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Depressive Symptoms as a Moderator of Diurnal Trends in Reward Seeking

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DEPRESSIVE SYMPTOMS AS A MODERATOR OF DIURNAL TRENDS IN REWARD SEEKING

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Abstract

Anhedonia, a cardinal symptom of a major depressive episode, is the decreased motivation to seek rewards. Individuals with depressive symptoms tend to report reduced positive affect, a distal measure of reward motivation, and engage in less reward-motivated behavior (i.e., reward seeking). However, diurnal rhythms may also influence reward-seeking. Both self-reported positive affect and behavioral measures of reward-seeking increase from the morning to the afternoon and then decreased in the evening. Therefore, the aim of this study was to examine whether reward-seeking varied across time of day and whether anhedonia moderated variation. Overall, reward-seeking did not vary across time of day. Diurnal trends in reward seeking may require within-subjects designs to detect individual variation over time. Additionally, anhedonia and depressive symptoms were not associated with reward seeking, nor moderated the relationship between reward seeking and the time of task completion. Risk taking may be too distal to reward seeking and anhedonia's influence may be specific to rewards without salient risks. Exploratory results found cubic trends in certain measures of reward-seeking that may be a result of fatigue evoked by the study design.

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Chapter 1: Literature Review

Depression is among the most common and costly mental disorders (Thornicroft et al., 2017). Individuals with depression are more likely to have decreased quality of life (Engel et al., 2018), increased risk of suicide (Lépine & Briley, 2011), and increased risk of comorbid medical (Moussavi, et al., 2007) and psychiatric (Hasin et al., 2018) conditions. Individuals with depression typically experience anhedonia (Dichter, 2010; Haarasilta et al., 2001). Anhedonia is likely caused by blunted reward processing that results in decreased motivation to seek rewards and receive pleasure from rewards (Rizvi et al., 2016). However, reward motivation also demonstrates diurnal variation. On behavioral tasks, reward seeking, a measure of reward motivation, increases from the morning to the afternoon and then decreases in the evening (Byrne & Murray, 2017). On more distal outcomes, such as self-reported positive affect, the diurnal pattern also holds with positive affect increasing from morning to afternoon and decreasing in the evening in individuals with high and low endorsement of depressive symptoms (Murray, 2007). Therefore, the purpose is to examine whether depressive symptoms moderate the diurnal pattern of reward seeking.

Depression is prevalent and common on university campuses, but the prevalence varies due to simplistic measurement paradigms. Two large national surveys reported that severe depression measured via the PHQ-9 occurred in approximately 21% of undergraduates (Duffy et al., 2019), while a national survey of 137 colleges/universities reported 14% of college students were diagnosed with or treated for depression (American College Health Association, 2016). Prevalence also varies by treatment setting, as 40% of hospitalized undergraduate students were diagnosed with depression as the primary diagnosis (Braider et al., 2019). Comorbidity between major depression and other disorders is also common. Depressive disorders were increasingly common as the number of comorbid disorders increased in first year undergraduate students (Auerbach et al., 2019). Depressive symptoms co-occurred with insomnia symptoms around 29% (Gress-Smith et al., 2015), and anxiety symptoms around 33% in undergraduates (Bitsika & Sharpley, 2012). Therefore, college students are a population particularly vulnerable to depression.

Depression is a heterogeneous disorder (Goldberg, 2011). The variety of individual presentations of major depressive disorder (MDD) is due to the number of possible symptoms (9) and the minimum number of required symptoms to meet criteria for a major depressive episode (5) (American Psychiatric Association, 2013). Aside from one of the two required symptoms (i.e., depressed mood or anhedonia), there are eight other possible symptoms available to meet the symptoms threshold for diagnosis. However, the heterogeneity of depressive disorders is further complicated by a multitude of subtypes that emerge through specifiers. Specifiers include variation in onset (e.g., peripartum, seasonal pattern) as well as the co-occurrence of psychotic and related symptoms (i.e., with catatonia), anxiety related symptoms (i.e., with anxious distress), and (hypo)manic symptoms (i.e., with mixed features). Specifiers also contain subtypes with symptoms unique to MDD and included: with melancholic features and with atypical features. Therefore, when examining depression, there is utility in examining specific symptoms because the symptom profile can vary widely among individuals experiencing major depressive disorder.

Two cardinal symptoms of depression required to diagnose a major depressive episode are depressed mood and/or anhedonia (American Psychiatric Association, 2013). Both symptoms are highly prevalent in cases of major depressive disorder (Buckner et al., 2008; Sharpley et al., 2017), but varies by population. For example, 54% of Spanish college students meeting criteria for MDD reported anhedonia (Vázquez & Blanco, 2008) while only 9% of healthy Chinese college students reported clinically significant anhedonia across three years (Yang et al., 2020). However, rather than one of many symptoms, anhedonia is implicated as a specific etiological process for depressive disorders (Clark & Watson, 1991). For example, behavioral theories of depression focus explicitly on how the schedule and salience of environmental rewards and punishment relate to both the development and maintenance of depression (e.g., Abramson et al., 1978; Dimidjian et al., 2011; Lewinsohn, 1974). Additionally, the emotion context insensitivity model suggests that anhedonia plays a strong etiological role in depression as individuals have blunted emotional reactivity to both aversive and pleasant stimuli (Benning & Oumeziane, 2017; Rottenberg et al., 2005). For episodes of depression, the presence of anhedonia is associated with worse outcomes than for episodes without anhedonia such as: poorer response to antidepressant treatment (McMakin et al., 2012), a more chronic course (Wilcox & Anthony, 2004), heightened illness severity, higher number of past depressive episodes, and increased suicidality (Gabbay et al., 2015), and higher risk for future recurrence (Wardenaar et al. 2012). Therefore, anhedonia may be a particularly salient symptom to consider in the development, maintenance, and sequelae of depressive disorders.

Anhedonia is linked to more basic reward processing by considering separate aspects anhedonia -- consummatory and motivational. Consummatory anhedonia is the reduced pleasurable experience from receipt of a reward. Consummatory anhedonia is the hedonic impact of a reward and is similar to the "liking" component of reward processing (Treadway & Zald, 2011). Liking is the amount of pleasure or positive emotions elicited from something rewarding (Berridge et al., 2009). Motivational anhedonia is the reduced motivation for rewards and is similar to the "wanting" component of reward processing (Treadway & Zald, 2011). Wanting is the subjective desire, internal cravings, and anticipation toward rewarding things (Berridge & Robinson, 2003). Theoretically, motivational and consummatory anhedonia are separate processes linked to separate parts of the reward processing pathway. For example, one could display deficits in motivational anhedonia that reduces the drive to seek a reward but when a reward is presented, the reward is enjoyed. Conversely, one could also have a drive for reward but when the reward is presented, the reward is not enjoyed. However, these reward processing pathways are interactive and mutually reinforcing (Berridge & Robinson, 2003). In reality, liking and wanting interact and support each other except when specific damage to only part of one pathway occurs in animal models (Pool et al., 2016). Therefore, anhedonia in humans must be considered from a multidimensional perspective in which deficits in consummation of rewards or motivation for rewards might be present.

Consummatory anhedonia is often measured through different tasks that use subjective ratings, and neural or physiological activity in reaction to positive stimuli. Individuals with depression report fewer positive emotions and have reduced physiological activity relative to healthy controls (Bylsma et al., 2008). Consummatory anhedonia can also be measured behaviorally through facial expressions. Facial expressions are a behavioral measure of hedonic impact (Berridge & Robinson, 2003). Individuals with depression are predicted to have fewer positive facial responses to positive stimuli compared to individuals without depression. Individuals with depression displayed less frequent positive facial expressions to pleasant images or video clips (Berenbaum & Oltmanns, 1992; Renneberg et al., 2005; Sloan et al., 2001; Tsai et al., 2003), imagined pleasurable situations (Gehricke & Shapiro, 2000) and sweet tasting liquids (Berenbaum & Oltmanns, 1992) compared to individuals without depression. Others have found no difference between depressed and non-depressed individuals in positive facial expressions

(Chentsova-Dutton et al., 2007; Rottenberg et al., 2002) or increased positive facial reactions in individuals with depression compared to non-depressed (Rottenberg et al., 2005). In summary, individuals with depression demonstrate deficits in consummatory pleasure across methods of assessment such as self-report and behavioral measures.

Motivational anhedonia is the reduced desire or motivation to seek after pleasurable things. Self-reported arousal to positive images has been used as a measure of reward motivation (Byrne & Murray, 2017). Self-reported ratings of arousal in response to positive and negative images are associated with physiological measures of arousal (e.g., increased pupillary response and skin conductance levels; Bradley et al., 2001; Bradley et al., 2008). Reduced self-reported arousal to positive images may then indicate motivational anhedonia though reduced physiological activation to engage in reward seeking behavior. As expected, individuals with depression rated positive images as less arousing (Sloan et al., 1997; Sloan et al., 2001) suggesting motivational anhedonia. However, self-reported arousal ratings are distal to reward processing. Arousal is a broad term and does not necessarily indicate cognitive desires for the stimuli. Self-reported arousal and physiological activity covarying together in response to positive images does not necessarily mean wanting behavior is indicated. For example, self-reported arousal could indicate a self-assessment of physiological sensations experience in response to the positive stimuli that may be wholly independent of the cognitive desire for the stimuli. An individual could subjectively report certain wants but behave in a contradictory fashion. Therefore, more proximal measures are needed to better understand the effect of motivational anhedonia.

One proximal measure of wanting is reward seeking. Reward seeking is the behavioral manifestation of wanting, or the observable behaviors engaged in as a measurement of reward motivation (Berridge & Robinson, 1998). Engagement or disengagement with the rewarding stimuli can be directly observed based on the individual's behavioral responses. Reward seeking could include the amount of effort expended or the selection of rewards immediately or at a later time. Therefore, measuring motivational anhedonia via instruments that measure reward seeking might result in a closer link to the wanting component of reward processing.

Tasks use effort as a metric of reward seeking. For example, reward seeking can be measured via the number of button presses (i.e., effort) a participant will engage in to earn monetary rewards (Treadway et al., 2009) or through force exerted on grip strength (Clery-Melin et al., 2011). Self-reported anhedonia and increased depressive symptoms were negatively associated with effort in these paradigms (Cléry-Melin et al., 2011; Treadway et al., 2009; Treadway et al., 2012; Yang et al. 2014). When using humorous images as a reward, the extent to which images were rated as pleasurable predicted the amount of effort expended in healthy controls, but not in individuals with depression (Sherdell et al., 2012). However, reward seeking can be measured through other methods. When measuring reward seeking based on decision-making of small, immediate rewards and large, delayed rewards, individuals with depression consistently chose to take an immediate reward rather than a larger delayed reward (Pulcu et al., 2014; Takahashi et al., 2011) suggesting a lack of valuation of future rewards. Therefore, reward seeking measured via effort and delayed discounting is attenuated in individuals diagnosed with depression or report depressive and anhedonic symptoms.

