ABSTRACT

Title of Thesis: MOTIVATION AND EFFORT IN INDIVIDUALS WITH SOCIAL ANHEDONIA

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The current study sought to better understand differences in motivation and effort in individuals with social anhedonia. Social anhedonia is a core negative symptom and one of the strongest predictors for the development of schizophrenia-spectrum disorders. Because current research examining motivation and effort deficits has focused on self-report questionnaires and behavioral tasks, little is known about possible underlying mechanisms of social anhedonia. Thus, the current study examined effortful decision making (monetary reward task) and physiological measures of effort mobilization (cardiovascular reactivity) and investigated whether findings were specific to social anhedonia or were shared with positive symptoms of schizophrenia spectrum disorders (e.g., perceptual aberrations and magical ideation, together referred to as 'PerMag') and healthy controls. Results indicated that elevated social anhedonia was related to more effortful decision making in the context of uncertain probability of reward, but there were no group differences with respect to physiological measures of effort.

# MOTIVATION AND EFFORT IN INDIVIDUALS WITH SOCIAL ANHEDONIA

by

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## Chapter 1: Introduction

Social anhedonia is a negative symptom that has been identified as one of the core features of schizophrenia spectrum disorders and refers to the lack of pleasure from social interactions (Blanchard, Gangestad, Brown, & Horan, 2000; Meehl, 1962). In addition to anhedonia, other negative symptoms include asociality (reduced social interest and engagement), avolition (diminished motivation and goal directed behavior), blunted affect (decreased emotional expression), and alogia (reduced verbal expression) (Kirkpatrick, Fenton, Carpenter, & Marder, 2006). Expanding our understanding of negative symptoms like social anhedonia is a priority because they are related to serious functional limitations (Bellack, Morrison, Mueser, & Wade, 1989; Bellack, Morrison, Wixted, & Mueser, 1990; Kirkpatrick et al., 2006). Additionally, social anhedonia has been reported to be a promising predictor of schizophrenia spectrum disorders, suggesting that this trait may be useful in the early identification of risk for developing such disorders in nonclinical populations or persons without a schizophrenia spectrum diagnosis (Blanchard, Collins, Aghevli, Leung, & Cohen, 2011; Gooding, Tallent, & Matts, 2005; Kwapil, 1998).

Although a number of studies have examined schizotypy-related correlates of social anhedonia, the underlying mechanisms of reduced hedonic capacity remain unclear. Individuals who are high in social anhedonia are likely to be less motivated to pursue social situations which may be due to difficulties in the anticipation of pleasurable events (Martin, Cicero, & Kerns, 2011b), reward processing (Lempert & Pizzagalli, 2010), and the motivation required in effortful decision making (Treadway et al. 2009). However, the relationship between anhedonia and individual differences

in effort and motivation warrants further exploration in social anhedonia research with nonclinical populations. Furthermore, no studies have examined differences in cardiovascular effort mobilization with respect to social anhedonia and positive schizotypy (e.g., perceptual aberrations, magical ideation) in college students. The current study aims to clarify these relationships by studying effortful decision making in a reward task and cardiovascular reactivity as a measure of effort mobilization in a cognitively demanding memory task with three groups of college students: elevated social anhedonia, elevated positive schizotypy, and a healthy control group. This design will clarify whether differences in choice to engage in effortful tasks and the ability to mobilize effort physiologically to meet task demands might be specific to individuals with social anhedonia or are shared with individuals who have positive schizotypy traits and healthy controls. To provide the context for this study, we present a review of the background of negative symptoms in relation to functional outcomes, an overview of social anhedonia, anticipatory pleasure, motivation and reward processing in individuals with social anhedonia, and physiological measures of effort mobilization.

**Negative Symptoms and Functioning**

Although negative symptoms manifest in unique combinations across individuals with schizophrenia, functional impairment is often a shared experience that may include difficulty fulfilling social roles (e.g., spouse, parent), developing close relationships, maintaining work, living independently, and expressing one's thoughts and feelings (Bellack et al., 2007). In studies that followed first episode patients (i.e., experiencing their first psychotic break) for 2, 3, and 7 years, negative

symptom severity has been associated with occupational impairment, less enjoyment of recreational activities, financial dependency, poor friendships, and low global assessments of functioning (Ho, Nopoulos, Flaum, Arndt, & Andreasen, 1998; Milev, Ho, Arndt, & Andreasen, 2005; Siegel et al., 2006). Even at a 10-year follow-up assessment, negative symptoms in first episode patients were related to fewer months engaged in work as well as the receipt of pensions and social security benefits (White, Stirling, Hopkins, Morris, Montague, Tantam, & Lewis, 2009). While antipsychotics are commonly prescribed early in the course of illness to mitigate symptoms of schizophrenia, they tend to target positive symptoms (e.g., hallucinations, delusions) while having a limited impact on negative symptoms (Arango, Buchanan, Kirkpatrick, & Carpenter, 2004; Buckley & Stahl, 2007; Erhart, Marder, & Carpenter, 2006; Kirkpatrick et al., 2006). Thus, gaining a better understanding of negative symptoms and their relationship with functioning will allow researchers and clinicians to create better interventions for the approximately 28-36% of individuals with schizophrenia who experience these symptoms (Blanchard, Horan, & Collins, 2005).

**Social Anhedonia**

**Background.** One of the primary features of negative symptoms is social anhedonia. People with social anhedonia experience less pleasure from social interactions (L. Chapman, J. Chapman, & Raulin, 1976). Building upon the work of Rado et al. (1956) on anhedonia, Meehl (1962) proposed that reduced hedonic capacity (hypohedonia) is a core feature of schizophrenia spectrum disorders. Meehl (1962) believed hypohedonia to be largely an interpersonal phenomenon and this

reduction of hedonic experience gave rise to the conceptualization of social anhedonia. According to Meehl, biological underpinnings explain patients' decrease in pleasure and he introduced the term *schizotaxia* to represent the neural integrative deficit that he felt would lead to a schizotypal personality organization. He stated that schizotypal personality was characterized by four core features: social anhedonia, cognitive slippage, ambivalence, and interpersonal aversiveness (1962). Although only approximately 10% of people with schizotypy transition to schizophrenia in the face of stressful environmental events, the schizotypal personality construct is requisite for this development, signifying that social anhedonia is likely present during both clinical and pre-clinical stages of schizophrenia (Meehl, 1962).

**Characteristics of individuals with schizophrenia.** Many, but not all, schizophrenia patients have higher social anhedonia levels compared to healthy controls (Blanchard, Mueser, & Bellack, 1998; Chapman et al., 1976; Potvin et al., 2008) and patients with other Axis I diagnoses like bipolar disorder (Blanchard, Bellack, & Mueser, 1994). For people who do have elevated levels of social anhedonia, this construct appears to be a relatively stable trait over time (Blanchard, Horan, & Brown, 2001; Blanchard et al., 1998; Keefe et al., 1991). First-degree relatives of schizophrenia patients have also been found to exhibit higher levels of social anhedonia (Docherty & Sponheim, 2008; Katsanis, Iacono, & Beiser, 1990; Kendler, Thacker, & Walsh, 1996); however, there are mixed findings supporting this assertion (Craver & Pogue-Geile, 1999; Kuha et al., 2011). Although the heritability of social anhedonia is uncertain, it is a promising predictor of the onset of schizophrenia spectrum disorders (Blanchard et al., 2011; Gooding et al., 2005;

Kwapil, 1998). Identifying and exploring social anhedonia in nonclinical populations affords several advantages including minimizing factors that complicate research in schizophrenia such as medication effects, economic deprivation, severe cognitive decline, social stigma, and institutionalization (Blanchard & Neale, 1992; Lenzenweger, 2006).

