivity may explain propensity for engaging in cigarette smoking but not necessarily its maintenance (Balevich et al., 2013), whereas negative mood appears to be a factor in the maintenance process (Baker, Brandon, & Chassin, 2004; Covey, Glassman, & Stetner, 1998). In this case the individual with higher sensation seeking might be receptive to a particular intervention prior to engaging in cigarette smoking, while the causes of impulsive behavior later in the addiction might be better targeted with emotion-based interventions. The results from the present experiment did not show a direct link with Negative Urgency and impulsive decisions made in a delay discounting task, either behaviorally or neurologically. However, recent research examining the role of Negative Urgency as a factor in cognitive control under negative mood induction (Gunn & Finn, 2015) supports the direction of the present study. The findings from the present study can be used to refine future hypotheses and to better understand the way in which this construct may be related to impulsivity and delayed gratification. On the other hand, the current study showed that there was a relationship between mood and decision-making, behaviorally as it related to other forms of impulsivity and coping measures, including planning

for the future, and neurologically in terms of trait anxiety levels correlating with increased activity in areas associated with cognitive control. Future studies will hopefully continue to illuminate the relationships between mood state, personality, and decision-making in ways that help us understand how reward and punishment function across different kinds of impulsive behaviors.

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APPENDICES

APPENDIX A: Self-Report Scores for Behavioral and fMRI Participants

Table 9 *Behavioral Self-Report Impulsivity and Mood Measures*

Measure Name	Mean	SD	Min	Max	Range
BIS11 – Total	63.66	10.76	42	87	45
Attention	10.83	2.90	5	16	11
Cognitive Instability	6.61	1.69	3	11	8
Motor	15.11	2.91	11	24	13
Perseverance	6.68	1.62	4	11	7
Self-Control	12.63	3.67	6	22	16
Cognitive Complexity	11.80	2.83	6	17	11
UPPS+P					
Negative Urgency	27.58	5.24	15	41	26
Premeditation (lack of)	22.98	4.89	13	36	23
Perseverance (lack of)	20.03	4.57	10	32	22
Sensation Seeking	37.28	5.22	23	48	25
Positive Urgency	28.26	5.41	16	39	23
SPSRQ					
Sensitivity to Punishment	11.15	4.74	3	22	19
Sensitivity to Reinforcement	13.89	4.03	6	24	18
BIS/BAS					
BAS Drive	11.20	2.12	6	15	9
BAS Fun Seeking	12.57	2.02	7	16	9
BAS Reward Responsiveness	17.77	1.74	13	20	7
BIS	22.96	3.36	16	29	13
Brief COPE					
Self-Distraction	5.71	1.56	2	8	6
Active Coping	6.03	1.22	4	8	4
Denial	2.77	0.95	2	5	3
Substance Use	3.32	1.73	2	8	6
Emotional Sup	5.32	1.76	2	8	6
Instrumental Sup	5.05	1.80	2	8	6
Behavioral Disengagement	3.18	1.30	2	8	6
Venting	4.28	1.32	2	8	6
Positive Reframing	5.86	1.55	2	8	6
Planning	6.12	1.42	2	8	6
Humor	5.43	1.86	2	8	6
Acceptance	6.45	1.15	3	8	5
Religion	3.82	1.87	2	8	6
Self-Blame	5.44	1.73	2	8	6
CES-D – Total	12.37	7.83	2	31	29
BAI-T – Total	10.42	8.07	0	32.38	32.38

Table 10 *FMRI Self-Report Impulsivity and Mood Measures*

Measure Name	Mean	SD	Min	Max	Range
BIS11 – Total	63.66	10.76	42	87	45
Attention	10.83	2.90	5	16	11
Cognitive Instability	6.61	1.69	3	11	8
Motor	15.11	2.91	11	24	13
Perseverance	6.68	1.62	4	11	7
Self-Control	12.63	3.67	6	22	16
Cognitive Complexity	11.80	2.83	6	17	11
UPPS+P					
Negative Urgency	27.58	5.24	15	41	26
Premeditation (lack of)	22.98	4.89	13	36	23
Perseverance (lack of)	20.03	4.57	10	32	22
Sensation Seeking	37.28	5.22	23	48	25
Positive Urgency	28.26	5.41	16	39	23
SPSRQ					
Sensitivity to Punishment	11.15	4.74	3	22	19
Sensitivity to Reinforcement	13.89	4.03	6	24	18
BIS/BAS					
BAS Drive	11.20	2.12	6	15	9
BAS Fun Seeking	12.57	2.02	7	16	9
BAS Reward Responsiveness	17.77	1.74	13	20	7
BIS	22.96	3.36	16	29	13
Brief COPE					
Self-Distraction	5.71	1.56	2	8	6
Active Coping	6.03	1.22	4	8	4
Denial	2.77	0.95	2	5	3
Substance Use	3.32	1.73	2	8	6
Emotional Sup	5.32	1.76	2	8	6
Instrumental Sup	5.05	1.80	2	8	6
Behavioral Disengagement	3.18	1.30	2	8	6
Venting	4.28	1.32	2	8	6
Positive Reframing	5.86	1.55	2	8	6
Planning	6.12	1.42	2	8	6
Humor	5.43	1.86	2	8	6
Acceptance	6.45	1.15	3	8	5
Religion	3.82	1.87	2	8	6
Self-Blame	5.44	1.73	2	8	6
CES-D – Total	12.37	7.83	2	31	29
BAI-T – Total	10.42	8.07	0	32.38	32.38

APPENDIX B: Mood rating figures for negative and neutral mood inductions.