Risk-taking tasks have also been used as a metric of reward seeking. For example, the number of pumps selected on a balloon to earn points despite the possibility of the balloon popping has been used for assessing reward seeking (e.g., Byrne & Murray, 2017) due to a positive relationship between the risk-taking task and BOLD signals related to reward motivation (i.e., fMRI recorded activity in reward-related brain regions; Rao et al., 2008). However, risk taking is not synonymous with reward motivation. Beyond the possibility of rewards, risk-taking includes the possibility of loss (i.e., punishment; Beyth-Marom et al., 1993). Risk-taking likely consists of inequities in both cognitive control systems (e.g., premeditation, fearlessness, impulsivity) and reward seeking (Harden et al., 2017). Additionally, the positive relationship between risk-taking behavior and other adjacent measures of reward motivation, such as positive affect (PA) are not always supported. Two risk taking tasks were not related to PA but were related to measures related to distal measures of punishment (i.e., negative affect; Koscielniak et al., 2016; Suhr & Tsanadis, 2007). Negative affect may be more related to risk taking than PA due to the strong influence of punishment when considering risky choices. Additionally, increases in PA were associated with reduced risk-taking behavior (Juergensen et al., 2018). PA's relationship may depend on the salience of the perceived potential negative consequences (Nygren, 1998). Therefore, the relationship between risk taking and reward motivation is unclear and requires accounting for additional factors, including cognitive control and punishment, to get a more proximal measure of reward seeking.

Depressive symptoms are associated with self-endorsed real-world risky behavior. Specifically in adolescents and young adults, depressive symptoms have a positive relationship with health-related risky behavior (Testa, & Steinberg, 2010), including the use of tobacco (Brooks et al., 2002; Fergusson et al., 2003), substances (Bannink et al., 2015; Hooshmand et al., 2012), and not using birth control (Brooks et al., 2002). However, the association between depressive symptoms and risky behavior is generally not maintained in studies utilizing behavioral tasks. Some studies have identified reduced risk-taking in individuals with more depressive symptoms (Hevey et al., 2009; Pietromonaco & Rook, 1987) or who were currently depressed (Hevey et al., 2017; Smoski et al., 2008). In contrast, vast majority of results find self-reported depressive symptoms (Dean et al., 2011; Loman et al., 2014; Pleskac et al., 2008; Qu et al., 2016) and lifetime history of a depressive episode (Huggins et al., 2019) to not be associated with risk-taking performance as measured on the Balloon Analogue Risk Task (BART; Lejuez et al., 2002). Additionally, self-reported symptoms of depression were unrelated to other behavioral measures of risk-taking (Pailing & Reniers, 2018; Panno et al., 2018). One possible explanation is that anhedonia may be driving deficits in risk taking behavior and not depression more generally. In studies of depressive symptoms, anhedonia may be poorly measured or not present in analog samples. If many samples lacked individuals with any anhedonic symptoms, then the driving factor for reduced reward seeking would be absent. Many of the aforementioned studies assessed depression through measures that only assess anhedonia through one or two items. Therefore, the effect of motivational anhedonia in the context of depression is readily seen in the context of effort and reward valuation but may be harder to detect in studies that measure risk-taking due to limitations of measures used to assess.

Positive Affect

Affect is conceptually similar to emotion, but distinct in several ways. First, affect is the broad underlying state that when triggered in response to specific things can be interpreted as an emotion (Fredrickson, 2001; Russell, 2003). Second, some emotions may form discrete categories (e.g., happy, sad, fear), while affect is typically conceptualized as varying across three dimensions: valence (e.g., Tellegen, Watson, & Clark, 1999), arousal (e.g., Russell & Barratt, 1999) and motivation (e.g., Harmon-Jones, Gable, & Price, 2013). Third, the components of emotions are multifaceted and includes physiological changes, facial expressions, and subjective experience; in contrast, affect is a broader description of the available feelings an individual has

(Fredrickson, 2001). However, PA is used as both a measure of valenced affect and as a subjective measure of reward motivation. As consumption of rewards trigger positive emotion (i.e., liking), positive affect (PA; i.e., high pleasantness and activation or high positive activation) is implicated in motivated behavior (i.e., wanting) and may prompt engagement with the environment (Fredrickson, 2001). PA is associated with reward-related brain areas (e.g., nucleus accumbens; Knutson et al., 2014) and self-reported reward sensitivity as a distal measure of the internal behavioral approach system (Carver & White, 1994; Erdle & Rushton, 2010; Gable, Reis, & Elliot, 2000; Jorm et al., 1998). Thus, PA is a subjective emotional state that may promote reward-related activity within the environment.

Diurnal Variation in Reward Processing and Depression

Many physiological processes follow a daily rhythm. Circadian rhythms, mediated by the suprachiasmatic nucleus and light exposure, regulate many physiological fluctuations such as hormone production (e.g., cortisol, melatonin) and body temperature. However, the influence of circadian rhythms is not limited to biologically based processes. Psychological processes such as attention (Fimm et al., 2016; Valdez et al., 2005; Valdez et al., 2010), alertness (Kraemer et al., 2000; Posner, 2008; Valdez et al., 2005), and aspects of reward processing (Byrne & Murray, 2017; Clark et al., 1989) also vary throughout the day suggesting a sleep-wake or circadian effect. For example, attention is optimal in the late morning and decreases in the early to mid-afternoon (Åkerstedt et al., 2004) while reward seeking and arousal increases from the morning to the mid-afternoon then decreases in the evening (Byrne & Murray, 2017). Therefore, the influence of circadian rhythm extends beyond purely biological processes to psychological processes.

PA is a distal measure of the wanting (i.e., motivation) facet of reward processing (Byrne & Murray, 2017; Knutson et al., 2014; Murray et al., 2009). In naturalistic settings, PA demonstrates a diurnal pattern such that PA increases during the morning and early afternoon to a mid-afternoon peak, and then decreases into the evening (Bower et al., 2010; Byrne & Murray, 2017; Clark et al., 1989; Miller et al., 2015; Murray, 2007; Peeters et al., 2006; Thayer, Takahashi, & Pauli, 1988; Watson et al., 1999). While ecologically valid, measuring affect in daily life is not a strong measure of circadian rhythm because diurnal rhythm might be because one's circadian rhythm, sleep-wake cycle, or environmental cues. One solution to differentiating circadian rhythm from sleep-wake cycle is to use a 27-hour constant routine protocol in which a person stays awake in a controlled environment for 27 hours so that only circadian rhythm is at play. In constant routine protocols, self-reported PA demonstrated the same rhythm of increasing in the morning, peaking in the mid-afternoon, and declining into the evening as defined by one's circadian rhythm (e.g., body temperature; Murray et al., 2002; Murray et al., 2009). Another solution to parse apart circadian rhythm from the sleep-wake cycle is to use a 28-hour forced desynchrony protocol such that individuals are awake for about 19 hours and sleep for nine hours consistently for a week and assessing the circadian pattern. In a forced desynchrony protocol, rather than following the rhythm of the new sleep-wake cycle, self-reported PA demonstrated the same rhythm of increasing in the morning, peaking in the mid-afternoon, and declining into the evening that was established by biological markers of circadian rhythm (e.g., body temperature, heart rate). Therefore, a distal measure of reward (i.e., PA) follows a diurnal rhythm that strongly linked to circadian rhythm.

In healthy controls, PA is associated with circadian rhythm. This link is conserved in individuals with major depression (Peeters et al., 2006) and elevated depressive symptoms

(Murray, 2007). Individuals with depressive symptoms have a blunted positive emotion peak and the peak may occur later in the day compared individuals with fewer or no depressive symptoms (Peeters et al., 2006; Murray, 2007). Positive affect varies as a function of the severity of depressive symptoms with individuals with more severe depressive symptoms having less PA overall and a later, blunted peak in PA. However, negative affect does not demonstrate a diurnal rhythm in individuals with or without depression (Peeters et al., 2006; Murray, 2007). Negative affect occurs in response to environmental triggers rather than endogenous factors. Therefore, diurnal variation in reward motivation for both healthy and depressed individuals is likely specific to rewards (i.e., PA).

Reward seeking is typically measured more directly via behavioral tasks than distally with self-report. Behavioral tasks may allow for aspects of anhedonia (e.g., consummatory/liking, motivational/wanting) to be measured more proximally. Wanting as measured as self-reported arousal to pleasant images and the ABART (Pleskac et al., 2008) demonstrated an increase from morning to afternoon followed by a decrease in the evening (Byrne & Murray, 2017). However, liking demonstrated an inconsistent diurnal pattern. Liking measured via self-reported state positive emotions increased from morning to afternoon to evening without a clear peak (Byrne & Murray, 2017). Liking as measured by cued pleasantness ratings of images did not change throughout the day (Byrne & Murray, 2017). Therefore, the diurnal variation in reward seeking is demonstrated most strongly via measures of wanting (i.e., motivational anhedonia) and less strongly through measures of liking (i.e., consummatory anhedonia).

Clinical Implications of Diurnal Rhythm in Depression

Of the subtypes of depression, MDD with melancholic features has cardinal symptoms most strongly related to anhedonia, including severe consummatory anhedonia with primary (i.e., lack of reactivity to pleasurable stimuli) and/or secondary rewards (i.e., pleasure in all or almost all activities; American Psychiatric Association, 2013). Other unique features include depressed mood characterized by despair or emptiness and a worse mood in the mornings compared to the rest of the day. However, individuals with MDD without melancholic features (Peeters et al., 2006), healthy individuals who report a high degree of depressive symptoms (Murray, 2007), and healthy individuals (Clark et al., 1989) without an MDD diagnosis (Peeters et al., 2006) or low self-reported depressive symptoms (Murray, 2007) also display worse mood in the mornings that improved as the day progressed. Experiencing worse mood in the morning does not differentiate MDD with and without melancholia (Martino et al., 2019). Therefore, positive mood variation as manifested by worse mood in the morning may be a typical pattern expected in all individuals with or without depression and may not be a unique symptom for differentiating melancholic features in MDD.

Behavioral Activation (BA) is an evidence-based treatment for depression (Dimidjian, Martell, Herman-Dunn, & Hubley, 2014) that addresses etiology implicated in the development of anhedonia (Abramson et al., 1978; Dimidjian et al., 2011; Lewinsohn, 1974). The purpose of BA for depression is to orient the individual toward how depression affects their behavior which leads to changes in mood, thoughts and other behaviors (Lejuez et al., 2011). An individual tracks their daily activities each week and rates the pleasure and importance of each activity. Through tracking, the individual recognizes the link between mood and behaviors. Symptoms are alleviated by engaging in regular positive activities that fit within areas of life that are important and align with an individual’s values. The activities begin to provide a sense of accomplishment and pleasure that make it difficult to concurrently feel depressed (Lejuez et al., 2011). However, BA could potentially be enhanced by using the findings and methodology used in diurnal mood studies, particularly with individuals endorsing depressive symptoms. As affect improves over the course of the day, it might be possible to target pleasant activity scheduling in the morning to increase the impact of the mood boost. Therefore, the pattern of diurnal variation in PA and reward seeking could inform general principles of positive activities engagement within BA treatment.