**Characteristics of nonclinical populations.** As mentioned previously, elevated social anhedonia is a core feature of schizotypy and is associated with increased rates of schizoid and paranoid personality disorders (Kwapil, Crump, & Pickup, 2002). One study found that 24% of a college sample with high social anhedonia developed paranoid, schizotypal, or schizoid personality disorders at a ten-year follow-up compared to only 1% of control participants (Kwapil, 1998). In another longitudinal study, after a five-year follow-up period, significantly more individuals were diagnosed with a schizophrenia spectrum disorder in the social anhedonia group compared to individuals with increased positive schizotypy traits (e.g. perceptual abnormalities, magical ideation) and controls (Gooding et al., 2005). However, no group differences were found between social anhedonia and control groups with respect to rates of mood or substance use disorders (Gooding et al., 2005). Alternatively, in a community sample, individuals with elevated social anhedonia did report higher rates of mood disorders compared to controls in addition to increased schizophrenia spectrum personality traits, negative symptoms, global functioning impairment, family conflict, and decreased social support (Blanchard et al., 2011).

Another set of features that have been linked to social anhedonia includes cognitive deficits in executive functioning, working memory, and attention (Cohen, Leung, Saperstein, & Blanchard, 2006; Diaz, 2006; Tallent & Gooding, 1999). Social anhedonia has been related to impaired social functioning (Diaz, 2006; Diaz, Dickerson, & Kwapil, 2003) and a preference for time alone in nonclinical populations (Brown, Silvia, Myin-Germeys, & Kwapil, 2007). Furthermore, individuals high in social anhedonia have been found to have significantly less self-reported positive affect and more negative affect compared to a normally hedonic group (e.g., Blanchard et al., 2011; Gooding and Tallent, 2003). On the other hand, one study reported less positive affect in individuals with social anhedonia but no difference in negative affect compared to controls (Leung, Couture, Blanchard, Lin, & Llerena, 2010). Collectively, these studies suggest that nonclinical samples of individuals with social anhedonia demonstrate higher rates of psychopathology, functional impairments, and disruptions in emotional experience. Many of these studies, however, do not take into account the time course of emotional experience that has become a recent emphasis in social anhedonia literature. Understanding how people anticipate pleasure or reward in the future may inform differences in motivation and effortful decision making in the context of goal-directed behavior.

**Anticipatory and Consummatory Pleasure**

**Anticipatory pleasure deficits in individuals with schizophrenia.** Social anhedonia has been defined as the lack of pleasure from social stimuli, but recent studies on anhedonia have caused a shift in how we conceptualize the experience of pleasure. Instead of a unitary construct of pleasure, researchers have proposed a

definition of pleasure based on its temporal unfolding that includes anticipatory and consummatory pleasure. Anticipatory pleasure is the experience of pleasure from expecting a future rewarding event (wanting), whereas consummatory pleasure is the experience of pleasure in the moment (liking) (Berridge & Robinson, 1998; D. Gard, Kring, A. Gard, Horan, & Green, 2007). This distinction has been applied to schizophrenia to better understand hedonic deficits. Numerous studies support the notion that people with schizophrenia have intact abilities for consummatory pleasure but may have difficulty experiencing anticipatory pleasure (Berenbaum & Oltmanns, 1992; Cohen, Najolia, Brown, & Minor, 2011; Gard et al., 2007; Loas, Monestes, Yon, Thomas, & Gard, 2010). Despite having consummatory pleasure, individuals with schizophrenia in one study had less engagement in goal-directed activities compared to controls implying a disconnect between emotional experience and behavior (Gard et al., 2007). The same study seems to explain this disconnect by finding a correlation between drive and reward seeking and anticipatory but not consummatory pleasure deficits (Gard et al., 2007). Additionally, anticipatory pleasure deficits appear to be related to social anhedonia and functional outcome (Gard et al., 2007). Together, most of these research findings support the idea that consummatory pleasure is relatively intact whereas anticipatory pleasure is somewhat impaired in patients with schizophrenia.

However, other studies have presented results that are inconsistent with the above assertion that schizophrenia patients may have anticipatory pleasure deficits but have normal consummatory pleasure. For example, one recent study found that schizophrenia patients had disruptions of consummatory but not anticipatory pleasure,

opposing results in the studies above (Strauss, Wilbur, Warren, August, & Gold, 2011b). Additionally, Barch and Dowd (2010) presented mixed findings in a study where patients demonstrated relatively intact arousal ratings but less valenced ratings than controls in response to positive and negative stimuli, which indicates that consummatory pleasure may not be entirely intact. These studies imply that anticipatory and consummatory pleasure deficits in individuals with schizophrenia may be present less consistently than previous studies suggest. Interestingly, disruptions of anticipatory and consummatory pleasure are also evident in nonclinical individuals who have social anhedonia.

**Anticipatory and consummatory pleasure deficits in nonclinical populations.** The deficits in anticipatory but not consummatory pleasure found in schizophrenia have not been replicated in many schizotypy studies conducted in nonclinical populations. For example, social anhedonia has been found to be associated with both decreased anticipatory and consummatory pleasure on self-report measures in college students (Martin et al., 2011b). In another study, social anhedonia in college students was associated with decreased positive affect intensity in laboratory tasks compared to participants with elevated positive schizotypy traits and controls (Kerns, Docherty, & Martin, 2008). In agreement with these studies, individuals with social anhedonia have reported less positive emotional responding than controls after viewing evocative film clips (Leung et al., 2010). Although students with increased social anhedonia responded with normal arousal ratings of emotion words they also demonstrated lowered valence ratings of the same words (Mathews & Barch, 2006). However, one study does lend support for a deficit in

anticipatory but not consummatory pleasure in individuals with negative schizotypy relative to controls (Shi, Wang, Cao, Wang, Wang, Zong, …& Chan, 2012). It appears that in most nonclinical samples, individuals with social anhedonia may have disruptions in both consummatory pleasure and anticipatory pleasure, but further research is required to better understand the nature of emotional experiences and how they relate to motivational processes. Importantly, research is needed to assess anticipatory and consummatory pleasure deficits across nonclinical schizotypal traits and explore the link between these deficits and subsequent engagement in effortful and rewarding activities. The underlying mechanisms of this relationship may stem from disruptions in motivation and rewarding processing.

## Motivation and Reward Processing

### Disruptions of motivation and reward in individuals with schizophrenia.

Motivation can be defined as "to be moved to do something and refers to the process whereby goal-directed activities are instigated and sustained," and this process seems to be disrupted in schizophrenia (Medalia & Brekke, 2010, p. 912). Barch and Dowd (2010) describe four primary components of motivation: liking, wanting, assessing value, and goal-directed behavior. While most evidence indicates that liking functions normally in schizophrenia patients, the latter three components appear to be impaired (Barch & Dowd, 2010). There is research indicating that physiological processes identified in neuroimaging studies (e.g., midbrain dopamine system involved in wanting, dorsolateral prefrontal cortex related to goal-directed behavior) and external variables like reward value are thought to influence individual levels of motivation (Medalia & Brekke, 2010). This is not surprising given that it is not

uncommon for individuals with schizophrenia to have difficulties with reward processing (Berridge & Robinson, 1998; Gold, Waltz, Prentice, Morris, & Heerey, 2008; Pizzagalli, 2010) which likely contribute to reduced motivation. For example, researchers have found that schizophrenia patients have deficits in probabilistic learning with positive feedback (Waltz & Gold, 2007), and reinforcement learning is especially a problem for patients with higher levels of negative symptoms (Polgár et al., 2008). Anhedonia, in particular, has been associated with reduced likelihood for patients to explore alternatives for more positive rewards (Strauss, et al., 2011a). In another study, Heerey and colleagues (2007) employed a delayed discounting task and found that individuals with schizophrenia chose smaller immediate rewards rather than larger distant rewards, suggesting that they may be have difficulty forming representations of future rewards. In addition to more steeply discounting delayed rewards, schizophrenia patients with social anhedonia have also demonstrated less effort to obtain rewards they deem desirable, especially when required to mentally represent value in the absence of a given rewarding stimulus (Heerey & Gold, 2007).