Figure 9 *Happy mood ratings for negative and neutral mood inductions*

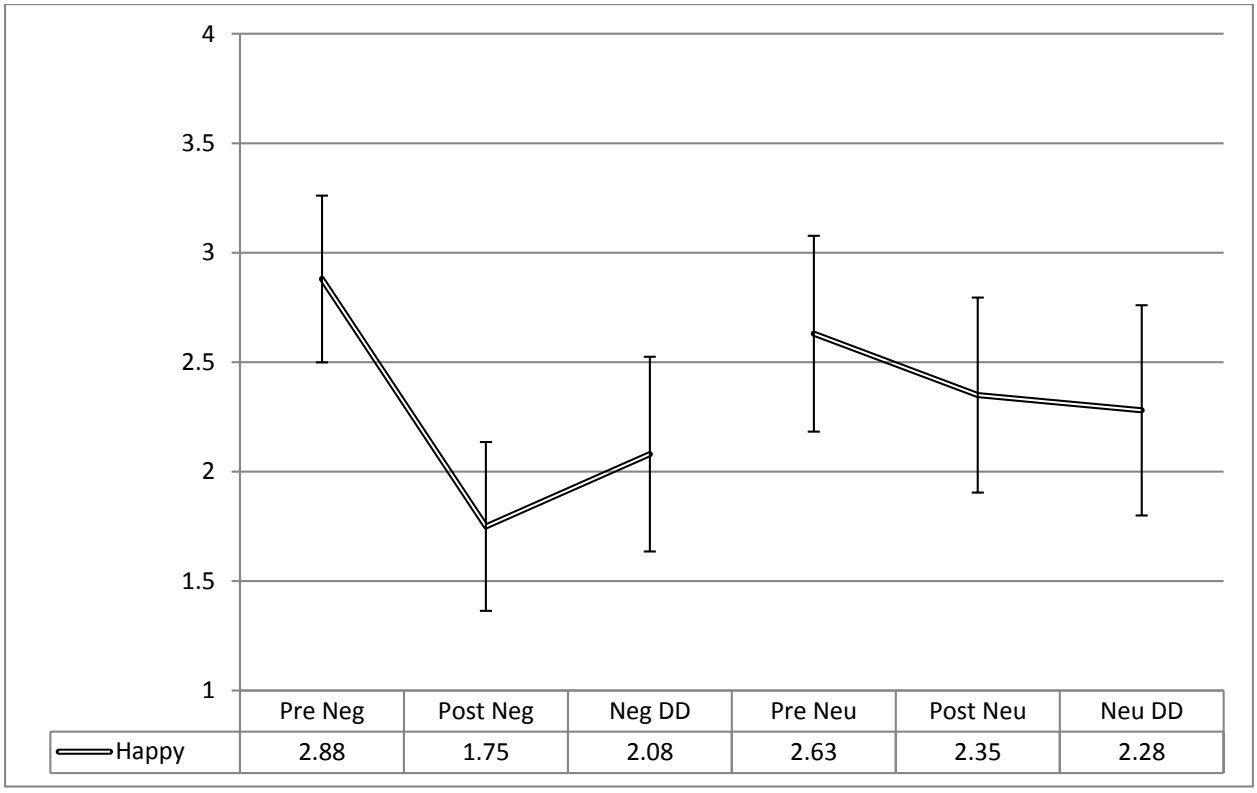


Figure 10 *Calm mood ratings for negative