Chapter 2: Purpose of Present Study

Reward processing, particularly self-reported PA (Bower et al., 2010; Clark et al., 1989; Miller et al., 2015; Murray et al., 2002; Murray, 2007; Murray et al., 2009; Peeters et al., 2006; Watson et al., 1999), self-reported arousal (Byrne & Murray, 2017; Thayer et al., 1988), and reward-seeking (Byne & Murray, 2017), demonstrate a diurnal rhythm that is likely linked to circadian rhythm. However, it is unclear the extent the diurnal variation generalizes behaviorally. The diurnal effects of reward seeking have only been examined using one behavioral task (Byrne & Murray, 2017). Other measures of reward seeking are needed to assess the scope and limitations of diurnal variation in reward seeking. Additionally, diurnal effects of wanting have not been examined as a between-subjects factor and thus the strength of this effect between individuals is unknown. Body temperature explained 25% of the variance in the diurnal variation in PA (Murray et al., 2009), but it is unclear if this effect is strong enough to be detected across individuals at different times of the day. Furthermore, while depressive symptoms (Murray, 2007) and diagnosis (Peeters et al., 2006) alter the phase and overall height of the diurnal pattern in self-reported PA, the impact of depression on diurnal reward seeking has not yet been examined. From a theoretical perspective, alterations in anhedonia are likely linking depression and blunted reward processing. Therefore, the purpose of this study was to expand previous findings indicating reward seeking following a diurnal cycle, assessing whether depressive symptoms alter the diurnal pattern, and whether anhedonia is a stronger moderator of the diurnal pattern than depressive symptoms generally.

Aims and Hypotheses

Aim 1. Examine whether reward seeking follows a diurnal cycle.

Hypothesis 1. I hypothesized that reward seeking will display a quadratic relationship with time of day such that performance will increase from morning to early afternoon with a peak in the early afternoon and decline in the late afternoon.

Aim 2. Examine whether anhedonia or depressive symptoms generally are a stronger predictor of reward seeking.

Hypothesis 2. I hypothesized that both depression and anhedonia will have a negative relationship with reward seeking such that as depressive or anhedonia symptoms increase, reward seeking will decrease.

Hypothesis 3. I hypothesized that anhedonia will have a stronger negative association than overall depression.

Aim 3. Examine whether depression and anhedonia moderate the diurnal relationship between reward seeking and time of day.

Hypothesis 4. I hypothesized that depression and anhedonia will both moderate the diurnal cycle of reward seeking. As depressive or anhedonic symptoms increase, I predict that the amplitude of reward seeking will be reduced and have a later peak.

Hypothesis 5. I hypothesized that anhedonia will be a significantly stronger moderator than depressive symptoms more generally.

Chapter 3: Method

Participants

Table 1 reports the demographic characteristics of the participants in this study. Participants consisted of undergraduate students 18 years or older recruited from a large, urban university in the southwest United States. Participants received 3 SONA research credits for participating in the study.

Measures

Balloon Analogue Risk Task (BART; Lejuez et al., 2002)

The BART assessed reward seeking. The BART consists of 90 trials. On each trial, participants are presented with their total score, the previous round score, the number of points earned on the current trial, and one of three different colored balloons. Balloons are blue, green, or red and each color is associated with a different range of popping probability (1 in 8, 1 in 32, & 1 in 128, respectively). The different colored balloons are presented in random order with 30 trials of each. Participants are instructed to earn points by pumping up the balloon. Participants choose to pump up the balloon and earn 5 points as many times as desired or to bank earnings for that trial and add the accrued points to the total score. Each balloon has a popping point that is identified as a random number between 1 and the trial type maximum (8, 32, or 128). If the participant pumps the balloon above the popping point, then the balloon pops to indicate the end of the trial and all points on the trial are lost. At the end of the task, participants are informed of their overall score. The outcome variable was the number of pumps on unpopped trials for the red balloon (i.e., lowest popping probability) because this allowed for the greatest variability in individually determined reward seeking as the participant chose when to stop and save points rather than the task.

Test-retest reliability for the BART varies considerable by the length of time between administrations. Test-retest reliability is good over one-week (r = .79; Weafer et al., 2013) and three-week (r = .66–.78; Buelow & Barnhart, 2017; White et al., 2008; Xu et al., 2013) test periods. Extended test periods indicate reasonable test-retest reliabilities during a developmentally sensitive window (i.e., puberty). Test-retest reliability ranged from .49 to .75 for one year, .38 to .65 for two years, .35 to .58 for three years, and .33 for four years (Collado et al., 2014).

Columbia Card Task (CCT; Figner et al., 2009)

The CCT also assessed reward seeking. Unlike the BART, the CCT distinguishes the decision-making related to reward seeking into a “hot” and a “cold” process. Participants are presented with thirty-two cards. Participants earn points by flipping over cards. Cards can be either gain cards or loss cards. Gain cards increase the score while loss cards decrease the score. Gain cards, loss cards, and the number of loss cards vary by trial. Participants are shown how much gain cards are worth (10, 20, or 30 points), how much loss cards are worth (250, 500, or 750 points), and the number of loss cards (1, 2, or 3 cards). If a loss card is selected, the trial ends and the next trial starts. Trials were programmed such that the loss cards were always among the final cards of the trial (e.g., if 3 loss cards then 30th card flipped over would result in a loss). There are 54 scoring trials consisting of two times the full crossing of three different gain cards by three different win amounts by three different loss amounts.

To measure a “hot” reward seeking process imbued with affect, participants flipped one card over at a time. On win trials, the card displayed a smiley face. On loss trials, a frowny face. An additional 9 dummy trials were randomly introduced into the 54 trials for a total of 63 trials. On the dummy trials, loss was randomly assigned to occur between the 2nd and 25th card turned over. Participants could stop flipping over cards at any time on all trials. To measure a "cold" reward seeking process decontextualized from affect, participants were presented with the 32 face down cards 54 times. Instead of flipping over cards individually, participants selected the number of cards they would like to flip over for each trial. Participants did not receive feedback. As measured in previous studies (e.g., Buelow, 2015; Buelow & Blaine, 2015) the outcome variable was the number of cards flipped over on each winning trial in both the hot and cold versions of the CCT. A modified version of the cold version of the CCT had adequate test-retest reliability three weeks apart (r = .57; Buelow & Barnhart, 2017).

General Behavior Inventory (GBI; Depue et al., 1981; Depue et al., 1989)

The GBI assessed depressive features and associated characteristics. The GBI consists of 73 self-report items measuring manic, depressive, and mixed mood features and characteristics. Items were rated on a 4-point Likert scale: 0 (*Never - Hardly Never)*, 1 (*Sometimes*), 2 (*Often*), and 3 (*Very Often - Almost Constantly*). Of the 73 items, 46 can be summed to measure depression where higher scores represent more severe depression (possible range 0 – 138). The GBI has good content validity (Depue et al., 1981), construct validity (Depue et al., 1981), discriminative validity (Danielson et al., 2003; Depue et al., 1981; Mallon et al.,1986; Klein et al., 1989; Pendergast et al., 2014), excellent internal consistency (.90-.96; Depue et al., 1989) including the depression subscale (α = .96; Pendergast et al., 2014), and acceptable test-retest reliability over 15 weeks (r = .73; Depue et al., 1981).

Additionally, items 9, 10, 13, and 70 have been combined into a parcel with overlapping content around losing interest or enjoyment in pleasurable things with adequate (α = .64; Danielson et al., 2003; Youngstrom et al., 2001) to acceptable (α = .76; Pendergast et al., 2015) internal consistency. However, other item content can be conceptualized within anhedonia, such as lack of enjoyment in life (item 16) and reduced or lack of emotions and connection with others (item 49). Therefore, an anhedonia subscale can be created from the GBI that consists of 6 items (9, 10, 13, 16, 49, and 70) with a range of 0 – 18. Preliminary reliability analysis indicated the constructed anhedonia subscale had acceptable internal consistency ($\alpha = .78$, 95% CI [.76, .80]). To reduce multicollinearity, items on the anhedonia scale will not be included on the depression scale, thus the total number of items on the depression scale will be 40 (range = 0 – 120).

Self-Assessment Manikin (SAM; Hodes et al., 1985; Lang 1980)

The SAM assessed positive affect. Based on the three-factor theory of affect (Russell & Mehrabian, 1977), the SAM uses an image-based, nine-point continuous scale to measure in-the-moment emotional responses across three dimensions: emotional valence (i.e., happy-unhappy), level of arousal (i.e., excited-calm), and level of dominance (control versus in-control). For the emotional valence scale, the SAM figures range from a smiling, happy figure to a frowning, unhappy figure. For the level of arousal scale, the SAM spans figures with eyes closed and a tired expression to eyes open with an excited expression. For the level of dominance scale, the SAM figures vary from a small figure representing feeling submissive and/or controlled to a large figure to represent feeling powerful, strong, and/or in-control (Morris, 1995). The outcome variable was emotional valance ratings at each time point such that higher scores indicate more negative affect and lower score indicate more positive affect.

Time of Day

Time of day was assessed through task completion timestamps on the BART, CCT-H, and CCT-C for each respective participant. Task completion ranged from approximately 9:00 am to 5:00 pm.

Pittsburgh Sleep Quality Inventory (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989)

Time awake was assessed using the PSQI. Participants' reported their usual awakening time in the last month. Usual awakening time was then subtracted from the respective timestamp of the behavioral tasks to derive the usual number of hours awake to establish an approximation of participants' sleep cycle.

Morningness-Eveningness Questionnaire (MEQ; Horne & Östberg, 1976)

Participants' time of day preference for sleep and awakenings was assessed using the MEQ. Participants' self-reported responses indicate three possible chronotypes: morning types (i.e., early birds), evening types, (i.e., night owls), and intermediate types. The MEQ has acceptable (α = .77; Lee et al., 2014) to good internal consistency (; α = .83-.84, Adan & Natale, 2002; α = .86, Treven Pišljar et al., 2019) in diverse samples, good split-half reliability (.80; Adan & Natale, 2002) and excellent test-retest reliability over two weeks (ICC = .96; Treven Pišljar et al., 2019 and four weeks (ICC = .90; Lee et al., 2014). Preliminary reliability analysis indicated the MEQ had acceptable internal consistency (α = .79, 95% CI [.76, .81]).

Research Design

Data Collection and Study Design

The data was collected from a larger study on irritability, distress, and internalizing symptoms that took participants approximately 2.5 – 3.0 hours to complete. Participants always completed the GBI at the beginning of the session. The PSQI and MEQ were randomly assigned to be completed either in the middle or near the end of the session. The SAM was complete at the end of the first questionnaire battery and at the beginning and end of each subsequent questionnaire battery. The CCT-C was randomly assigned to either be the first or last task the participant completed. The CCT-H and the BART were randomly assigned such that one was given early in the session and the other was given late in the session. Participants completed other questionnaires and behavioral tasks between the administration of the questionnaires and behavioral tasks which were the focus of the current study.