Further support for reward processing deficits has also been investigated in animal models of negative symptoms in schizophrenia. Researchers have examined the hedonic sensitivity of mice with genetic over-expression of striatal D2 receptors (D2R-OE), creating an animal model of negative symptoms, and they found no differences in experience of pleasure to food rewards compared to normal mice (Ward, Simpson, Richards, Deo, Taylor, Glendinning, … & Balsam, 2012). However, they did find the D2R-OE mice worked less to consume a preferred physical reward compared to a less preferred but freely available physical reward

(Ward et al., 2012). Furthermore, they also found evidence for reduced incentive motivation for future rewards in the D2R-OE mice compared to controls, and this difference emerged as the difficulty to obtain rewards increased; thus, animal models of schizophrenia also demonstrate deficits in reward processing and motivation in the context of negative symptoms (Ward et al., 2012). Other studies have also found that both negative symptom and control mice eventually cease working for reward as difficulty or cost of obtaining the reward increases, but the negative symptom mice quit significantly sooner than controls (Drew et al., 2007). Another study also demonstrated that across work requirement conditions, negative symptom mice demonstrated less effort to work for reward than control mice (Simpson et al., 2011); for a review, see Ward, Simpson, Kandel, & Balsam (2011).

Thus, the results of behavioral studies and animal models suggest that for individuals with schizophrenia who have greater social anhedonia, the prospect of future rewarding experiences might not elicit the anticipation of reward or motivation to engage in pleasurable activities because they may not seem valuable enough to pursue. Moreover, even if patients high in social anhedonia do find events pleasurable when they occur, they may not exert the effort to facilitate such experiences. Though much of the research on reward and motivation presented above has centered on individuals with schizophrenia or animal models approximating this condition, reward appraisal and the decision to engage in effortful tasks that are inherent to motivation and goal-directed behavior also appear to be compromised in nonclinical individuals with social anhedonia.

**Disruptions of motivation and reward in nonclinical populations.** Similar to deficits in motivation and reward processing found in schizophrenia, such deficits are also seen in nonclinical populations. Deficits in motivation have been studied in a variety of contexts including using experience sampling and laboratory paradigms. Using an experience sampling method to measure daily behavior, college students with greater social anhedonia were less likely to seek out the company of others, preferred being alone, and were more often alone during a one week study period (Kwapil et al., 2009). This result indicates that those individuals high in social anhedonia might be less motivated to seek out social interactions. Laboratory studies have provided an opportunity to more directly address questions about motivation in individuals who infrequently seek out pleasurable experiences.

In a sample of undergraduate students, decreased responsiveness to reward on a signal detection task was found to correlate with more severe anhedonia scores on a depression scale (Pizzagalli, Jahn, & O'Shea, 2005). This finding demonstrated that individuals high in anhedonia fail to develop a response bias for more frequently reinforced monetary rewards. Furthermore, the impaired reward responsiveness in this study was related to greater anhedonia at a one month follow-up after controlling for negative affect (Pizzagalli et al., 2005). From these results, we can conclude that individuals with higher anhedonia scores have diminished responses to pleasurable stimuli (e.g., monetary rewards) compared to those with lower anhedonia scores and this impaired responsiveness is related to less pleasure and interest in daily life. From this study of response bias, however, it is unclear whether anhedonia is related to the

choice to engage in rewarding but demanding tasks. A novel study that addresses this issue is described below.

Treadway et al. (2009) investigated anhedonia in relation to motivation by studying whether anhedonia was related to differences in choosing to exert more effort for reward through a novel effortful decision making task, the Effort-Expenditure for Rewards Task (EEfRT) that involves making choices to perform a 'hard' or 'easy' button tapping task to win monetary rewards. Participants made a series of choices to complete a 'hard' or 'easy' task based on potential reward values ('easy' task completions could only earn a $1 reward; 'hard' task completions could earn a range of rewards up to about $4) and probability of receiving the reward (12%, 50%, or 88%); however, successful task completion did not guarantee a reward. In this study, individuals with greater anhedonia made less effort to choose 'hard' tasks when the potential reward was 'high' (>$3.50) and the probability of reward was uncertain (50%) (Treadway et al., 2009). While the results of Treadway et al. (2009) offer encouraging findings about how social anhedonia is related to reward processing and effort, interpretation of this study is constrained by several factors. For instance, anhedonia was assessed as a broad aggregate of physical and social anhedonia rather than focusing on a specific form of anhedonia. Another issue is the study's lack of a comparison group to investigate the specificity of less effortful decision making in social anhedonia. Researchers have demonstrated that negative symptoms are distinct from manifestations of other disorders and are not secondary to depression, anxiety, or positive symptoms (Blanchard & Cohen, 2006). Thus, it is important to investigate whether findings related to social anhedonia are distinct from

other pathology like positive schizotypy and depressive symptoms. Lastly, neurobiological processes have been linked to reward and motivation (Medalia & Brekke, 2010), but use of the EEfRT has yet to be assessed with respect to any physiological phenomena in individuals with social anhedonia. The present study aims to address these issues in the replication of the EEfRT study and to introduce accompanying physiological measures of effort mobilization to better understand the underlying features of motivation in individuals with social anhedonia.

**Effort Mobilization and Cardiovascular Reactivity**

The motivation intensity theory proposed by Brehm (1989) outlines predictors of motivation and proposes cardiovascular responses as markers of resource or effort mobilization (Brehm & Self, 1989; Wright, 1996). According to the motivation intensity theory, three elements are responsible for an individual's reaction to a task requiring effort: task difficulty, importance of task success, and self-appraisal of ability to complete the task (Wright & Kirby, 2001). As task difficulty increases people exert effort proportional to the task and this effort manifests in cardiovascular responses. The titration of effort continues until the task is deemed impossible to complete successfully or simply not worth the effort that one deems able to exert.

Many studies utilize heart rate and blood pressure to capture the change in cardiovascular reactivity involved in effort mobilization (Kemper et al., 2008; Richter, 2010; Richter, Friedrich, & Gendolla, 2008). Systolic blood pressure, in particular, has been well established as an indicator of effort mobilization (Brinkmann, Schüpbach, Joye, & Gendolla, 2009; Richter et al., 2008; Silvestrini & Gendolla, 2009; Silvia, Jones, Kelly, & Zibaie, 2011; Wright & Kirby, 2001).

Systolic blood pressure is a measure of sympathetic beta-adrenergic reactivity that is more consistent than measures of diastolic blood pressure or heart rate, both of which are influenced by sympathetic and parasympathetic arousal (Richter et al., 2008; Silvestrini & Gendolla, 2009). Due to the recent emphasis for pure measurements of beta-adrenergic reactivity, some researches have begun to include assessments of the preejection period which is "the time interval between the onset of ventricular depolarization and the opening of the aortic valve" in addition to systolic blood pressure data which is not exclusively determined by beta-adrenergic reactivity (Richter & Gendolla, 2009, p. 451-452). However, systolic blood pressure remains an important cardiovascular target for effort mobilization research (Kemper et al., 2008).