and neutral mood inductions*

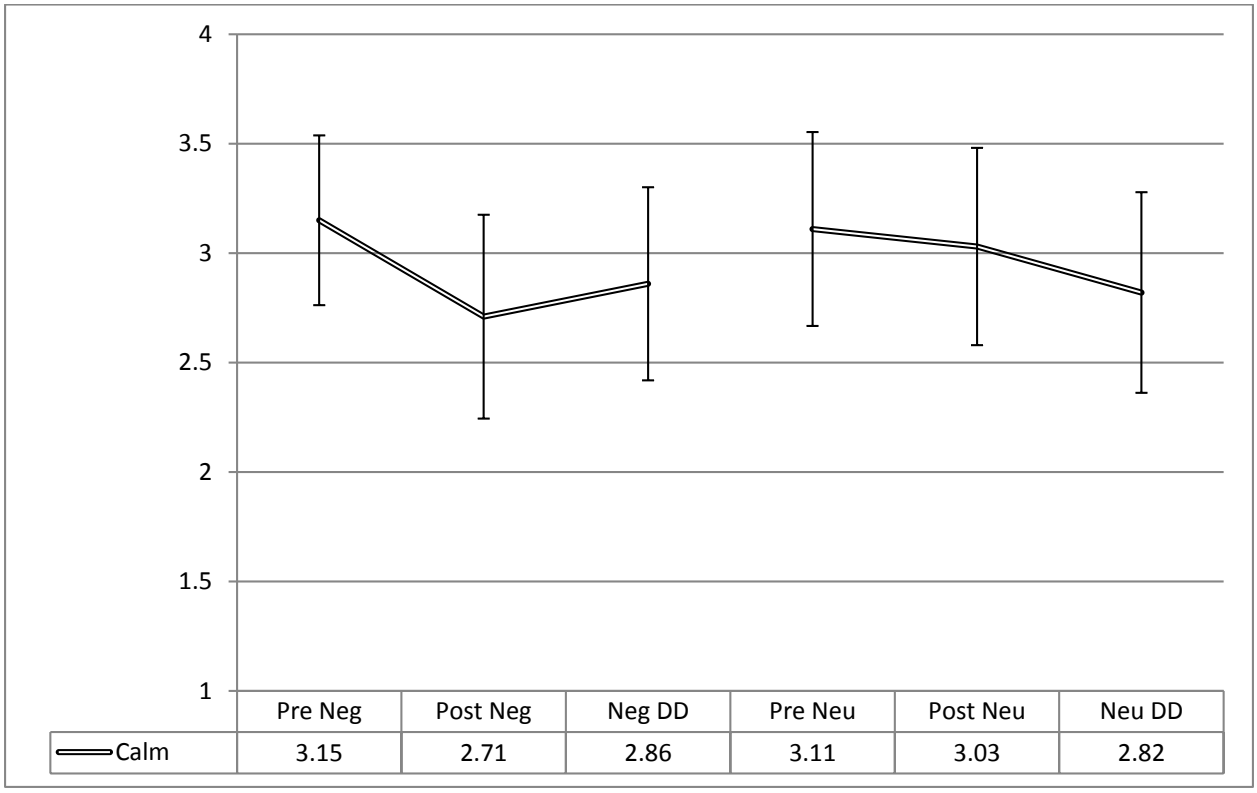


Figure 11 *Sad mood ratings for negative and neutral mood inductions*