Procedure

Participants self-selected into either a morning (9 a.m. to 12 p.m.) or afternoon (1:30 p.m. to 4:30 p.m.) session. A single study session lasted approximated 3 hours. Participants completed a series of questionnaires and behavioral tasks on the computer that measured their mood and risky behaviors. Research assistants trained in the research protocol guided participants through the consent process and study procedures. Participation was voluntary, and participants reserved the right to withdraw from the study procedures at any point throughout the process.

Chapter 4: Analytic Plan

Primary analyses were conducted using R (R Core Team, 2013). The primary dependent variables were reward seeking from the CCT-H and BART. Reward seeking on the CCT-H was operationalized as the mean number of cards flipped over on win trials. Reward seeking on the BART was operationalized as the mean number of pumps on unpopped red balloon trials (i.e., trials with a 1 in 128 risk of popping). Secondary dependent variables were reward seeking from the CCT-C, high-reward-low-loss reward seeking on the CCT-H and CCT-H, and PA from the SAM. Reward seeking on the CCT-C was operationalized as the mean number of cards flipped over on win trials and was an exploratory dependent variable. The CCT-C assesses deliberate reward seeking behavior without affective components. Theory is unclear if the same pattern is expected as with the CCT-H and thus analysis with the CCT-C was exploratory. High reward-low-loss reward seeking on the CCT-H and CCT-C was defined as the mean number cards flipped over on trials with the most reward (i.e., 30 points earned per card) and least punishment (i.e., 250 points lost on loss cards) and was an exploratory variable. Due to the potential influence of punishment on reward seeking, modified reward seeking attempted to parse out the influence of punishment as much as possible and was exploratory. PA on the SAM was defined as the sum of the pleasantness and arousal scales at each respective time point and was an exploratory dependent variable. The use of PA serves as a manipulation check to assess whether the previously found effect of diurnal variable in mood holds in the current sample.

The covariates were gender and age. Gender was dummy coded with female as the reference category. Race and ethnicity were included as a covariate in exploratory analyses to assess for any influence not accounted for by other covariates. Race was dummy coded with Asian as the reference category. Ethnicity was dummy coded with Latinx/Hispanic as the reference category. The independent variables were the depression and anhedonia scores on the GBI, time of day as assessed by the time of completion for both versions of the CCT and start time for the BART, endorsed time of awakening over the last month on the PSQI, hours awake as assessed by subtracting endorsed time of awakening over the last month from time of day on each behavioral task, and chronotype as assessed on the MEQ.

First, all data were screened for missing and out of range values using univariate statistics (e.g., for continuous variables: mean, median, mode, and standard deviation; for categorical variables: frequency tables). Missing or out of range data on the covariates or independent variables were listwise excluded such that entire cases were removed if any of the values were missing or out of range. Missing or out of range data on the primary and secondary dependent variables were pairwise excluded such that analyses were conducted with differing available data for each dependent variable. For example, analyses with a primary dependent variable (e.g., CCT-H) included all available cases and were not matched to the available cases of another dependent variable with fewer available cases (e.g., the BART). The reason for this is that since the BART was introduced mid-way through the study protocol, BART analyses by definition excluded approximately 54% of the total participants. Due to missing data, CCT-H and CCT-C analyses excluded approximately 14% and 20% of the total participants, respectively. Missing data was due to task failure, experimenter error, or participants skipping certain questions, questionnaires, or tasks.

Second, data was screened for low effort. Questionnaire data was assessed for straight-line responding. Straight-line responding refers to excessively selecting the same response option throughout a series of questions on questionnaires, usually in an attempt to quickly finish the questionnaire. Participants' engagement was assessed by analyzing the response pattern of other non-essential questionnaires completed in the same questionnaire block as the GBI that utilize reverse scoring. Since questionnaires with reversed scored items often require the selection of a different response option for consistent endorsement within participants, observed straight-line responding on a questionnaire with reverse scored items (i.e., IDAS; Snaith et al., 1978) were criteria for excluding participants for low effort. Straight-line responding criteria was defined as selecting the same response option on 50% or more of all the items (i.e., 9 or more items on the IDAS). Only one participant met criteria for low effort responding on the IDAS and was removed from analyses. Low effort on behavioral tasks was assessed through mean response patterns. Low engagement on the behavioral tasks was defined as engaging in the task with a mean of approximately 5% or less of the possible responses for the task. Low engagement on the task represented consistent poor engagement across trials of the task and not any specific trial. Since the BART has 128 maximum possible pumps, if a participant has a mean engagement of approximately 5% or less (i.e., less than 7 pumps), then the participant was excluded. 26% of participants met criteria for low effort responding on the BART and were removed. Since either version of the CCT have 32 maximum cards that can be selected, if a participant had a mean engagement of approximately 5% or less (i.e., less than 2 cards), then the participant was excluded. 2% and 1% of participants met criteria for effort responding on the CCT-H and CCT-C and were removed, respectively.

Third, all continuous variables were evaluated for potential outliers at the univariate level (e.g., +- 3 standard deviations). If outliers were identified, then a sensitivity analysis was conducted that removed outliers and analyses were reran. If substantive findings did not change, the outliers were included in each model.

Fourth, preliminary bivariate analyses were conducted on the primary dependent variables measuring reward seeking (i.e., BART, CCT-H) and between the independent measures using Pearson's correlation. Additionally, using logistic regression, exploratory secondary analyses were conducted to identify whether chronotype had any influence on participants' self-selection into a morning or afternoon session.

Finally, a series of hierarchical regression were conducted on each dependent variable. In each set of analyses, depression, anhedonia, and time of day were mean-centered when performing the interaction between depression and time of day and anhedonia and time of day. We used two-tailed $\alpha = .05$ for significance testing. The assumptions of regression (e.g., homogeneity of variance, normality of residuals) were examined via a series of plots. In cases where assumptions were violated and the sensitivity analysis suggests differences in findings, robust regression was conducted using the r-package MASS (Venables & Ripley, 2002). Substantive findings did not change when using robust regression techniques. Thus, the original findings are presented. Transformations were conducted depending on the assumptions violated. For example, for heteroscedasticity of the residuals, using logarithmic or square-root transformations on the dependent variables was implemented. Substantive findings did not change when using transformation techniques. Thus, the original findings are presented.

To assess hypothesis 1, reward seeking will display a diurnal pattern, a series of separate hierarchical linear regression models were conducted for each dependent variable. The first step included the covariates gender, age, and race predicting reward seeking. The second step added the linear time of day component such that gender, age, race, and time of day are predicting reward seeking. The third step added time of day squared, such that gender, age, race, time of day, and time of day square are predicting reward seeking. Secondary/Exploratory analyses were conducted replicating the above models but utilizing hours awake instead of time of day. Sensitivity power analyses for two tailed, $\alpha = .05$, 80% power would detect a ΔR^2 of .01 for the CCT-H and CCT-C and ΔR^2 of .02 for the BART.

To further assess hypothesis 1, exploratory analyses with PA using multilevel modeling were conducted. Multilevel modeling is a statistical approach used to assess group or clustered data in which times of measurement vary between subjects (Buxton, 2008). Participants rated their PA times in a testing session, and data was nested within subjects (Level 1) and then between subjects (Level 2) using the using the r-package lme4 (Bates et al., 2014). Self-reported PA served as Level 1 predictors of time of day (i.e., five time points when SAM was completed by each participant). These analyses serve as a manipulation check to assess if the robust within-person changes are present in the current sample.

To assess hypothesis 2, reward seeking will have a negative relationship with depression and anhedonia, a series of separate hierarchical linear regression models were conducted for each dependent variable. The first step included the covariates gender, age, and race predicting reward seeking. The second step added depression as a predictor such that gender, age, race, and depression are predicting reward seeking. The third step added anhedonia as a predictor, such that gender, age, race, depression, and anhedonia are predicting reward seeking. Regression coefficient values were assessed to determine the relationship between depression, anhedonia, and reward seeking. Sensitivity power analyses for two tailed, $\alpha = .05$, 80% power would detect a ΔR^2 of .01 for the CCT-H and CCT-C and ΔR^2 of .02 for the BART.

To assess hypothesis 3, anhedonia will be a stronger predictor of reward seeking than other depressive symptoms, dominance analysis was used to identify whether anhedonia or overall depressive symptoms are a stronger predictor of reward seeking (Budescu, 1993; Azen &

Budescu, 2003) using the r-package dominanceanlaysis (Bustos & Soares, 2019). Briefly, dominance analysis starts by selecting pairs of predictors to compare. Changes in R^2 attributable to each predictor across every possible subset of the remaining variables is calculated. The predictor with the greatest ΔR^2 is considered the "dominant" predictor. Thus, gender, age, and race were covariates, depression and anhedonia were predictors being compared and reward seeking will be the dependent variable. Depression and anhedonia was iteratively included at every possible step with and without all other covariates to predict reward seeking. Exploratory analyses were conducted replicating the above models but utilizing hours awake instead of time of day. Sensitivity power analyses for two tailed, $\alpha = .05$, 80% power would detect a ΔR^2 of .01 for the CCT-H and CCT-C and ΔR^2 of .02 for the BART.

To assess hypothesis 4, anhedonia and depression will be a moderating effect on the diurnal relationship between reward seeking and time of day, a series of separate hierarchical linear regression models were conducted for each dependent variable. The first step included the covariates gender, age, and race predicting reward seeking. The second step added the predictors time of day, squared time of day, depression, and anhedonia such that gender, age, race, time of day, time of day squared, depression, and anhedonia are predicting reward seeking. The third step added the interaction terms between time of day squared and depression and time of day squared and anhedonia such that gender, age, race, time of day, time of day squared, depression, anhedonia, the interaction between time of day squared and depression, and the interaction between time of day squared and anhedonia are predicting reward seeking. Sensitivity power analyses for two tailed, $\alpha = .05$, 80% power would detect a ΔR^2 of .01 for the CCT-H and CCT-C and ΔR^2 of .02 for the BART.

To assess hypothesis 5, anhedonia will have a stronger moderating effect on reward seeking compared to depression, dominance analysis was conducted. The covariates included gender, age, and race. The independent variables included time of day, time of day squared, depression, and anhedonia. The interactions included time of day squared by depression and time of day squared by anhedonia. Dominance analysis was conducted by selecting the interactions of time of squared by depression and time of day squared by anhedonia and iteratively selecting each interaction at every possible step to assess for the larger overall contributor to variance in predicting reward seeking. Sensitivity power analyses for two tailed, $\alpha = .05$, 80% power would detect a ΔR^2 of .01 for the CCT-H and CCT-C and ΔR^2 of .02 for the BART.