The cardiovascular response to effort has been primarily studied in healthy participants by examining effort intensity in a variety of tasks and assessments of mood on effort mobilization and comparing effort in agentic introverted and extraverted samples (Gendolla, Abele, & Krüsken, 2001; Kemper et al., 2008; Richter & Gendolla, 2006). Kemper et al. (2008) identified individuals who had high or low extraversion which includes traits of social dominance, assertiveness, enthusiasm, and achievement striving, and they found that individuals with agentic introversion had lower perceived ability to complete a laboratory task, perceived the task as being more difficult, and resulted in greater effort mobilization on an easy memory task but the opposite effect on a hard memory task. These results suggest that individuals who are less extraverted may display less effort mobilization with increasingly demanding tasks, and although this study did not examine social anhedonia one might

hypothesize similar findings with individuals who have elevated social anhedonia. A small number of studies have also studied effort mobilization in undergraduate samples with dysphoria (e.g. Brinkmann & Gendolla, 2007). One study that recruited high and low sub-clinical depressive groups reported that individuals with high depressive scores demonstrated less cardiovascular reactivity than controls in response to potential punishment or reward (Brinkmann et al., 2009). A second study discovered that on an easy task dysphoric students displayed more effort mobilization (perhaps, because they perceived the task as possible to complete but more difficult than controls), but on a hard task non-dysphoric students demonstrated greater effort mobilization (Brinkmann & Gendolla, 2008). While these studies assessed dysphoria with measures that may tap aspects of anhedonia, to date, no studies have examined the relationship between cardiovascular reactivity of effort mobilization and social anhedonia or positive schizotypy. Additionally, there has been no research on anticipatory pleasure, depression, and social functioning in relation to cardiovascular reactivity in a single sample. The current study will be the first to explicitly test physiological markers of effort mobilization in individuals who have social anhedonia or positive schizotypy traits and how effort mobilization and effortful decision making are related to anticipatory pleasure, depression, and social functioning.

**The Current Study**

**Aims and hypotheses.** The primary aim of the current study is to replicate and expand upon prior findings (Treadway et al., 2009) of a relationship between social anhedonia and diminished effortful decision making. The current study provides a unique contribution to the literature by determining if less effortful

decision making is specific to social anhedonia or is also evident in individuals with other deviant traits or healthy controls. Specifically, this study involves comparisons across three groups: elevated social anhedonia, elevated in positive schizotypy traits (i.e., perceptual aberration and magical ideation), and controls. This study is also the first to assess whether patterns of effortful decision making are related to cardiovascular measures of effort mobilization in individuals with social anhedonia or characteristics of positive schizotypy. The primary hypotheses are as follows:

1) The social anhedonia group will demonstrate diminished effortful decision making compared to controls and those high in positive schizotypy traits. Specifically, individuals high in social anhedonia will less frequently choose hard tasks on the EEfRT compared to the PerMag and control groups.

2) The social anhedonia group will demonstrate less physiological effort mobilization compared to the PerMag and control groups. Particularly, individuals high in social anhedonia will display less change in systolic blood pressure between baseline and task performance periods during the memory task (described in the methods section) compared to the PerMag and control groups.

3) We will examine how individual differences in anticipatory pleasure, depression, and social functioning are related to effortful decision making and effort mobilization. We expect that the social anhedonia group will exhibit greater anticipatory and consummatory pleasure deficits, higher depressive scores, and

increased functional impairment, compared to the PerMag and control groups; furthermore, we expect these variables to correlate with effortful decision making on the EEfRT and systolic blood pressure measures of effort mobilization on the memory task.

## Chapter 2: Methods

### Participants

Research participants were recruited from the University of Maryland at College Park (UMD) through a mass online testing pool of college students and recruitment flyers posted around campus. The flyers advertised an online link to a survey similar to that of the mass online testing. Eligible study participants were between the ages of 17 and 40. People under the age of 17 were unlikely to be enrolled at UMD and people above the age of 40 were deemed to have exceeded the risk period for developing schizophrenia and schizotypal personality disorders (Baron, Gruen, Asnis, & Kane, 1983). Individuals who were 17 years of age obtained parental consent and complete an assent form to participate in the study.

The online screening survey included the Social Anhedonia Scale – Brief (SAS-B; Reise et al., 2011) which is comprised of items from the Revised Social Anhedonia Scale (RSAS; Eckblad et al., 1982), 7 items from the Perceptual Aberration Scale (PerAb; Chapman et al., 1978), and 8 items from the Magical Ideation Scale (MagicId; Eckblad & Chapman, 1983). The latter two scales comprise what is referred to as the PerMag scale which is used to identify positive schizotypal traits; screening items for this scale were chosen based on their utility in the participant recruitment process of previous research studies (e.g., Kerns et al., 2008, Martin et al., 2011b). Selected items from the above scales were used rather than the full scales to adhere to the survey length guidelines of mass testing and to reduce participant burden. Scores from these measures constituted the basis for participant selection. Additionally, the Infrequency Scale (L. Chapman & J. Chapman, 1983)

was used in the online assessment to measure invalid responding (e.g. responding 'true' to all items). We excluded people who responded in an unexpected direction on three or more items of the Infrequency Scale which is consistent with other studies that have used this scale (L. Chapman, J. Chapman, & Raulin, 1976; Kerns et al., 2008; Martin, Becker, Cicero, Docherty, & Kerns, 2011a). A more detailed description of the RSAS and PerMag Scales is outlined in the study measures section below.

Individuals were divided into three groups based on their scores on the SAS-B and the PerMag Scale items for potential inclusion in the research study. The social anhedonia (SocAnh) and positive schizotypy (PerMag) groups were comprised of individuals with scores falling within the top 10% of the collected SAS-B and PerMag scores, respectively. These scores would evaluated by sex because psychosis-proneness scales may vary across males and females (Chmielewski, Fernandes, Yee, & Miller, 1995). Individuals who met criteria for both groups were excluded from the study to establish an extreme-groups design (Kerns et al., 2008). Previous studies have used a threshold of 1.96 standard deviations above the mean to determine high-risk participants with regard to social anhedonia (Kerns et al., 2008; Kwapil et al., 2002), but this study included participants who scored at or within the top 10% of scores on the SAS-B and PerMag Scale to obtain a greater sample size. The control group was recruited from people who scored less than 0.5 standard deviations above the mean because this criterion has successfully distinguished control groups from SocAnh and PerMag groups in previous literature (L. Chapman, J. Chapman, Kwapil, Eckblad, & Zinser, 1994; Horan, Brown, & Blanchard, 2007;

Kerns et al., 2008; Kwapil, 1998; Kwapil et al., 2002). The SocAnh, PerMag, and control groups each included 30 participants creating a total sample of 90, and matching participants' gender and age across groups was conducted to the greatest extent possible. An a priori power analysis of our most complex interactions was run in G*Power, assuming a medium effect size (Cohen's $f = .25$) with Power (1-β) set at 0.90, and it indicated that a sample size of 90 would be sufficient to detect a significant interaction between group and memory task difficulty in terms of cardiovascular reactivity as well as a separate interaction between group, probability, and reward on the EEfRT.

## Measures

### Screening measures.

***Invalid responding.*** The Infrequency Scale (L. Chapman & J. Chapman, 1983) is a 13-item true/false assessment that served as an index for invalid responses on the screening measures. Individuals who rated more than two responses in the unexpected direction were not eligible for the study as this suggests invalid responding across all screening measure questions. Sample items include, "On some mornings, I didn't get out of bed immediately when I first woke up" and "There have been a number of occasions when people I know have said hello to me." The Infrequency Scale has been used in many research studies examining social anhedonia with the RSAS and SAS-B (e.g., Blanchard et al., 2011, Reise et al., 2011).

***Social anhedonia.*** The Social Anhedonia Scale – Brief (SAS-B; Reise et al., 2011) is a 17-item true/false self-report questionnaire that

assesses trait levels of diminished pleasure experienced from social interactions. This measure was adapted from the RSAS (Eckblad, Chapman, Chapman, & Mishlove, 1982) because results of bi-factor item response theory modeling yielded a better statistical fit to the SAS-B than the fit of either one-dimensional or bi-factor models to the RSAS (Reise et al., 2011). The RSAS is a 40-item true/false self-report questionnaire that assesses trait levels of diminished pleasure experienced from social interactions. Sample items include, "If given the choice, I would much rather be with others than be alone," (keyed false) and "Making new friends isn't worth the energy it takes," (keyed true) (Eckblad et al., 1982). Although other measures like the Pleasure Scale (Fawcett, Clark, Scheftner, & Gibbons, 1983) and the Snaith-Hamilton Pleasure Scale (Snaith et al., 1995) also measure anhedonia, the RSAS has been one of the most widely used and established measures to specifically assess social anhedonia. The RSAS has documented good internal consistency (Blanchard et al., 1998; Mishlove & Chapman, 1985), as well as high test-retest reliability (Blanchard et al., 1998; Blanchard, Horan, & Brown, 2001).