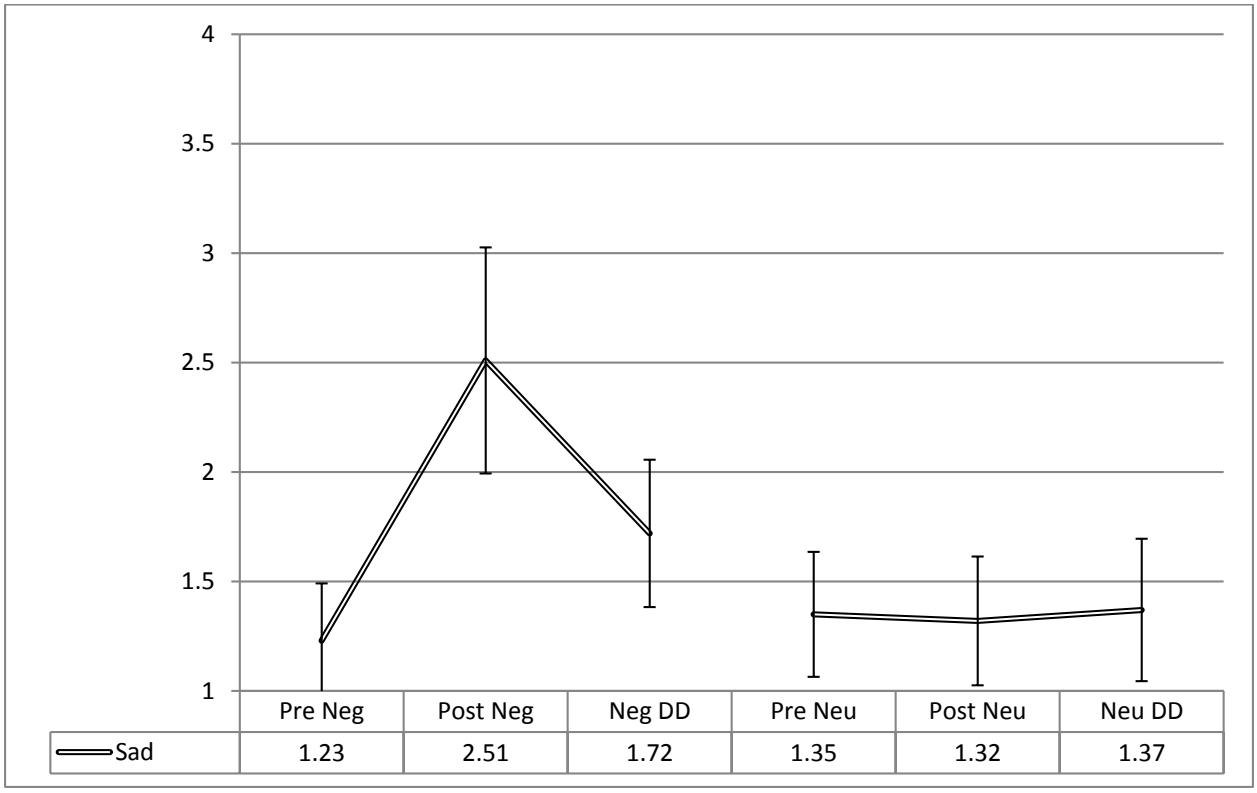


Figure 12 *Bored mood ratings for negative and neutral mood inductions*

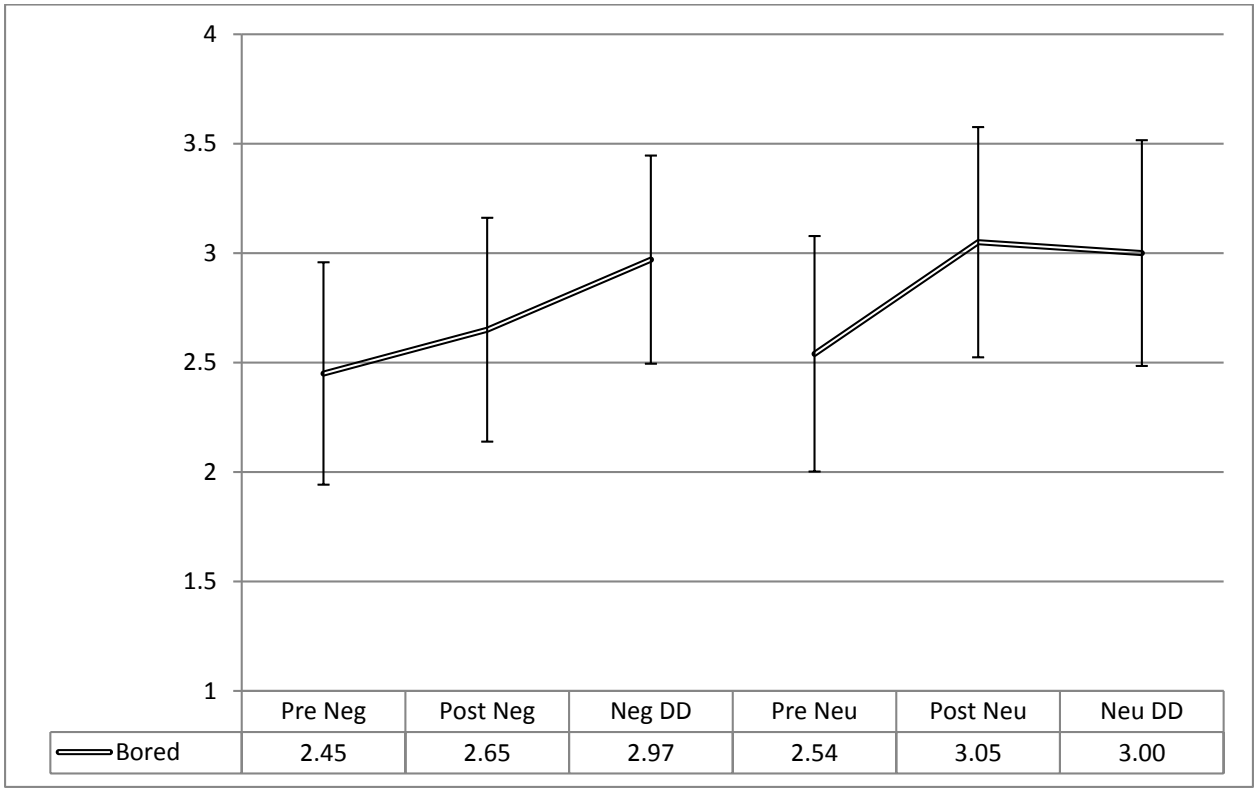