Chapter 5: Results

Preliminary Analyses

Table 2 reports the bivariate Pearson correlations among the primary independent variables and each reward-seeking behavioral task. Depressive symptoms and anhedonia were strongly positively associated. Depressive symptoms and anhedonia were not significantly associated with time of day or reward seeking on the CCT-C or CCT-H. However, depressive symptoms and anhedonia were weakly negatively associated with reward seeking on the BART. Time of day was weakly positively associated with reward seeking on the CCT-C, but not on the CCT-H or BART. The CCT-C was moderately positively associated with reward seeking on the CCT-H but was not associated with the BART. Reward seeking on the CCT-H was not associated with reward seeking on the BART. Exploratory analyses including the low effort responders mostly confirmed the confirmatory findings. The CCT-C and CCT-H were still moderately correlated ($r(356) = .34$, 95% CI [.27, .40], $p < .001$) and the BART and the CCT-C were not significantly associated with each other, r(356) = .09, 95% CI-.02, .19], $p = .10$. In contrast to the confirmatory analyses, the exploratory analyses indicated a weak association between the BART and the CCT-H, $r(379) = .13$, 95% CI [.03, .23], $p < .01$. In summary, the BART is likely measuring a distinct, unrelated construct compared to both versions of the CCT and the CCT-H, while the CCT-H and CCT-C are measuring similar constructs.

Additional exploratory analyses examined whether chronotype or usual time awake had any influence on participants' enrollment in a morning or afternoon study session. After covarying age and gender, chronotype was not associated with the log-odds of participating in a morning or afternoon session, 95% CI [-.02, .02], $p = .69$. Results matched when considering chronotype as discreet categories (morning-type, 95% CI [-.59, .78], $p = .78$; intermediate-type, 95% CI [-.43, .36], $p = .85$). After covarying age and gender, usual awake time within the last month was not associated with the log-odds of participating in a morning or afternoon session, 95% CI [-.03, .18], $p = .18$. Therefore, chronotype and usual wake time in the past month had no influence on whether participants chose a morning or afternoon for the study.

H1: Time of Day and Reward-Seeking

I hypothesized that reward seeking will increase from morning to afternoon and then decrease in late afternoon. Table 3 and Figure 1 display the regression results for the CCT-C, CCT-H, and BART. After adjusting for participants' age and gender, performance on the CCT-C increased from the early morning to the late morning, declined in the early afternoon, and increased in the late afternoon. Exploratory analyses probed this pattern of results. Participants were assigned to complete the CCT-C first or last in the session. There were no significant differences in reward seeking between participants who completed the CCT-C first in the morning session ($M = 11.92$, $SD = 4.25$) and first in the afternoon session ($M = 11.80$, $SD = 4.54$; $t(311.55) = .25$, $p = .80$, Cohen's d = .03) or last in the morning ($M = 21.52$, $SD = 7.25$) and last in the afternoon ($M = 21.12$, $SD = 7.42$), $t(300.45) = .47$, $p = .64$, Cohen's d = .05. Reward seeking was significantly higher between early ($M = 11.92$, $SD = 4.25$) and late morning ($M = 21.52$, $SD = 7.25$; $t(226.32) = 13.56$, $p < .001$, Cohen's d = 1.61) and early ($M = 11.80$, $SD = 4.54$) and late afternoon ($M = 21.12$, $SD = 7.42$), $t(267.28) = 14.27$, $p < .001$, Cohen's d = 1.55. Additional exploratory analyses matched the aforementioned findings when restricting participant age range to 18 to 25-year-olds, including race and ethnicity as covariates, using a high-reward-low-loss measure of reward seeking, or removing outliers. However, when using hours awake as an alternative measure of diurnal variation, cubic trends were no longer significant. In summary, participants who completed the CCT-C later in their session engaged in more reward seeking relative to participants who completed earlier in their session regardless of time of day.

In contrast to the CCT-C, after covarying for participants' age and gender, time of day was not associated with reward seeking on the CCT-H. Additional exploratory analyses fit polynomial regressions to assess for higher order polynomial trends. Time of day was significantly associated with reward seeking on the CCT-H cubically. Figure 1b displays the cubic plot. Examination of the cubic plot did not yield an obvious curvilinear pattern. Additional exploratory analyses probed this pattern of results. Participants were assigned to complete the CCT-H first or third among the randomized behavioral tasks in the session. There were no significant differences in reward seeking between participants who completed the CCT-H first in the morning session (M = 23.60, SD = 7.02) and first in the afternoon session (M = 23.98, SD = 6.60; $t(297.54) = .51$, $p = .61$, Cohen's d = .06) or third in the morning (M = 25.04, SD = 5.29) and third in the afternoon (M = 24.20, SD = 6.38), $t(364.92) = 1.37$, $p = .17$, Cohen's d = .05. Among morning participants, reward seeking significantly increased for participants who completed the CCT-H third (M = 25.04, SD = 5.29) compared to participants who completed the CCT-H first (M = 23.60, SD = 7.02; $t(265.43) = 2.01$, $p < .05$, Cohen's d = .23). Among afternoon participants, there were no differences between participants who completed the CCT-H third (M = 23.98, SD = 6.60) and first (M = 24.20, SD = 6.38); $t(407.99) = .35$, $p = .73$, Cohen's d = .03). There were no significant differences when comparing participants who completed the CCT-H third in the morning (M = 25.04, SD = 5.29) to first in the afternoon (M = 23.98, SD = 6.60), $t(370.96) = 1.71$, $p = .09$, Cohen's d = .17. Additional exploratory analyses matched the aforementioned findings when restricting participant age range to 18 to 25-year-olds, including race and ethnicity as covariates, using a high-reward-low-loss measure of reward seeking.

However, the mean difference between early and late morning did not remain significant when removing outliers. When using hours awake as an alternative measure of diurnal variation, cubic trends were no longer significant. Exploratory analyses conducted including low effort responders matched the pattern of findings. In summary, participants who completed the CCT-H later in the morning were more reward-seeking than participants early in the morning and reward-seeking stabilized throughout the afternoon.

Adjusting for participants' age and gender, reward seeking on the BART was not associated with time of day. Exploratory analyses including low effort responders matched the pattern of findings. Additional exploratory analyses matched the aforementioned findings when restricting participant age range to 18 to 25-year-olds, including race and ethnicity as covariates, using a high-reward-low-loss measure of reward seeking, removing outliers or using time awake as an alternative for time of day. In summary, reward seeking on the BART did not vary significantly across the day.

Exploratory Analysis of SAM Affect Rating

A multilevel growth model examined self-reported affect across 5 time points in each session. A quadratic growth model interacting time of day (i.e., AM/PM) with only the linear time point and including both random intercepts and slopes was the best fitting model. As seen in Figure 2, affect ratings increased and became more unhappy across the first four assessments and then decreased and became happier during the last affect rating, $b_{time} = .39$, 95% CI [.32, .47], $b_{time}{}^2 = -.08$, 95% CI [-.09, -.06]. Affect ratings increased more rapidly and to a higher peak in the afternoon than in the morning, $b_{timeXtimeofday} = .06$, 95% CI [.02. .11]. A separate piecewise multilevel growth model confirmed the pattern of results.

H2: Reward Seeking's Association with Depressive and Anhedonic Symptoms

Depressive and anhedonic symptoms were predicted to be negatively associated with reward seeking. Table 4 presents the final hierarchical regression for the CCT-C, CCT-H, and BART. After covarying for age and gender, neither anhedonia nor depressive symptoms were significantly associated with reward seeking on the CCT-H or CCT-C. Exploratory analyses including low effort responders did not find an association between reward-seeking on the CCT-H or CCT-C and anhedonia or depressive symptoms separately or included in the same model. Additional exploratory analyses matched the aforementioned findings when restricting participant age range to 18 to 25-year-olds, including race and ethnicity as covariates, using a high-reward-low-loss measure of reward seeking, or removing outliers. In summary, self-reported depressive and anhedonic symptoms do not influence an individual to be more or less inclined to seek after rewards on the CCT-C or CCT-H.

After covarying for age and gender, when only anhedonia was added, anhedonia was significantly associated with reward seeking on the BART (b = -.42, 95% CI [-.81, -.03], β = -.12, ΔR^2 = .01). In contrast, when only depressive symptoms were added, depressive symptoms were not significantly associated with reward-seeking on the BART, b = -.06, 95% CI [-.13, .01], β = -.10, ΔR^2 = .01, p = .07. However, when including both anhedonia and depressive symptoms in the same linear model, neither anhedonia nor depressive symptoms were significantly associated with reward seeking on the BART, ΔR^2 = .01. A sensitivity analysis including low effort responders did not find a significant association with reward seeking on the BART when anhedonia alone was added, b = -.24, 95% CI [-.59, .12], β = -.06, ΔR^2 = .004, p = .20. Exploratory analysis using all depressive symptoms, including anhedonia, as a single score was not significantly associated with reward seeking on the BART, b = -.06, 95% CI [-.12, .00], β = -

.11, $\Delta R^2 = .01$, $p = .06$. Additional exploratory analyses restricting participant age range to 18 to 25-year-olds, including race and ethnicity as covariates, and removing outliers did not find an association between anhedonia alone and reward seeking on the BART. Therefore, anhedonia alone was associated with reward seeking on the BART but did not offer a unique contribution when adjusting for other depressive symptoms.

H3: Strength of Anhedonic and Depressive Symptoms as Predictors of Reward Seeking

I hypothesized that anhedonia will be a stronger predictor of reward seeking than depressive symptoms. Using dominance analysis, anhedonia and depression did not differ in importance on the CCT-C ($R^2 = .000$ and .000, respectively) or CCT-H ($R^2 = .002$ and .002, respectively). In contrast, anhedonia was a stronger predictor ($R^2 = .011$) compared to depression ($R^2 = .007$) for predicting reward seeking on the BART. Exploratory analyses including low effort responders, restricting participant age range to 18 to 25-year-olds, including race and ethnicity as covariates, using a high-reward-low-loss measure of reward seeking on the CCT-C and CCT-H, and removing outliers found no substantive difference in strength between anhedonia and depression on the CCT-C, CCT-H, and BART. Overall, anhedonia may be a slightly stronger predictor for reward seeking when measured via performance on the BART but not other measures of reward seeking on the CCT-C and CCT-H.

H4: Depression and Anhedonia's Effect on Diurnal Reward Seeking

Anhedonia and depression were predicted to moderate the quadratic effect of time of day on reward seeking. Table 5 displayed the final hierarchical regression results for the CCT-C, CCT-H, and BART. After covarying for age, gender, linear and quadratic time of day, neither depression nor anhedonia significantly moderated the quadratic relationship between time of day and the reward seeking on the CCT-C, CCT-H, or BART, or the cubic relationship between time of day and the reward seeking on the CCT-C, CCT-H. Exploratory analyses found no relationship between cubic time of day and depression after controlling for age, gender, linear, quadratic, and cubic time of day, and anhedonia on the CCT-C, or CCT-H. No association was found between cubic time of day and anhedonia after controlling for age, gender, linear, quadratic, and cubic time of day, and depression on the CCT-C, CCT-H, or BART. Exploratory analyses including low effort responders, restricting participant age range to 18 to 25-year-olds, including race and ethnicity as covariates, using a high-reward-low-loss measure of reward seeking on the CCT-C and CCT-H, and removing outliers matched the aforementioned findings. Therefore, anhedonia and depressive symptoms did not influence changes in reward seeking across the day.