***Positive schizotypy.*** The Perceptual Aberration Scale (PerAb; L. Chapman, J. Chapman, & Raulin, 1978) and the Magical Ideation Scale (MagicId; Eckblad and Chapman, 1983): items from the PerAb and MagicId Scales (together referred to as 'PerMag') were administered to screen for individuals with positive schizotypy for the PerMag group. The PerAb Scale (Chapman et al., 1978) is a 35-item true-false measure of distortions in the

perception of one's own body and the environment, which includes items such as "I have sometimes felt that part of my body no longer belonged to me" (keyed true). The MagicID Scale (Eckblad & Chapman, 1983) is a 30-item true-false scale measuring beliefs about causation that deviate from the norm, including items such as "I have sometimes felt that strangers were reading my mind" (keyed false). Individuals with schizophrenia show elevations on these measures, which supports their construct validity (Chapman et al., 1978). Additionally, the PerAb and MagicID Scales have been shown to have good convergent and discriminant validity (Bailey, West, Widiger & Freiman, 1993).

**Self-report measures.**

***Schizotypal personality traits.*** The Schizotypal Personality Questionnaire (SPQ; Raine, 1991) is a 74-item self-report yes/no questionnaire that assesses the symptoms for schizotypal personality disorder as described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R, 1987); these symptoms remained unchanged in the DSM-IV-TR (2000). The SPQ was used as a secondary measure to ensure that the SocAnh and PerMag group had high negative and positive schizotypy scores, respectively, and that the control group has comparatively lower scores. Total scores range from 0-74 (Bora & Baysan Arabaci, 2009) and nine subscales are included in the SPQ: ideas of reference, excessive social anxiety, odd beliefs or magical thinking, unusual perceptual experience, odd or eccentric behavior, no close friends, odd speech, constricted affect and paranoid ideation (Raine,

1991). These subscales typically fall into three factors: 1) cognitive-perceptual (positive schizotypy): ideas of reference, odd beliefs or magical thinking, unusual perceptual experience, and suspiciousness; 2) interpersonal (negative schizotypy): excessive social anxiety and no close friends; and 3) disorganized: odd or eccentric behavior, odd speech, and constricted affect (Raine, Reynolds, Lencz, & Scerbo, 1994). An example of an SPQ item is "I have little interest in getting to know other people." Psychometric data on the SPQ indicate that the total scale is internally consistent (Cronbach's $\alpha = .91$), as were the subscales (Cronbach's $\alpha = .71$-$.78$), and the total scale had good criterion validity ($r = .68$, $p < .005$), test-retest reliability ($r = .82$, $p < .0005$), convergent validity ($r = .65$-$.81$, $p < .001$), discriminant validity ($r = .19$-$.37$, $p < .05$) (Raine, 1991).

***Anticipatory and consummatory pleasure.*** The Temporal Experience of Pleasure Scale (D. Gard, Gard, Kring, & John, 2006) is an 18-item self-report scale of the expectation (anticipatory) of and in-the-moment (consummatory) pleasure. There are 10 items in the anticipatory pleasure scale and 8 items in the consummatory pleasure scale. Each item is rated on a Likert scale from 1-6, with a score of 1 indicating "very false for me" and a score of 6 indicating "very true for me." An example of an anticipatory pleasure item is "When something exciting is coming up in my life, I really look forward to it." A sample consummatory pleasure item is "The smell of freshly cut grass is enjoyable to me." The overall scale was found to have good internal consistency (Cronbach's $\alpha = .79$) and the anticipatory and

consummatory pleasure scales exhibited similar reliability (Cronbach's α = .74 and .71, respectively) (Gard et al., 2006). Additionally, test-retest reliability was high for the overall, anticipatory, and consummatory scales ($r$ = .81, .80, and .75, $p < .001$, respectively) (Gard et al., 2006). Furthermore, the anticipatory pleasure scale has shown a relationship with reward responsiveness, whereas the consummatory pleasure scale is linked to appreciation of positively valenced stimuli and openness to experiences, and while both scales are related to other pleasure scales they are distinct from each other (Gard et al., 2006).

***Social Functioning.*** The Social Adjustment Scale (Weissman & Bothwell, 1976) is a 54-item self-report questionnaire that measures role performance over the past two weeks. Six life areas are measured with the SAS-SR: work (paid worker, unpaid homemaker, or student), social/leisure activities, family relationships, role as a marital partner, role as a parent, and role within the family unit. Items are scored on a 5 point scale (0-4) with higher scores reflecting poorer functioning and the total score is calculated by averaging all items. The SAS-SR was originally developed for use in depression but has subsequently been used in schizophrenia and non-patient samples (Tso, Grove, & Taylor, 2010). The SAS-SR is formatted with skip-outs so that items that do not apply to the participant are omitted. Due to the university sample that we aimed to recruit, we used 27 items to assess work as a student, social/leisure activities, family relationships, and role within the family unit, because items pertaining to roles as a spouse or parent did not

apply to the majority of undergraduate students (Weissman & Bothwell, 1976). The SAS-SR has good concurrent validity with a similar scale of social adaptation ($r = .57$, $p < .0001$).

***Depression.*** The Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) is a 21-item self-report questionnaire that is used to assess depressive symptoms in adults over the past two weeks, including today. The BDI-II is a modified version of the original BDI (Beck, Steer, & Brown, 1978) that measured symptoms over the past week and featured differences in item content and format (Dozois, Dobson, & Ahnberg, 1998). Cognitive, affective, and physiological symptom characteristics are evaluated with items like "Self Dislike," "Sadness," and "Loss of Energy." Severity of items is scored from 0-3 with a score of 0 meaning that participants do not endorse the item and higher scores meaning increasing severity of endorsed items; summary scores range from 0-63. Cutoff summary scores for undergraduate student samples are as follows: 0-12 (non-depressed), 13-19 (dysphoric), 20-63 (dysphoric or depressed, depending on whether a person meets diagnostic criteria); these scores correspond to the cutoffs for the BDI as outlined by (Dozois et al., 1998; Kendall et al., 1987)). The BDI-II has high internal consistency for college students ($\alpha = .91$-$.93$) and outpatients ($\alpha = .92$), as well as good convergent validity with the BDI ($r = .93$, $p < .01$) (Beck et al., 1996; Dozois et al., 1998). Due to the University of Maryland Institutional Review Board requirements and experimenter error, the suicide item was excluded from the BDI-II questionnaire used in the present study, and only the first 14

items were collected for all participants. Although using the incomplete set of 14 items is not ideal, these items demonstrated good internal consistency (Cronbach's $\alpha = .86$).

**Laboratory motivation measures.**

***Effortful decision making.*** The Effort-Expenditure for Rewards Task (EEfRT; Treadway et al., 2009) combined reward processing and effortful decision-making to produce an objective assessment of effort. The task lasts 20 minutes and consists of a series of potential reward values ranging from $1 (easy task) to $1.24-$4.30 (hard task) and probabilities (low = 12%, medium = 50%, high = 86% chance) of receiving each reward that are conditional upon completing the button pressing task presented to participants; rewards are not guaranteed even with successful task completion. Based on the reward and probability information presented, each trial begins with a 1 second fixation cross and participants had 5 seconds to choose whether to perform an easy or hard task in the pursuit of gaining the reward otherwise the participant is randomly assigned to one of the two task difficulties. The easy task involves pushing a computer key 30 times in 7 seconds with the dominant index finger, whereas the hard task involves pushing a computer key 100 times in 21 seconds with the non-dominant index finger. Following each task, participants viewed a feedback screen for 2 seconds with information about whether they successfully or unsuccessfully completed the task. If the task was successfully completed, feedback was given about whether the reward was won. In addition to the base compensation for participation, all

participants were told that they would be compensated an additional amount taken from two randomly chosen 'win' trials (this could range from $2 to $8.60), but they were actually be paid a standard amount of $8. The number of trials completed depends on the type of task difficulty chosen by the participant. The proportion of hard tasks chosen was the dependent variable of effortful decision making. The EEfRT has been assessed only once in a nonclinical population but it provides preliminary validity as an objective measure effortful decision making to achieve rewards.