Figure 13 *Depressed mood ratings for negative and neutral mood inductions*

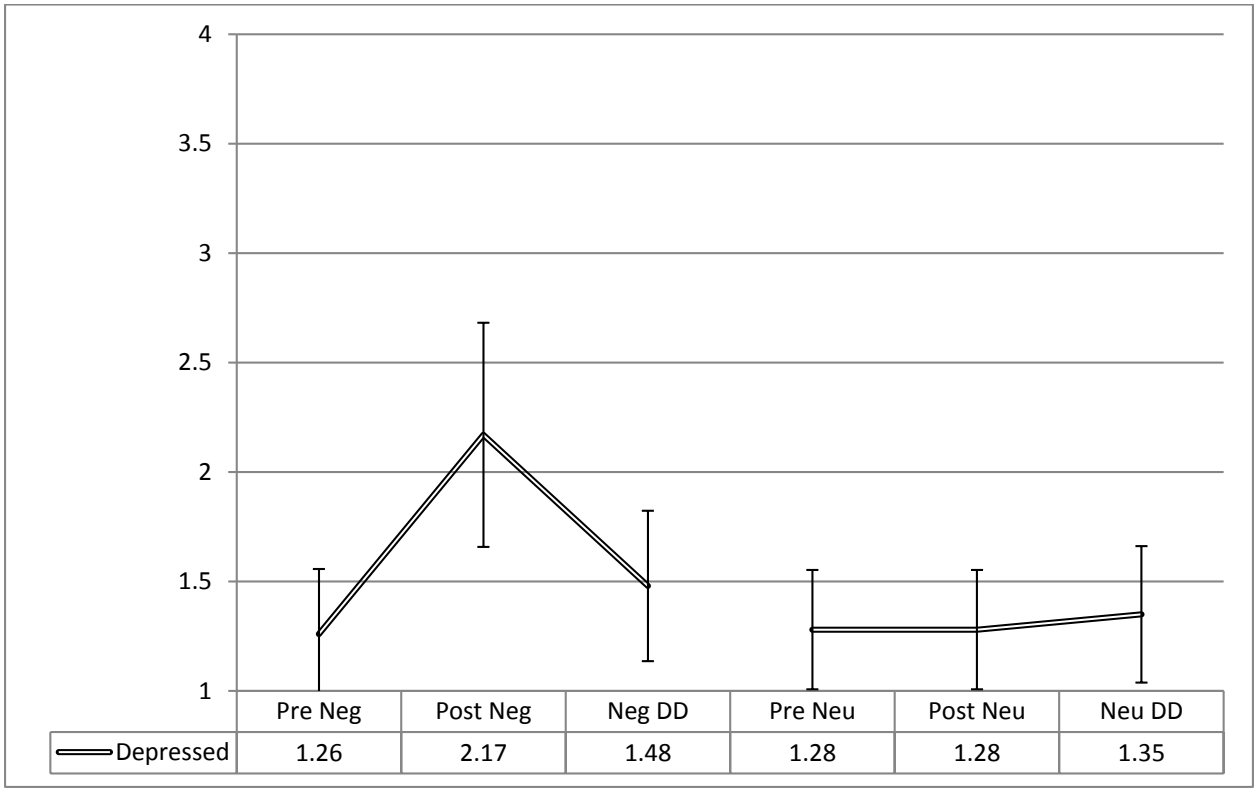
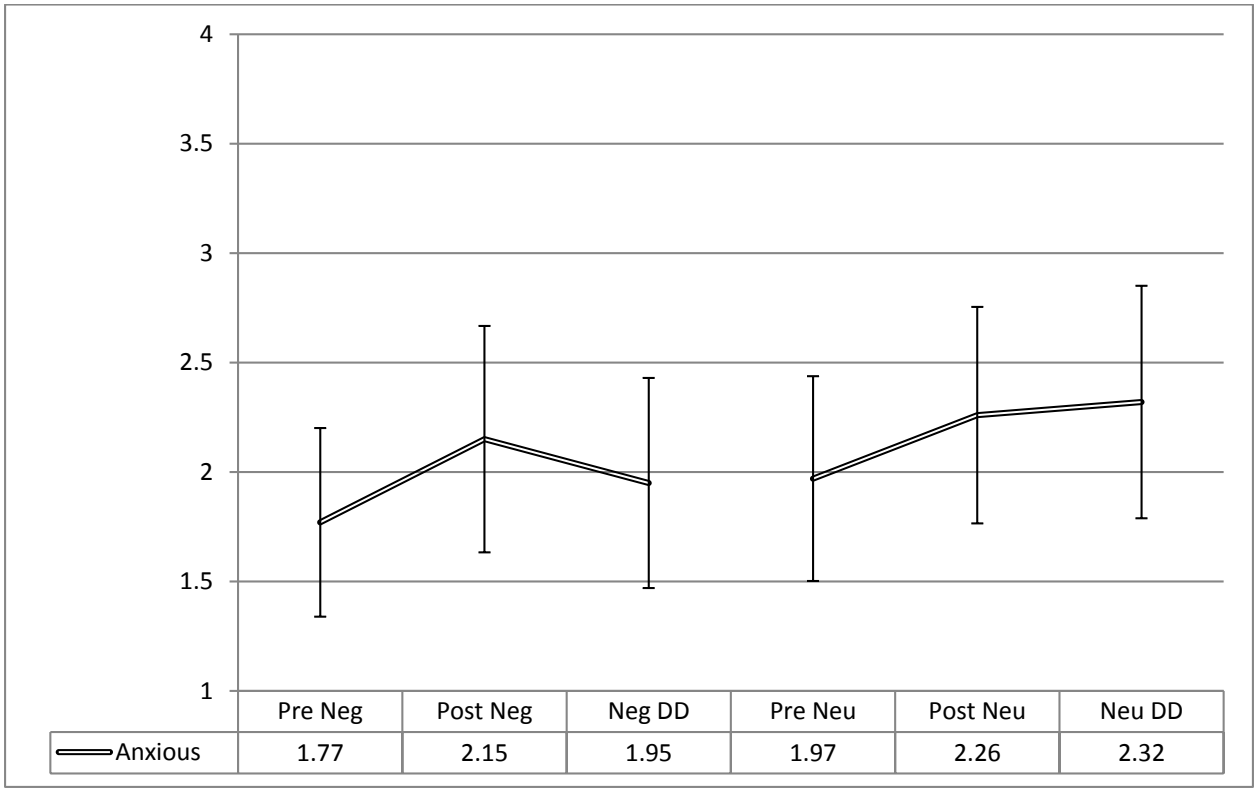