H5: Strength of Anhedonia and Depression as Moderators of Diurnal Reward Seeking

I hypothesized that anhedonia would be a stronger moderator of time of day than depressive symptoms. Neither anhedonia nor depressive symptoms moderated the relationship between time of day and reward-seeking across tasks. Findings remained consistent when including low effort responders, restricting participant age range to 18 to 25-year-olds, including race and ethnicity as covariates, using a high-reward-low-loss measure of reward seeking on the CCT-C and CCT-H, or removing outliers. Therefore, neither anhedonia nor depressive symptoms were a stronger moderator of diurnal trends in reward seeking.

Chapter 6: Discussion

In prior studies, self-reported PA, a distal measure of reward-seeking, increases from morning to mid-afternoon and then decreases in the evening (Bower et al., 2010; Clark et al., 1989; Miller et al., 2015; Murray et al., 2002; Murray, 2007; Murray et al., 2009; Peeters et al., 2006; Watson et al., 1999). Using a within-subjects design, reward-seeking measured on behavioral tasks preliminary appears to follow a similar diurnal curve (Byrne & Murray, 2017). The presence of depressive symptoms or a current major depressive episode resulted in lower amplitudes and peaks of self-reported PA (Murray, 2007; Peeters et al., 2006). However, whether these within-person diurnal trends in reward-seeking are identifiable across individuals is unknown. Whether depressive symptoms generally or anhedonia specifically is driving the reductions in amplitude and peak is unknown. Therefore, this study examined whether (a) reward-seeking followed a diurnal pattern between subjects, (b) depressive symptoms or anhedonia reduced reward-seeking, and (c) depressive symptoms or anhedonia moderated the diurnal pattern of reward seeking.

Reward-seeking was predicted to follow a diurnal trend marked by an increase in reward-seeking behavior from morning to mid-afternoon followed by a late afternoon decline. In contrast to within-subjects design, the current study did not support this hypothesis in a between-subjects design. Reward-seeking on the CCT-C, CCT-H, or BART was not related to time of day. One possible reason for findings in this study could be due to the use of a between-subjects design. While diurnal variation was found previously in a between-subjects design using a task of reward learning (Whitton et al., 2018), the findings did not match the general trend found in the broader context of diurnal variation in reward-related constructs within individuals. Within-subjects designs allow for the detection of changes in an individual across time (Shaughnessy et al., 2009). Reward seeking is a known individual difference. Prior work indicates the presence of a within-person increase and decrease in reward seeking across the course of a day. In my study, the between-subjects variability may have masked any potential effect. Therefore, using a within-subjects design would be better equipped at detect detecting diurnal variation in reward-related constructs.

Another possible explanation for null findings could be because each task was not measuring reward seeking. The behavioral tasks used in this study may better be conceptualized as measuring risk-taking. Risk-taking is a multidimensional construct that combines reward-seeking and impulsivity (Harden et al., 2017) with environmental cues (Figner & Weber, 2011). Consistent with prior studies (Buelow & Blaine, 2015; Buelow & Barnhart, 2017), the BART was not related to the CCT-C and CCT-H in the current study indicating that they are measuring distinct constructs. The BART is most likely measuring a combination of sensation-seeking and impulsivity (Lauriola et al., 2014) and is at best weakly associated with markers of punishment sensitivity (Maner et al., 2007). In contrast, the CCT-C and CCT-H are not associated with sensation-seeking and impulsivity (Penolazzi et al., 2012) or self-reported reward motivation (Buelow, 2015). Unlike the BART, the CCT-C and CCT-H may be measuring punishment sensitivity (Panno et al., 2015) and factors related to executive functioning (Buelow, 2015). The BART, CCT-C, ad CCT-H are unlikely to be measuring reward-seeking and are more likely to be measuring distinct constructs related to different aspects of risk-taking. Therefore, using tasks designed specifically to measure reward seeking may be required to get a closer approximation of the diurnal variation expected in reward motivation.

Exploratory analyses indicated that the CCT-C displayed a cubic relationship with time of day such that performance increased from early to late morning, decreased in the early afternoon, and increased in the late afternoon. Due to the CCT-C's non-association with reward constructs and unexpected diurnal pattern, the underlying mechanism why performance varied across the day is unlikely to be reward-related. An alternative explanation for the cubic trend could be increases in performance due to fatigue. Sleep-related fatigue (Peach & Gaultney, 2013; Womack et al., 2013) and mental fatigue (Silva et al., 2017) were associated with increased risk taking. In this study design, the study session lasted about three hours. Participants could have either completed the CCT-C first, before any questionnaires or behavioral tasks, or last, after completing a battery of questionnaires and behavioral tasks. It is possible participants completing the task last were more mentally fatigued once reaching the CCT-C near the end of the session compared to the start of the session. Therefore, fatigue may have caused participants to engage in more risk-taking behavior regardless of time of day.

Another possible explanation for the cubic trend in CCT-C performance could be participants were primed to be more risk-taking due to the previous tasks completed. By the end of the session, participants completed multiple questionnaires asking about reward and risk-related preferences as well as computerized tasks with the explicit objective to earn as many points as possible. As the first task in the study session, participants may have behaved conservatively due to unfamiliarity with tasks and study expectations. However, by the end of the session, participants had multiple direct experiences with risk and reward tasks and may have internalized the expectations of the study procedures. Therefore, participants may have engaged in more risk-taking due to comfortability and familiarity with expectations as the session progressed to the end.

Additional exploratory analyses examined diurnal variation in reward motivation through a distal measure of affect within-subjects. In contrast to broader trends seen in diurnal variation in positive affect within-subjects, participants' self-reported happiness decreased throughout the study session and increased at the end. A possible reason for this finding could be limitations of the measure of affect. Historically, positive and negative affect have been parsed apart to measure varying levels of each. However, the SAM scale combines affective valance along a single continuum. As a result, distinguishing between either affective state is difficult, as low levels of positive affect are described as high levels of negative affect on the single continuum. Additionally, study tasks and overall manipulations were designed to evoke distress and frustration. Increases in negative affect or decreases in positive affect would be expected given the study design. In the future, using discreet measures of positive and negative affect while reducing emotion-related confounds from study manipulation would likely lead to clearer results. In summary, negative affect increased throughout the study session regardless of time of day and may be due to limitation is the measures and study design used.

Reward-seeking was hypothesized to be related to depressive symptoms and/or anhedonia. In the final models including both depressive symptoms and anhedonia, neither depressive symptoms nor anhedonia were associated with reward-seeking across the reward-seeking behavioral tasks. Neither were identified as being substantially more or less important than the other. Prior studies examining the BART and depressive symptoms did not find an association (Dean et al., 2011; Huggins et al., 2019; Loman et al., 2014; Pleskac et al., 2008; Qu et al., 2016). Exploratory findings in this study match prior results when examining the relationship with all depressive symptoms or depressive symptoms without anhedonia. In the context of the BART, this is the first study to examine a relationship with anhedonia independent of other depressive symptoms. It is possible previous studies may have detected an association with anhedonia if examined discreetly from other depressive symptoms. However, even when examined discreetly, anhedonia did not have incremental utility above other depressive symptoms. Aside from limitations in the behavior tasks used (as previously discussed), it may be that the anhedonia measure used in the current study did not measure the construct appropriately. While the measure displayed adequate internal consistency, the number of questions were limited and measured anhedonia through items assessing both enjoyment and interest. If anhedonia is better conceptualized as deficits in reward motivation, then measures of anhedonia should reflect a contemporary conceptualization. Therefore, anhedonia may be weak a predictor of reward-seeking, but as measured, anhedonia does not add incremental utility in predicting reward-seeking above depressive symptoms more generally.

Reward-seeking was hypothesized to be moderated by depressive symptoms and/or anhedonia. In contrast to within-subjects designs findings reporting alterations in the diurnal trend based on self-reported depressive symptoms or depressive diagnostic status, anhedonia and depressive symptoms did not moderate the diurnal trend of reward seeking across multiple behavioral tasks. Based on findings from the previous hypotheses, the results were expected. None of the tasks displayed the predicted diurnal pattern and were unassociated with anhedonia and depressive symptoms overall. As previously discussed, findings may be due to limitations in the between-subject design, the true underlying constructs measured by each behavioral task, or the measurement of self-reported anhedonia. In summary, anhedonia and/or depressive symptoms may moderate diurnal trends in reward seeking if more appropriate research designs and measures are implemented.

Clinical Implications

Depressive symptoms do not appear to be associated with increased risk-taking. Individuals with depressive symptoms, including anhedonic symptoms, are not more or less expected to engage in reward seeking in the context of risky decisions. Risk-taking may be too distal to reward seeking. Anhedonia may not be implicated in the underlying mechanisms of reward seeking when considered in the context of risk taking. Anhedonia's influence may be specific to rewards without salient risks or punishment. The reward seeking component of risk may not be strong enough to influence change in individuals with depressive or anhedonic symptoms. In summary, when measuring anhedonia behaviorally, a construct other than risk taking is needed to capture reward-related deficits.

Depressive symptoms are positively related some real-world risky behaviors (Bannink et al., 2015; Brooks et al., 2002; Fergusson et al., 2003; Hooshmand et al., 2012; Testa, & Steinberg, 2010). If increased symptoms of depression are associated with increased risk-taking, then the underlying factor driving the association is unlikely to be the reward seeking component of risk-taking or anhedonic symptoms in the context of all depressive symptoms. Potential underlying factors could be social influences from peers such that individuals with higher depressive symptoms could be more susceptible to peer pressure, other symptoms interfering with effective decision making (e.g., rumination, diminished ability to think or concentrate), cognitive control (e.g., impulsivity), or to distract from current distressing symptoms. In summary, the link between depressive symptoms and risk-taking is unclear, but is likely something other than reward seeking and anhedonia.

Appendix A: Tables

Table 1.

Demographic Characteristics

	Total Sample	Behavioral Tasks		
		BART	CCT-H	CCT-C
N	898	298	720	654
Male		107	244	216
Female		191	476	438
White		114	265	248
African American		22	59	56
Native American		0	2	1
Asian		59	145	131
Hawaiian/Pacific Islander		8	10	8
Other		42	122	103
Multi-Racial		49	108	100
Not Reported		4	9	7
Hispanic/Latinx		84	215	188
Non-Hispanic/Latinx		214	505	466
Age in years				
Mean (SD)		20.46 (3.98)	20.23 (4.05)	20.26 (4.14)
Range		18.00 – 42.00	18.00 – 52.00	18.00 – 52.00
Task Performance				
Mean (SD)		22.07 (12.89)	24.22 (6.36)	16.32 (7.62)
Range		7.00 – 74.00	3.00 – 30.00	2.00 – 31.00
High-Reward-Low-Loss				
Mean (SD)			24.80 (6.31)	16.90 (8.16)
Range			2.00 – 31.00	2.00 – 31.00
Depressive symptoms				
Mean (SD)		33.01 (21.32)	32.67 (21.48)	32.64 (21.05)
Range		0.00 – 99.00	0.00 – 100.00	0.00 – 100.00
Anhedonia symptoms				
Mean (SD)		5.19 (3.72)	5.19 (3.64)	5.24 (3.64)
Range		0.00 – 18.00	0.00 – 18.00	0.00 – 18.00
Time Completed				
Mean (SD)		12.57 (2.23)	12.94 (2.21)	12.75 (2.49)

Range	9.00 – 16.00	10.00 – 17.00	9.00 – 17.00

Table 2.