***Memory task.*** To induce variation in participants' effort mobilization based on task difficulty we employed a variation of a memory task that has been used in previous studies on motivation intensity using cardiovascular reactivity (e.g., Richter & Gendolla, 2006, 2007; Richter, 2010). The task asked participants to memorize a series of senseless letter strings each comprised of 4 letters (e.g., ALMP) within a 5 minute period and to write down the recalled strings at the end of the 5 minutes. The task involves three levels of difficulty that all participants completed: easy (4 strings), difficult (7 strings), and impossible (15 strings) (Gendolla & Krusken, 2002). Participants were given the incentive to win an additional entry to a $50 raffle with each successful task level completion. After reading instructions to complete the task, participants answered three questions: (1) "How difficult does the task appear to you?" (2) "How well do you think you will perform on the task?" and (3) "How worthwhile is successful performance on the task for you?" Blood pressure measurements were collected every 2 minutes in each

of the 5 minute task periods. Order of the three task difficulty levels was randomized.

***Cardiovascular reactivity.*** We used systolic blood pressure (SBP) as the principle physiological measure of effort mobilization. SBP refers to the maximum pressure during myocardial contraction and reflects beta-adrenergic sympathetic activity; increases in SBP are viewed as reliable markers of effort mobilization (Brinkmann & Gendolla, 2007). In addition to SBP, we also collected dystolic blood pressure (DBP), and pulse rate (PR); all cardiovascular measures were collected with the GE Carescape v100 monitor with an automatically inflatable cuff on the participant's non-dominant arm using an oscillometric measure of blood pressure. We collected 8 minutes of baseline data (Brinkmann et al., 2009) prior to and 5 minutes of performance data during the completion of each of the three difficulty levels of the memory task. The blood pressure cuff automatically inflated every two minutes beginning at the start of the baseline and the start of the memory task yielding 4 baseline data points and 3 performance data points for each task difficulty level. Changes in cardiovascular reactivity was measured as the difference between the physiological measures collected during the performance periods and the baseline period prior to the task.

**Procedure**

People who were interested in the research study completed the online screening questionnaire and a demographic form; those who were eligible for the study were called or emailed and scheduled for an appointment on the UMD campus.

If individuals elected to participate in the study, they were emailed a copy of the informed consent form and online links to complete the SPQ, SAS-SR, and TEPS prior to their scheduled appointment. They were instructed to complete these measures at home in order to minimize the duration of the study visit. Participants were reminded via email to complete the measures before they arrived to the lab. Participants were re-consented with a researcher when they arrived to lab. If participants had not completed the measures prior to their arrival they were asked to do so during their lab assessment.

After the informed consent procedures, participants read a magazine for an 8 minute baseline measure with blood pressure monitored at two minute intervals. Then, they read the instructions for the memory task, answered the three questions about the task, and commenced the memory task. Subsequently, participants removed the blood pressure monitoring equipment and read the instructions for the EEfRT. Next, they completed the 20 minute EEfRT. Lastly, participants were given the BDI-II and any remaining self-report questionnaires to complete. Participants were debriefed and compensated with either UMD course credit or cash ($10/hour), the "reward" of $8 for the EEfRT, and any entries earned toward the $50 raffle at the completion of the study visit.

**Data Analysis**

SPSS was used to conduct the analyses. One-way ANOVA's and Pearson Chi-Squared analyses were conducted to determine differences in participant characteristics (e.g., age, sex, schizotypy). Generalized estimating equation (GEE) models were used to test the effects of probability, reward, and group on effortful

decision making; the first 50 trials for each participant was used for consistency of GEE analysis following Treadway et al., (2009). A repeated-measures ANOVA was used to assess cardiovascular reactivity change in SBP, DBP, and PR across memory task difficulty levels and between the three participant groups. One-way ANOVA's were also conducted to examine anticipatory/consummatory pleasure, depression, and social functioning across groups. Finally, correlations were run between the self-report measures and both the proportion of hard tasks chosen on the EEfRT and measures of cardiovascular reactivity.

## Chapter 3: Results

### Overview

We will review the stages of our analysis below. First, we examine demographic data across the social anhedonia (SocAnh), perceptual aberration and magical ideation (PerMag), and control groups with Pearson Chi-Square analysis and one-way ANOVAs. Second, we assessed group differences across clinical characteristics (schizotypy) with a one-way ANOVA. Third, we examined group differences in effortful decision making with the EEfRT across probability levels and with respect to reward value. Fourth, we tested whether there were group differences in physiological measures of effort mobilization during the memory task. We also examined group differences in the appraisals of the memory task and their working memory performance. Fifth, we conducted correlations between anticipatory pleasure, depressive symptoms, and social functioning and the proportion of hard tasks chosen in the EEfRT as well as the measures of effort mobilization as measured by cardiovascular reactivity within each group. We also assessed the within group correlations between schizotypy and the other clinical and functioning variables. Through these analyses, we hope to identify whether individuals with elevated social anhedonia are distinct from controls and individuals high in positive schizotypy on multiple measures of motivation and effort.

### Demographics and Clinical Characteristics

One hundred individuals from the University of Maryland, College Park campus recruited during between 2011 and 2012 participated in the study. The sample was comprised of 74% women with a mean age of 19.89 (*SD* = 2.55), and

53% of participants identified as Caucasian, 19% identified as African American, 19% identified as Asian, 5% identified as Hispanic, and 4% identified as 'Other.' Participants were divided into SocAnh ($n$ = 30), PerMag ($n$ = 30), and control ($n$ = 40) groups. Demographic data for each group are presented in Table 1. The results of Pearson Chi-Square analyses reflected similarities in gender, handedness, and race across the SocAnh, PerMag, and control groups ($p$'s > .05). An ANOVA revealed a significant difference in age between the three groups ($F(2, 97) = 4.45$, $p = .01$). In subsequent independent sample t-tests, we identified that the PerMag group ($M$ = 18.77, $SD$ = 0.97) was significantly younger than the SocAnh group ($M$ = 20.40, $SD$ = 3.35); $t(33.85) = 2.57$, $p = .02$). The PerMag group was also significantly younger than the control group ($M$ = 20.35, $SD$ = 2.47); $t(53.72) = 3.70$, $p = .001$. However, the SocAnh and control groups were not statistically different in age ($p > .05$). Due to the significant group difference found above, we examined effects controlling for age in all subsequent analyses that allowed for the use of covariates.

Clinical characteristics are presented in Table 2. The three groups significantly differed with respect to total schizotypal (SPQ) scores ($F(2, 97) = 17.52$, $p < .001$, $\eta^2 = .27$). Participants in the SocAnh and PerMag groups had significantly greater total schizotypy than the control group; $t(43.45) = -5.95$, $p < .001$ and $t(40.19) = -4.09$, $p < .001$, respectively. Upon examining the subscales of the SPQ, the SocAnh and PerMag groups exhibited significantly greater scores in the cognitive perceptual domain of the SPQ (positive schizotypy) relative to controls; $t(37.36) = -4.18$, $p < .001$ and $t(35.67) = -5.13$, $p < .001$, respectively. Additionally, the SocAnh group displayed significantly higher scores in the interpersonal domain of the SPQ

(negative schizotypy) relative to both the PerMag ($t(58) = -3.62$, $p = .001$) and control groups ($t(68) = -5.98$, $p < .001$).