Figure 14 *Anxious mood ratings for negative and neutral mood inductions*



APPENDIX C: Pairwise comparisons for self-report mood ratings

Table 11 *Pairwise Comparisons for Happy Mood Rating*

(I) time	(J) time	Mean Difference (I-J)	SE	Sig.
1	2	1.12*	.10	<.000
	3	.80*	.11	<.000
	4	.25	.12	.775
	5	.52*	.09	<.000
	6	.60*	.11	<.000
2	1	-1.12*	.10	<.000
	3	-.32*	.08	.002
	4	-.88*	.11	<.000
	5	-.60*	.10	<.000
	6	-.52*	.12	<.000
3	1	-.80*	.11	<.000
	2	.32*	.08	.002
	4	-.55*	.11	<.000
	5	-.28	.09	.068
	6	-.20	.11	.954
4	1	-.25	.12	.775
	2	.88*	.11	<.000
	3	.55*	.11	<.000
	5	.28*	.09	.038
	6	.35*	.09	.004
5	1	-.52*	.09	<.000
	2	.60*	.10	<.000
	3	.28	.09	.068
	4	-.28*	.09	.038
	6	.08	.07	1.000
6	1	-.60*	.11	<.000
	2	.52*	.12	<.000
	3	.20	.11	.954
	4	-.35*	.09	.004
	5	-.08	.07	1.000

Bonferroni adjusted for multiple comparisons.
Mean differences based on estimated marginal means
* The mean difference is significant at the .05 level.

Table 12 *Pairwise Comparisons for Calm Mood Rating*

(I) time	(J) time	Mean Difference (I-J)	SE	Sig.
1	2	.45*	.12	.005
	3	.29	.12	.231
	4	.05	.13	1.000
	5	.12	.13	1.000
	6	.34	.13	.160
2	1	-.45*	.12	.005
	3	-.15	.12	1.000
	4	-.40*	.12	.030
	5	-.32	.13	.243
	6	-.11	.14	1.000
3	1	-.29	.12	.231
	2	.15	.12	1.000
	4	-.25	.13	.872
	5	-.17	.11	1.000
	6	.05	.13	1.000
4	1	-.05	.13	1.000
	2	.40*	.12	.030
	3	.25	.13	.872
	5	.08	.11	1.000
	6	.29	.13	.397
5	1	-.12	.13	1.000
	2	.32	.13	.243
	3	.17	.11	1.000
	4	-.08	.11	1.000
	6	.22	.11	.775
6	1	-.34	.13	.160
	2	.11	.14	1.000
	3	-.05	.13	1.000
	4	-.29	.13	.397
	5	-.22	.11	.775

Bonferroni adjusted for multiple comparisons.
Mean differences based on estimated marginal means
* The mean difference is significant at the .05 level.

Table 13 *Pairwise Comparisons for Sad Mood Rating*

(I) time	(J) time	Mean Difference (I-J)	SE	Sig.
1	2	-1.28*	.14	<.000
	3	-.49*	.09	<.000
	4	-.12	.07	1.000
	5	-.09	.06	1.000
	6	-.14	.07	.869
2	1	1.28*	.14	<.000
	3	.79*	.12	<.000
	4	1.15*	.12	<.000
	5	1.19*	.13	<.000
	6	1.14*	.14	<.000
3	1	.49*	.09	<.000
	2	-.79*	.12	<.000
	4	.37*	.08	.001
	5	.40*	.09	.001
	6	.35	.09	.006
4	1	.12	.07	1.000
	2	-1.15*	.12	<.000
	3	-.37*	.08	.001
	5	.03	.07	1.000
	6	-.02	.08	1.000
5	1	.09	.06	1.000
	2	-1.19*	.13	<.000
	3	-.40*	.09	.001
	4	-.03	.07	1.000
	6	-.05	.07	1.000
6	1	.14	.07	.869
	2	-1.14*	.14	<.000
	3	-.35*	.09	.006
	4	.02	.08	1.000
	5	.05	.07	1.000

Bonferroni adjusted for multiple comparisons.
Mean differences based on estimated marginal means
* The mean difference is significant at the .05 level.

Table 14 *Pairwise Comparisons for Bored Mood Rating*

(I) time	(J) time	Mean Difference (I-J)	SE	Sig.
1	2	-.20	.12	1.000
	3	-.52*	.10	<.000
	4	-.09	.16	1.000
	5	-.60*	.14	.001
	6	-.55*	.14	.003
2	1	.20	.12	1.000
	3	-.32*	.08	.003
	4	.11	.14	1.000
	5	-.40*	.12	.026
	6	-.35	.12	.067
3	1	.52*	.10	<.000
	2	.32*	.08	.003
	4	.43*	.13	.027
	5	-.08	.12	1.000
	6	-.03	.11	1.000
4	1	.09	.16	1.000
	2	-.11	.14	1.000
	3	-.43*	.13	.027
	5	-.51*	.12	.002
	6	-.46*	.14	.030
5	1	.60*	.14	.001
	2	.40*	.12	.026
	3	.08	.12	1.000
	4	.51*	.12	.002
	6	.05	.12	1.000
6	1	.55*	.14	.003
	2	.35*	.12	.067
	3	.03*	.11	1.000
	4	.46	.14	.030
	5	-.05	.12	1.000

Bonferroni adjusted for multiple comparisons.
Mean differences based on estimated marginal means
* The mean difference is significant at the .05 level.