Correlations with Confidence Intervals

Variable	1	[95% CI]	2	[95% CI]	3	[95% CI]	4	[95% CI]	5	[95% CI]
1. Depressive Symptoms										
2. Anhedonia	.81**	[.79, .84]								
3. Time of Day	-.03	[-.11, .05]	.01	[-.07, .09]						
4. CCT-C	-.02	[-.09, .06]	-.01	[-.08, .07]	.21**	[.14, .28]				
5. CCT-H	.03	[-.04, .11]	-.01	[-.08, .06]	.01	[-.06, .09]	.33**	[.26, 40]		
6. BART	-.13*	[-.24, -.02]	-.14*	[-.25, -.03]	.05	[-.07, .16]	.05	[-.08, .17]	.03	[-.09, .15]

Note. * indicates $p < .05$. ** indicates $p < .01$.

Table 3.

Hierarchical Regression of Mean Performance on Reward Seeking Tasks Predicted by Gender, Age, and Linear, Quadratic, and Cubic Time of Day

	CCT-C		CCT-H		BART	
Predictors	*b*	[95% CI]	*b*	[95% CI]	*b*	[95% CI]
Constant	16.04***	[13.45, 18.63]	26.08***	[23.49, 28.66]	19.51***	[11.00, 28.03]
Gender (Male)	.16	[-.89, 1.22]	-.46	[-1.43, .52]	5.00**	[1.97, 8.03]
Age	.00	[-.12, .12]	-.09	[-.21, .02]	.06	[-.31, .43]
Time of Day	-3.46***	[-4.06, -2.86]	-1.06***	[-1.68, -.45]	.28	[-.36, .93]
Time of Day^2	.24***	[.13, .35]	.14	[-.08, .35]	-.10	[-.77, .58]
Time of Day^3	.45***	[.39, .51]	.19***	[.10, .28]		
Observations		654		720		298
R^2		.290		.028		.037

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Table 4.

Hierarchical Regression of Mean Performance on Reward Seeking Tasks Predicted by Gender, Age, Depressive Symptoms, and Anhedonia

	CCT-C		CCT-H		BART	
Predictors	*b*	[95% CI]	*b*	[95% CI]	*b*	[95% CI]
Constant	16.03***	[12.85, 19.22]	25.63***	[23.02, 28.24]	22.41***	[14.10, 3.72]
Gender (Male)	.50	[-.77, 1.77]	-.43	[-1.42, .57]	4.57**	[1.53, 7.61]
Age	.01	[-.13, .15]	-.07	[-.18, .05]	.01	[-.35, .38]
Depressive Symptoms	-.01	[-.06, .04]	.03	[-.01, .07]	-.01	[-.13, .11]
Anhedonia	.05	[-.23, .33]	-.19	[-.41, .03]	-.39	[-1.06, .28]
Observations	654		720		298	
R^2	.001		.008		.049	

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 5.

Hierarchical Regression of Mean Performance on Reward Seeking Tasks Predicted by Gender, Age, Linear, Quadratic, and Cubic Time of Day, Depressive Symptoms, and Anhedonia

	CCT-C		CCT-H		BART			
Predictors	*b*	[95% CI]	*b*	[95% CI]	*b*	[95% CI]	*b*	[95% CI]
Constant	16.07***	[13.46, 18.68]	25.89***	[23.27, 28.50]	2.18***	[11.67, 28.70]	2.06***	[11.53, 28.58]
Gender (Male)	.14	[-.94, 1.22]	-.41	[-1.40, .57]	4.62**	[1.56, 7.69]	4.67**	[1.61, 7.73]
Age	.00	[-.12, .12]	-.08	[-.20, .03]	.03	[-.34, .40]	.03	[-.34, .40]
Depressive Symptoms	-.00	[-.04, .04]	.03	[-.01, .07]	-.02	[-.23, .19]	-.00	[-.12, .12]
Anhedonia	-.00	[-.24, .24]	-.18	[-.40, .04]	-.40	[-1.08, .27]	-.16	[-1.22, .90]
Time of Day	-3.47***	[-4.07, -2.86]	-1.05***	[-1.67, -.43]	.30	[-.34, .95]	.33	[-.32, .98]
Time of Day^2	.24***	[.13, .35]	.14	[-.07, .36]	-.07	[-.75, .60]	-.05	[-.73, .63]
Time of Day^3	.45***	[.39, .51]	.19***	[.10, .28]				
Time of Day^2 X Depressive Symptoms					.00	[-.03, .03]		
Time of Day^2 X Anhedonia							-.05	[-.22, .12]

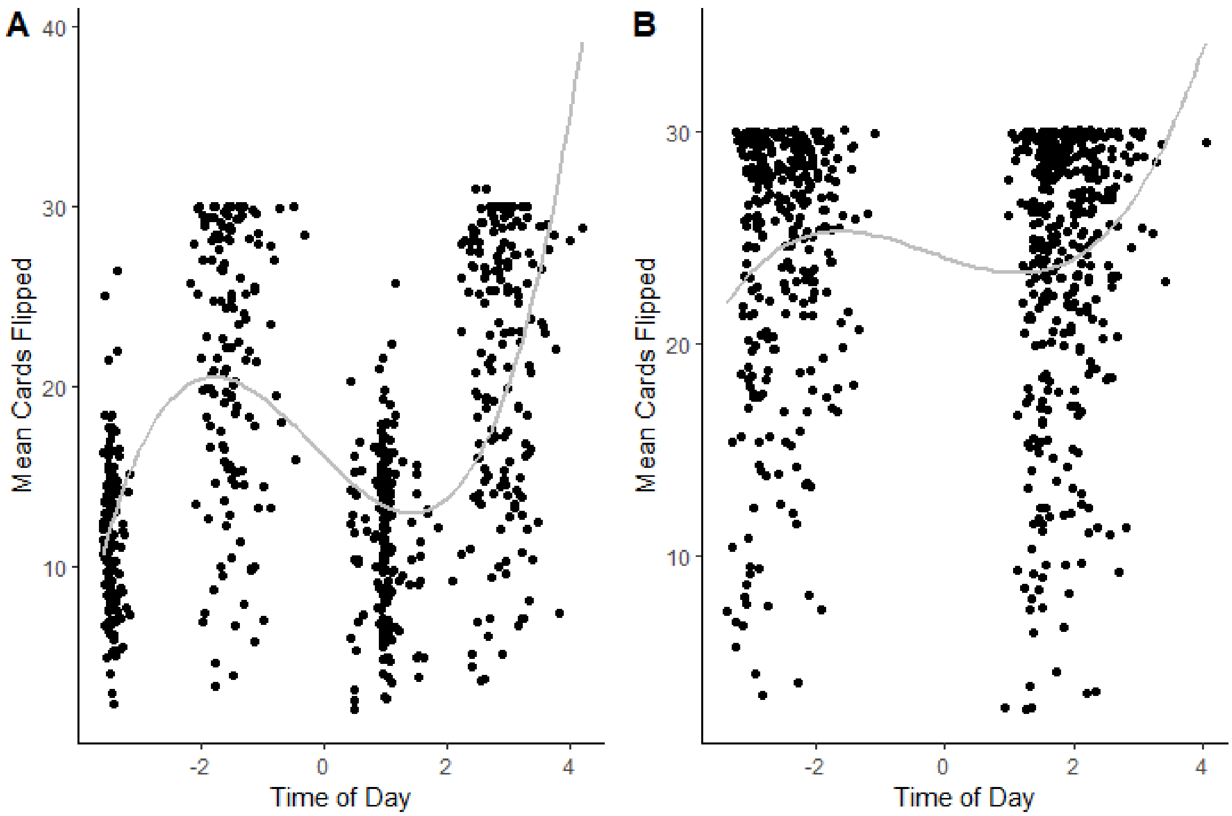
Time of Day^3 X Anhedonia	-.00	[-.01, .01]	.00	[-.01, .01]				
Observations		654		720			298	
R^2		.290		.033		.052		.053

Note. * $p < .05$ ** $p < .01$ *** $p < .001$

Appendix B: Figures

Figure 1.

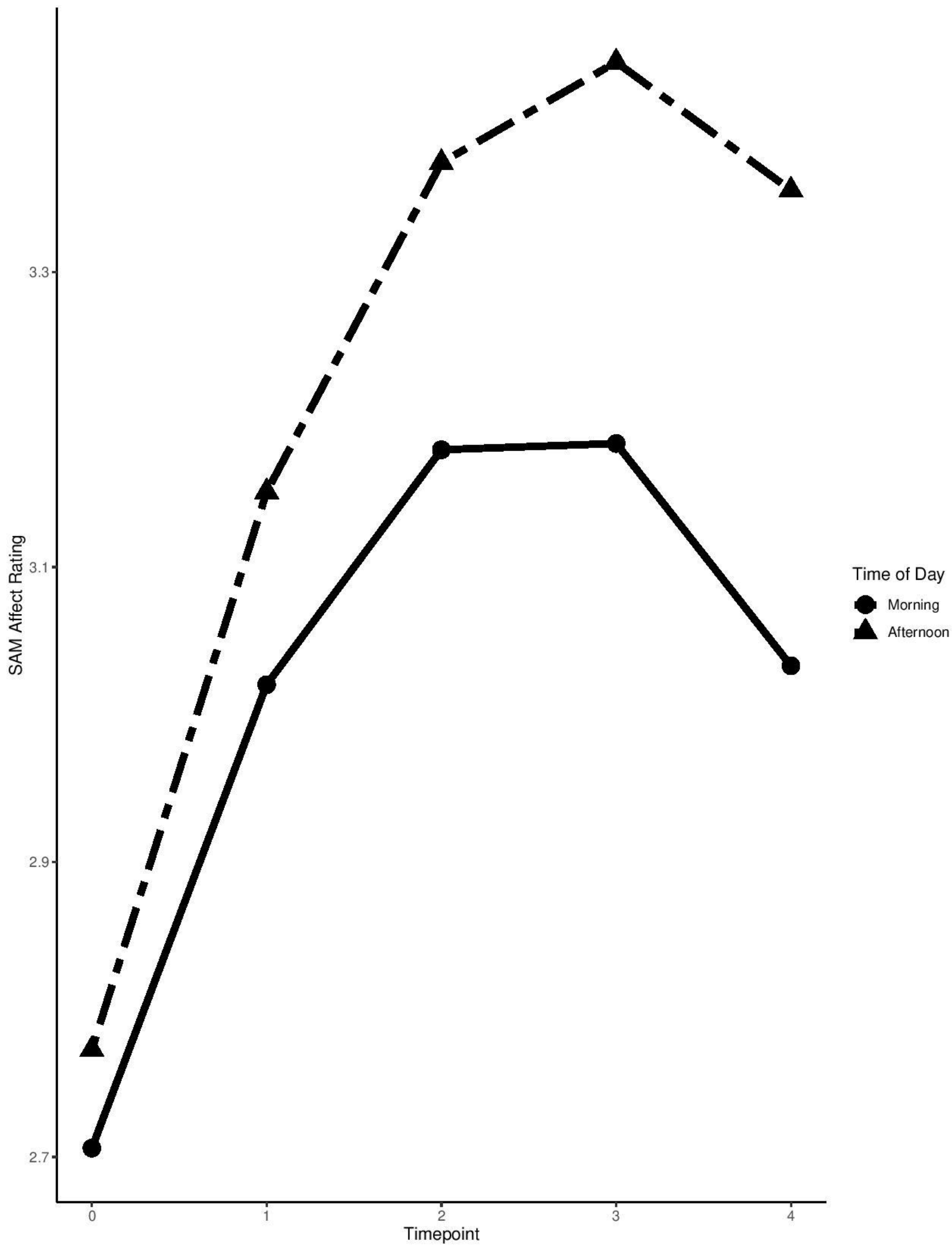
Scatterplot of Reward Seeking by Time of Day with Fitted Cubic Trend Line



Note. 1a. Scatterplot of CCT-C mean cards flipped by time of day with a fitted cubic trend line. 1b. Scatterplot of CCT-H mean cards flipped by time of day with a fitted cubic trend line.