**Effortful Decision Making**

To examine our hypothesis that the SocAnh group would display diminished effortful decision making compared to controls and the PerMag group, we conducted a generalized estimating equations (GEE) analysis to evaluate 1) group differences in selecting to complete a hard task for reward across all trials, 2) interactions between group and probability of reward, 3) interactions between group and the hard task reward value, and 4) the relationship between group, probability level, and reward value to assess the conditions under which group differences in effortful decision making emerge. Proportions of choosing the hard task across groups are presented in Table 3. Reward value was decomposed into three levels according to Damiano, Aloi, Treadway, Bodfish, & Dichter (2012): small is defined as any value between $1.24 and $2.00, medium as values between $2.01 and $3.00, and large as values between $3.01 and $4.12. Due to group differences in age, we included age as a covariate in our analysis. Given that Treadway and colleagues (2009) found a main effect of gender on the overall proportion of hard tasks chosen, we used a one-way ANOVA to assess gender across all participants. We found no main effect of gender on the total proportion of hard tasks chosen ($F(1, 98) = 1.33$, $p = .25$) and, thus, did not include gender as a variable in our analyses.

**Data reduction and analyses.** All participants completed 20 minutes of trials on the EEfRT, and the amount of trials varied across participants ($M = 53.13$, $SD = 7.42$, range = 31-76). We used the first 50 trials for each participant, which is

consistent with the original study using the EEfRT (Treadway et al., 2009). Participants who completed less than 50 trials were included in analyses with missing trial data only comprising 3.1% of the total data representing effortful decision making. We also examined group differences in total trials attempted, but this difference was not significant ($F(2, 97) = 1.27$, $p = .28$), and total trials attempted was not included as a covariate in our analyses. The GEE analyses were conducted in SPSS 20 using an unstructured correlation matrix and a binary logistic distribution to model the dichotomous outcome of choosing the hard vs. easy task in the EEfRT. Wald chi-square statistics were tested with a Type III sums of squares approach, two-tailed. We chose to analyze the EEfRT data with GEE as it does not assume linearity or normality of data, and using GEE is consistent with prior studies using the EEfRT (e.g., Treadway et al., 2009). We conducted a full-factorial GEE analysis that included main effects of Group (SocAnh vs. PerMag vs. Controls), Probability (12% vs. 50% vs. 88%), and Reward (Low vs. Medium vs. High), two-way interactions of interest (Group x Probability, Group x Reward, Probability x Reward), and the three-way interaction between Group, Probability, and Reward. Group, Probability and Reward were entered as between subjects factors, Trial Number was entered as a within subjects variable, and Age was entered as a covariate. In post hoc analyses within the main effects and interactions sections below, we present means which are estimated marginal means that account for the covariate of age in the GEE model. The power for our highest three-way interaction was 0.94, which was calculated with a Monte Carlo simulation in MPlus.

**Main effects.** Our GEE model revealed a non-significant main effect of group ($\chi 2$ (2) = 4.384, $p$ = .11), reflecting similar levels of effort across groups across all trials while not taking either probability or reward value into consideration. However, there was a significant main effect of probability on the tendency to choose the hard task to obtain rewards ($\chi 2$ (2) = 417.10 $p$ < .001). Post-hoc probing of pairwise comparisons indicated that greater probability of reward was associated with more effort (choosing the hard task more frequently) across all three groups. Participants chose the hard task more often with the high (88%) probability of reward ($M$ = .78, $SE$ = .02) compared to the medium (50%) probability of reward ($M$ = .52, $SE$ = .03) (Mean difference = .25, $SE$ = .023, $p$ < .001) and the low (12%) probability of reward ($M$ = .24, $SE$ = .02) (Mean difference = .53, $SE$ = .02, $p$ < .001). Participants also displayed a higher proportion of hard tasks chosen in trials with a medium probability trials compared to those with a low probability of reward (Mean difference = .28, $SE$ = .02, $p$ < .001). When controlling for depression, our analyses maintained significance.

The main effect of reward was also significant in that participants in the three groups more frequently chose the hard task with the opportunity for greater magnitude of reward ($\chi 2$ (2) = 274.82, $p$ < .001). Post hoc analyses revealed that participants chose the hard task more often with high reward values above $3.00 ($M$ = .70 $SE$ = .03) than with medium reward values between $2.01 and $3.00 ($M$ = .55, $SE$ = .02) (Mean difference = .15, $SE$ = .02, $p$ < .001) or low reward values $2.00 and below ($M$ = .30, $SE$ = .02) (Mean difference = .40, $SE$ = .032, $p$ < .001). Participants also chose the hard task more frequently in trials with medium reward values relative

to those with low reward values (Mean difference = .25, *SE* = .02, $p < .001$). The above analyses remained significant when controlling for depression scores.

**Interactions.** There was a significant two-way interaction between group and probability ($\chi 2$ (4) = 9.55, $p < .05$). Post hoc comparisons indicated that within trials with a low (12%) probability of reward, the SocAnh group (*M* = .31, *SE* = .04) and the control group (*M* = .24, *SE* = .03) chose a similar proportion of hard tasks (Mean difference = -.06, *SE* = .05, *p* = .18). The control and PerMag (*M* = .19, *SE* = .03) groups also chose a comparable number of hard tasks on trials with low probability of reward (Mean difference = .06, *SE* = .04, *p* = .14). However, the SocAnh group chose the hard task significantly more than the PerMag group (Mean difference = -.12, *SE* = .05, *p* = .01).

Within trials with a medium (50%) probability of reward, the SocAnh group (*M* = .64, *SE* = .05) demonstrated more effortful decision making than the control (*M* = .49, *SE* = .05) and PerMag groups (*M* = .45, *SE* = .05) (Mean difference = .15, *SE* = .07, *p* = .04 and Mean difference = .19, *SE* = .07 *p* = .01, respectively). The control and PerMag groups were not significantly different in choosing the hard task on trials with medium probability of reward (Mean difference = .04, *SE* = .07, *p* = .57).

In the trials with a high (88%) probability of reward, there were no significant differences in proportion of hard tasks chosen between the SocAnh group (*M* = .78, *SE* = .04) and controls (*M* = .76, *SE* = .02) (Mean difference = .02, *SE* = .05, *p* = .74), between the SocAnh and PerMag (*M* = .79, *SE* = .03) groups (Mean difference = -.01, *SE* = .05, *p* = .83), or between the control and PerMag groups (Mean difference = -.03, *SE* = .04, *p* = .51. To summarize the results of the two-way interaction of group

and probability, unexpectedly, the SocAnh group exhibited greater effortful decision making than controls on trials with the greatest uncertainty of reward (50% probability). Additionally, individuals in the SocAnh group chose the hard task more frequently than individuals in the PerMag group in trials with both 12% and 50% probability of reward.

The two-way group x reward interaction was not significant ($\chi 2$ (4) = 7.36, $p$ = .12), but we did find that the three-way group x probability x reward interaction was significant ($\chi 2$ (8) = 17.71, $p$ = .02). We conducted post hoc analyses for the three-way interaction, and results from the pairwise comparisons are described below.

In trials with low (12%) probability of reward and low reward value, unexpectedly, the SocAnh ($M$ = .22, $SE$ = .03) displayed higher levels of effort than controls ($M$ = .16, $SE$ = .02), but this difference was not significant (Mean difference = .05, $SE$ = .04, $p$ = .16). However, the SocAnh and control groups chose the hard task significantly more than the PerMag group ($M$ = .08, $SE$ = .02) (Mean difference = .13, $SE$ = .04, $p$ < .001 and Mean difference = .08, $SE$ = .03, $p$ = .002, respectively). There were no significant group differences in trials with the medium and high reward values with corresponding low probability of receiving those rewards. We found consistent results when controlling for depression.