Table 15 *Pairwise Comparisons for Depressed Mood Rating*

(I) time	(J) time	Mean Difference (I-J)	SE	Sig.
1	2	-.91*	.12	<.000
	3	-.22	.09	.217
	4	-.02	.07	1.000
	5	-.02	.07	1.000
	6	-.09	.08	1.000
2	1	.91*	.12	<.000
	3	.69*	.11	<.000
	4	.89*	.12	<.000
	5	.89*	.12	<.000
	6	.82*	.12	<.000
3	1	.22	.09	.217
	2	-.69*	.11	<.000
	4	.20	.08	.153
	5	.20	.07	.121
	6	.12	.08	1.000
4	1	.02	.07	1.000
	2	-.89*	.12	<.000
	3	-.20	.08	.153
	5	.00	.07	1.000
	6	-.08	.08	1.000
5	1	.02	.07	1.000
	2	-.89*	.12	<.000
	3	-.20	.07	.121
	4	.00	.07	1.000
	6	-.08	.03	.376
6	1	.09	.08	1.000
	2	-.82*	.12	<.000
	3	-.12	.08	1.000
	4	.08	.08	1.000
	5	.08	.03	.376

Bonferroni adjusted for multiple comparisons.
Mean differences based on estimated marginal means
* The mean difference is significant at the .05 level.

Table 16 *Pairwise Comparisons for Anxious Mood Rating*

(I) time	(J) time	Mean Difference (I-J)	SE	Sig.
1	2	-.38	.14	.117
	3	-.18	.11	1.000
	4	-.20	.11	.973
	5	-.49*	.11	.001
	6	-.55*	.13	.001
2	1	.38	.14	.117
	3	.20	.13	1.000
	4	.18	.16	1.000
	5	-.11	.15	1.000
	6	-.17	.16	1.000
3	1	.18	.11	1.000
	2	-.20	.13	1.000
	4	-.02	.12	1.000
	5	-.31	.12	.183
	6	-.37*	.12	.046
4	1	.20	.11	.973
	2	-.18	.16	1.000
	3	.02	.12	1.000
	5	-.29	.12	.328
	6	-.35	.14	.181
5	1	.49*	.11	.001
	2	.11	.15	1.000
	3	.31	.12	.183
	4	.29	.12	.328
	6	-.06	.09	1.000
6	1	.55*	.13	.001
	2	.17	.16	1.000
	3	.37*	.12	.046
	4	.35	.14	.181
	5	.06	.09	1.000

Bonferroni adjusted for multiple comparisons.
Mean differences based on estimated marginal means
* The mean difference is significant at the .05 level.

APPENDIX D: FMRI Environment Screening Form

Hoglund Brain Imaging Center

Magnetic Resonance Imaging (MRI Environment Screening Form

HBIC

The MR system has a very strong magnetic field that may be hazardous to individuals entering the MR environment or MR system room if they have certain metallic, electronic, magnetic, or mechanical implants, devices, or objects. Therefore, all individuals are required to fill out this form BEFORE entering the MR environment or MR system room. ***Be advised, the MR system magnet is ALWAYS on.***

Personal Health History

Please answer the following:

☐Yes ☐No Cardiac Pacemaker	☐Yes ☐No Previous MRI	☐Yes ☐No Harrington Rods
☐Yes ☐No Gastric Pacemaker	☐Yes ☐No Able to Lie Flat	☐Yes ☐No Eyelid Spring/Wire
☐Yes ☐No Cardiac Defibrillator	☐Yes ☐No Claustrophobic	☐Yes ☐No Prosthetic Device
☐Yes ☐No Heart Valve Replacement	☐Yes ☐No BB, Foreign Body, GSW	☐Yes ☐No Dentures/Partials
☐Yes ☐No Aneurysm/Vascular Clips	☐Yes ☐No Neurostimulation Device	☐Yes ☐No History of Seizures
☐Yes ☐No Stents, Filters or Coils	☐Yes ☐No Hearing Aide	☐Yes ☐No Motion Disorder
☐Yes ☐No Kidney/Liver Transplant	☐Yes ☐No Cochlear Implant	☐Yes ☐No Body Piercing(s)
☐Yes ☐No Kidney Disease or Diabetes	☐Yes ☐No History of Metal in Eyes	☐Yes ☐No Permanent Eyeliner
If yes, type of dialysis _____	☐Yes ☐No Medication Skin Patch	☐Yes ☐No Bladder Stimulator
☐Yes ☐No Liver Cirrhosis/Cancer	☐Yes ☐No Vascular IV Access	☐Yes ☐No Insulin Pump
If yes, Creatinine ____ *GFR* ____	☐Yes ☐No Hydrocephalus/Spinal Shunt	☐Yes ☐No Implantable Device

Surgeries

Have you ever had surgery? ☐*Yes* ☐*No If yes, Please indicate below.*

Year	Type	Year	Type
Year	Type	Year	Type

Current Medications

Have you taken any medications today (e.g., pain, sedative, medications)? ☐*Yes* ☐*No If yes, Please indicate below.*

Drug Name	Dosage	Time of Last Dose	Drug Name	Dosage	Time of last dose

Female Patients

If applicable, please answer the following questions:

☐Yes ☐No I.U.D. Device ☐Yes ☐No Pregnant (or suspect) ☐Yes ☐No Breastfeeding ☐Yes ☐No Late Menstrual Cycle

I attest that the above information is correct to the best of my knowledge. I have read and understand the entire contents of this form and have had the opportunity to ask questions regarding the information on this form.