Figure 2.

Multilevel Growth Model of SAM Affect Ratings Across the Day



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Curriculum Vitae

Rogers, Erick

PERSONAL

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EDUCATION

Doctor of Philosophy, Psychology — August 2017- Present
University of Nevada-Las Vegas, Las Vegas, NV

Bachelor of Arts, Psychology — August 2013-May 2016
University of Nevada-Las Vegas, Las Vegas, NV
Cum Laude

Associate of Arts, Psychology — August 2010-August 2013
College of Southern Nevada, Las Vegas, NV
High Honors

Associate of Business — January 2013-August 2013
College of Southern Nevada, Las Vegas, NV
High Honors

PRE-DOCTORAL PRACTICUM TRAINING

Doctoral Practicum Student — **August 2019 – Present**
Desert Willow Treatment Center — 16 hours per week
Las Vegas, NV
Supervisor: Caron Evans, Ph.D.

- Conduct psychological evaluations and assessments, including the WISC-V, WRAT-5, MMPI-A-RF, Vineland-3, Connors 3, and the Children's Uniform Mental Health Assessment (CUMHA)
- Provide evidence-based assessment and intervention services for adolescents on acute and residential psychiatric inpatient units.
- Conduct weekly individual and family therapy to address a range of behavioral and emotional concerns (e.g., depression, bipolar disorder, suicidal ideation, oppositional behavior, etc.).
- Complete comprehensive integrated assessment reports and feedback sessions with adolescents and caregivers.
- Co-facilitate weekly psychoeducational and skills-based group therapy in various modalities (e.g., Dialectical Behavior Therapy, Anger Replacement Training).

Doctoral Practicum Student — **August 2018 – August 2019**
The PRACTICE Community Mental Health Clinic — 10 to 15 hours per week
Department of Psychology, UNLV
Supervisors: Kristen Culbert, Ph.D.; Stephen Benning, Ph.D.

- Providing comprehensive reports and feedback, conducting psychological evaluations and assessments, including WJ-IV, WAIS-IV, D-KEFS, SCID-5, WMS-IV, CVLT-II, and self-report measures including, SCID-II, PAI, PID-5, Vineland-3 and other self-report measures
- Provide individual psychotherapy interventions using a cognitive-behavioral approach for students, general adults, and geriatric populations
- Provide tele-health counseling services for schools in rural Nevada

PROFESSIONAL PRESENTATIONS

Mann, B., **Rogers, E., A.**, & Freeman, A., J. (2019, November). *Callous-unemotional traits are not related to reward seeking.* Poster presented at the 2019 Association for Behavioral and Cognitive Therapies (ABCT) Conference, Atlanta, GA.

Rogers, E., A., Mann, B., & Freeman, A., J. (2018, November). *Reward sensitivity, gender, and depressive symptoms*. Poster presented at the 2018 Association for Behavioral and Cognitive Therapies (ABCT) Conference, Washington, D.C.

Ibarra, M., G., **Rogers, E., A.**, Santarsieri, B., E., Sherwood, S., N., Chen, Y., & Freeman, A., J. (2017, November). *Gender, chronotype, and affective symptoms*. Poster presented at the 2017 Association for Behavioral and Cognitive Therapies (ABCT) Conference, San Diego, CA

HONORS AND AWARDS

2019	Competitive Travel Award (Fall Session), University of Nevada, Las Vegas
2019-2020	UNLV Graduate Access Grant: $2000
2015	Psi Chi International Honor Society
2015	Dean’s Honor List, University of Nevada, Las Vegas
2011-2013	Dean’s Honor List, College of Southern Nevada
2013	Accelerated Associate of Business Grant Program
2012	President’s Honor List, College of Southern Nevada
2012	Phi Theta Kappa Honor Society

TEACHING EXPERIENCES

Introductory Psychology (PSY 101) — Las Vegas, NV
University of Nevada, Las Vegas — August 2019 – Present
Instructor of Record

Statistics for Psychologists II (PSY 709) — Las Vegas, NV
University of Nevada, Las Vegas — January 2019 – May 2019
Teaching Assistant

Assessment of Children (PSY 715) — Las Vegas, NV
University of Nevada, Las Vegas — August 2018 - December 2018
Teaching Assistant

Introduction to Statistics (PSY 210) — Las Vegas, NV

University of Nevada, Las Vegas — August 2017 - May 2018
Teaching Assistant

PROFESSIONAL TRAINING

Not all that blows up is Bipolar: Evidence-Based Assessment And Treatment for Bipolar Disorder in Youth and Young Adults — **Fall 2019**
Instructor: Eric Youngstrom, Ph.D.
One-day live workshop in theory and practical applications for assessing pediatric bipolar disorder. Areas of training included theoretical and research consensus on pediatric bipolar disorder, differential diagnoses of pediatric bipolar disorder, practical skills and resources to conduct evidence-based assessment.

Comprehensive Training in Dialectical Behavior Therapy, Part II — **Fall 2019**
Instructor: Armida Rubio Fruzzetti, Ph.D.
Three-day live workshop with instruction in a variety of DBT skills and appropriate use of respective skills. Areas of training included instruction on specific DBT skills, chain analysis, case conceptualization, guided role-playing of DBT skills, and phone couching.

Comprehensive Training in Dialectical Behavior Therapy, Part I — **Fall 2019**
Instructor: Alan E. Fruzzetti, Ph.D.
Three-day live workshop with instruction in theoretical underpinnings and application DBT to treat a variety of psychological problems. Areas of training included theory and proposed mechanisms of change, chain analysis, case conceptualization, and guided role-playing of DBT skills.

Interprofessional Education Program — **Spring 2019**
Supervisor: Michelle Paul, Ph.D.
Annual eight-hour workshops aimed at increasing awareness of interprofessional practice, education, and responsibilities across healthcare professions with the goal of understanding how integrated health teams should function to better serve clients/patients.

Acceptance and Commitment Therapy (ACT) Workshop — **Fall 2018**
Instructor: Steven Hayes, Ph.D.
Two-day live workshop with instruction in the use of ACT to treat a variety of psychological problems. Areas of training included theory and proposed mechanisms of change, instruction on specific ACT skills, and guided role-playing of ACT delivery.

RESEARCH EXPERIENCE

Development of Irritability, Mood and Emotions Laboratory — August 2017-Present
Department of Psychology, University of Nevada, Las Vegas
Graduate Student

Responsibilities: **1)** Coding, programming, and debugging tasks used in the study protocol; **2)** Administering paper tasks and assessments and debriefing participants; **3)** Designing experience sampling survey apps and automated compliance scripts for future studies **4)** Data collection, entry, and analysis using R, SPSS, and Microsoft Excel **5)** Training new research assistants **6)** Conducting clinical interviews for research studies 7) Managing laboratory teams of research assistants and delegating research tasks

Psychophysiology of Emotion and Personality Laboratory *January 2016-May 2017*
Department of Psychology, University of Nevada, Las Vegas
Research Assistant

Responsibilities: **1)** Working with other research assistants and researchers to correctly and efficiently run participants through experimental protocols; **2)** Following standard operating procedures of guiding participants through the experimental protocols, using sanitary procedures to prepare participants' skin, effectively using conductive gel for electrodes, properly placing and adjusting EEG sensors and EEG cap, recording ERP data, correctly handling and cleaning sensors, setting up and cleaning the laboratory area, filling out activity logs, and burning data disks; **3)** Data collection, entry, and corrections; **3)** Providing debugging support for online surveys and demographic questionnaires and reporting any issues; **4)** Providing feedback on academic articles written by other lab members; **5)** Troubleshooting and finding solutions for computers and experimental program software issues

Development of Irritability, Mood and Emotions Laboratory August 2015-May 2017
Department of Psychology, University of Nevada, Las Vegas
Research Assistant

Responsibilities: **1)** Coding, programming, and debugging tasks used in the study protocol, e.g. the Balloon Analogue Risk Task (BART) using the program PsychoPy; **2)** Administering paper tasks and assessments and debriefing participants; **3)** Data collection, entry, and analysis using SPSS, Microsoft Excel, and the Spyder IDE; **4)** Actively participating in the lab Coding Club by developing new tasks in PsychoPy, e.g. the Effort Expenditure for Rewards Task (EEfRT), and using Microsoft Excel and the Spyder IDE to analyze behavioral task data; **5)** Assisting in training new research assistants

Auditory Cognitive Neuroscience Laboratory August 2014-May 2016
Department of Psychology, University of Nevada, Las Vegas
Research Assistant
Responsibilities: **1)** Assisting in training new research assistants on study protocols;; **2)** Data collection, entry, and analysis using Microsoft Excel and Google Drive; **3)** Assisting in using Brain Electrical Source Analysis (BESA) software to average ERP data; **4)** Gathering, analyzing, and editing audio files to be used as experimental stimuli

RELATED SKILLS AND EXPERIENCE

- Statistical software (R and SPSS)
- Microsoft Office Suite (e.g., Excel, Word, Outlook)
- Windows XP/Vista/7/8/8.1/10
- Assessment scoring software (e.g., WJ-IV, WAIS-IV, WMS-IV, D-KEFS, PAI, MMPI-2, MMPI-A-RF, CPT3, Connor 3)

- Electroencephalography (EEG) electrode and data
- Audiometer testing and audiogram manual recording
- Python programming
- JavaScript and mobile device application programming for Android and iOS

PROFESSIONAL AFFILIATIONS

Association for Behavioral and Cognitive Therapies (ABCT), Student Member	2018 – Present
Society for the Teaching of Psychology (Division 2), Student Member	2019 – Present