_____ *Patient Name (Please Print)*

___/___/___ *Date of Birth*

_____ *Weight*

_____ *Medical Record Number*

_____ *Patient Signature*

___/___/___ *Date*

Form completed by (if not patient): ☐*Spouse* ☐*Relative* ☐*Legal Guardian* ☐*Nurse* ☐*Technologist* ☐*Other*

_____ *Print Name*

_____ *Signature*

IMPORTANT INSTRUCTIONS

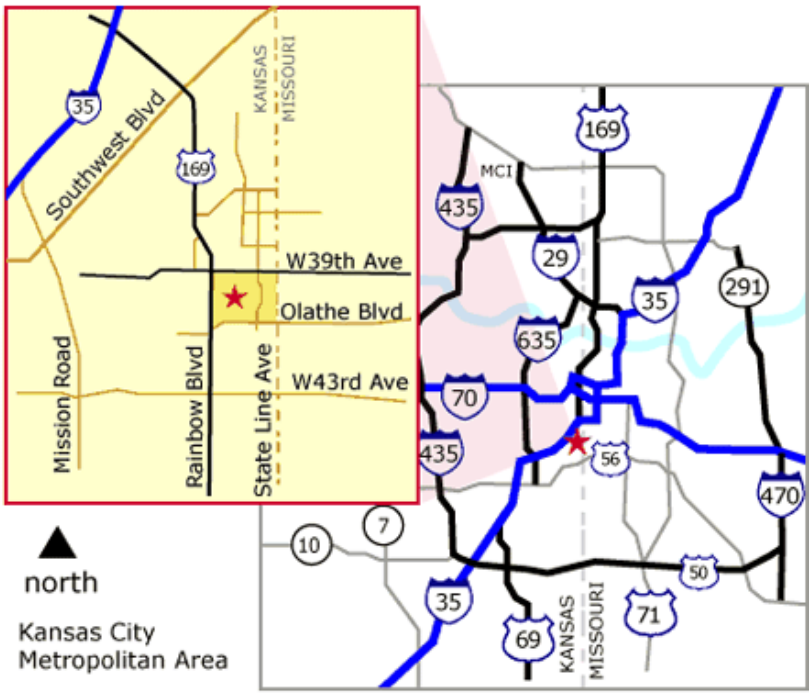
Before entering the MR environment or MR system room, you must remove all metallic objects including hearing aids, dentures, partial plates, keys, beeper, cell phone, eyeglasses, hair pins, barrettes, jewelry, body piercings, watch, safety pins, paperclips, money clip, credit cards, bank cards, magnet strip cards, coins, pens, pocket knife, nail clipper, tools, clothing with metal fasteners & clothing with metallic threads. ***Lockers are provided.***

APPENDIX E: FMRI participant travel instructions

Provided below are maps and directions to Hoglund Brain Imaging Center (HBIC) at the KU Med Center campus. Please read carefully as the location can be difficult to find. Parking for participants is free and available in the spaces directly in front of the HBIC entrance. Please follow the directions for HBIC at the end of this document specifically as many GPS and mapping software will guide you to the main hospital entrance but not HBIC.

This study will involve time being scanned in an fMRI machine. This is not recommended for those with metallic medical implants or claustrophobia. You have been prescreened via SONA for most of these conditions, but if you have any concerns or questions about this process, or need more specific directions to the HBIC, please contact **Ty Owens (###-###-####).** If for any reason you are unable to make this appointment, please let us know ahead of time so we can make the appropriate changes to our schedule. Thank you for your participation in this study.

Directions to the University of Kansas Medical Center



The University of Kansas Medical Center is centrally located on the major interstate highway system. The medical center campus is a mile south of I-35 and 7th St. Trafficway South, at 39th Avenue and Rainbow Boulevard (3901 Rainbow Boulevard) in Kansas City, Kansas. The main entrance of the hospital is located on Cambridge Street.

From the North (Kansas City International Airport)
I-29 South to I-35 South
Exit 7th St. Trafficway South, 7th St. becomes Rainbow Blvd.
Continue south on Rainbow Blvd. to 39th St.
Turn left at 39th St. and go to Cambridge St.
Turn right at Cambridge St.

From the West
I-70 East to 7th St. Trafficway South
Exit 7th St. Trafficway South
7th St. becomes Rainbow Blvd.
Continue south on Rainbow Blvd. to 39th St.
Turn left at 39th St. and go to Cambridge St.
Turn right at Cambridge St.

From the East
I-70 West to downtown Kansas City, MO
Merge onto I-35 South and go to 7th St. Trafficway
Exit 7th St. Trafficway South
7th St. becomes Rainbow Blvd.
Continue south on Rainbow Blvd. to 39th St.
Turn left at 39th St. and go to Cambridge St.
Turn right at Cambridge St.

From the South
Via I-35; travel North on I-35 to Rainbow Blvd. exit
head south on Rainbow to 39th St.
Turn left at 39th St. and go to Cambridge St.
Turn right at Cambridge St. or

Exit I-435 at State Line Road
head north on State Line Road to 39th Street
Turn left at 39th St. and go to Cambridge St.
Turn right at Cambridge St.

Hoglund Brain Imaging Center Building (North campus)

Directions:From I-70 or I-35, exit on US 169 south toward Seventh Street Trafficway/Rainbow Boulevard.

Proceed south on US 169/Seventh Street Trafficway/Rainbow Boulevard.

Turn left (east) on 39th Street and take the next left (north). HBIC is the second building on the right.