In trials with medium (50%) probability of reward and low reward value, the SocAnh ($M$ = .40, $SD$ = .05) group displayed greater levels of effort than both controls ($M$ =.24, $SD$ = .04) and the PerMag group ($M$ = .24, $SE$ = .04) (Mean difference = .16, $SE$ = .06, $p$ = .01 and Mean difference = .15, $SE$ = .07, $p$ = .02, respectively). Similar results were found in the medium reward value trials with the

SocAnh group ($M$ = .68, $SD$ = .05) showing higher levels of effort compared to controls ($M$ = .53, $SD$ = .05) and the PerMag group ($M$ = .49, $SD$ = .06) (Mean difference = .15, $SE$ = .07, $p$ = .05 and Mean difference = .18, $SE$ = .08, $p$ = .02, respectively). In trials with high reward values, the SocAnh group ($M$ = .80, $SD$ = .05) showed significantly greater effort than the PerMag group ($M$ = .62, $SD$ = .06) (Mean difference = .18, $SE$ = .08, $p$ = .02). There were no additional group differences of significance in with a medium probability of reward. The results remained significant when controlling for depression.

Finally, in trials with a high (88%) probability of reward and low reward values, the post hoc analyses revealed no significant group differences in trials with across all reward levels. When controlling for depression, null results were found.

**Invariant responding and completion rates.** To further characterize the responses of the three study groups, we assessed rates of invariant responding and completion rates to assess possible effects of fatigue. Across the SocAnh, PerMag, and control groups, all participants chose a mix of hard and easy tasks to complete except for two participants; one participant in the SocAnh group chose the easy task for all trials, and one participant in the control group chose the hard task for all trials. There was also a significant difference in the percentage of completed trials (out of attempted trials up to the cutoff of 50) across groups ($F$(2, 4844) = 34.90, $p$ < .001). The control group ($M$ = .95, $SD$ = .22) completed a smaller percentage of trials than the SocAnh ($M$ = .99, $SD$ = .09) ($t$(2795.28) = -7.76, $p$ < .001) and PerMag groups ($M$ = .98, $SD$ = .13) ($t$(3192.39) = -6.09, $p$ < .001). No significant difference was identified for the proportion of completed trials between the SocAnh and PerMag

groups ($t(2682.88) = -1.68$, $p = .09$). On average, each group completed between 95% and 99% of trials with an overall average of 97%, suggesting minimal evidence of fatigue during the task.

In summary, contrary to predictions, individuals with elevated social anhedonia exhibited more effortful decision making for rewards in the EEfRT relative to controls and individuals high in positive schizotypy in trials with the greatest uncertainty of reward (50% probability). Additionally, both the SocAnh and control groups exhibited higher proportions of choosing the hard task relative to the PerMag group in trials with the lowest probability of reward (12%). Furthermore, our results do not appear to be impacted by the presence of depressive symptoms. These findings fail to support our hypothesis that the SocAnh group would be characterized by diminished expressions of effortful intent.

**Physiological Effort Mobilization**

To address the hypothesis that the SocAnh group will exhibit less physiological effort mobilization as measured by indices of cardiovascular reactivity (systolic blood pressure, diastolic blood pressure, and pulse rate,) we used one-way and repeated-measures ANOVAs, given that our data approximated a normal distribution and were not highly skewed. Baseline and cardiovascular reactivity data are presented in Table 4. First, we examined whether there were group differences in the baseline measures of the above cardiovascular variables with a one-way ANOVA. Baseline scores were computed as the mean of the last three data points collected during the 8 minute habituation period (Cronbach's $\alpha$'s > .93). No significant differences in baseline were detected between groups for systolic blood pressure and

pulse rate. However, the results of the one-way ANOVA were significant for group differences in baseline diastolic blood pressure ($F(2, 97) = 5.99$, $p < .01$). Thus, we included the baseline condition as a covariate for the diastolic blood pressure analyses. For all repeated-measures ANOVA analyses, we also used body mass index (BMI) and age as covariates, as these variables have been noted as predictors of cardiovascular reactivity and basal blood pressure (Matthews & Stoney, 1988; Steptoe & Wardle, 2005). Cardiovascular task scores were comprised of the means of all measures obtained within each of three difficulty levels of the memory task; three data points were collected from each 5 minute difficulty level.

Next, we conducted the repeated measures ANOVAs to assess main effects of group and memory task difficulty (3 levels: easy, medium, and hard). Surprisingly, our results for the analysis of systolic blood pressure revealed non-significant effects of group ($F(2, 95) = 1.26$, $p = .29$, partial $\eta^2 = .03$), memory task difficulty ($F(2, 190) = .49$, $p = .62$, partial $\eta^2 = .01$), and the interaction of group and memory ($F(4, 190) = .77$, $p = .55$, partial $\eta^2 = .02$). Parallel results were also evident in the analyses of diastolic blood pressure with non-significant main effects of group ($F(2, 94) = 2.39$ $p = .10$, partial $\eta^2 = .05$), task difficulty ($F(2, 188) = .65$, $p = .52$, partial $\eta^2 = .01$), and the interaction of group and memory ($F(4, 188) = .19$, $p = .94$, partial $\eta^2 = .004$). Finally, we found similar null results for pulse rate, with no significant main effects of group ($F(2, 95) = 1.11$, $p = .33$, partial $\eta^2 = .02$), task difficulty ($F(1.83, 173.34) = .14$, $p = .85$, partial $\eta^2 = .001$), and the interaction of group and memory ($F(3.65, 173.34) = .49$, $p = .72$, partial $\eta^2 = .01$). When we conducted the above analyses with change scores (measurements from each task difficulty relative to baseline), the

results were also non-significant. Thus, our hypothesis that individuals high in social anhedonia would display decreased physiological effort mobilization relative to controls and individuals with increased positive schizotypy was not supported by our data.

**Ancillary analyses.** Given our findings above, we assessed whether another variable might account for our null results. We investigated the effect of gender on all of the cardiovascular baseline measures across groups. Using one-way ANOVAs, we found that there was significant effect of gender on baseline systolic blood pressure ($F(1, 98) = 25.76$, $p < .001$). Given the baseline differences in gender, we conducted repeated measures ANOVAs, controlling for age and BMI, to assess gender differences within the SocAnh, PerMag, and control groups for the average measures of systolic blood pressure during memory task performance.

When examining systolic blood pressure, we found a significant gender effect in the control group ($F(1, 36) = 28.43$, $p < .001$) during memory task performance. Subsequent independent sample t-tests revealed that male controls tended to have higher rates of systolic blood pressure than female controls during the easy ($t(38) = 5.08$, $p < .001$), medium ($t(12.79) = 3.35$, $p < .01$), and hard ($t(38) = 5.05$, $p < .001$) memory tasks performance. There were no significant effects of gender on performance systolic blood pressure in the SocAnh ($F(1, 26) = 1.74$, $p = .20$) or PerMag groups ($F(1, 26) = 2.80$, $p = .11$). In sum, only in the control group did we identify any gender differences on physiological measures of effort, and this difference persisted across all levels of the memory task with males having higher systolic blood pressure than females.

**Task appraisals and cognitive ability.** During the memory task, participants were asked three questions about their appraisals of task difficulty, expected performance, and importance of successful performance on the task prior to starting each difficulty level (easy = four letter strings, medium = seven letter strings, hard = 15 letter strings). Task appraisal data are presented in Table 5. To assess within and between group differences on task appraisals, we conducted a series of repeated measures ANOVAs, controlling for age. With respect to subjective ratings of task difficulty, the main effects of group ($F(2, 96) = 1.48$, $p = .23$, partial $\eta^2 = .03$) and task difficulty ($F(1.75, 168.29) = .03$, $p = .95$, partial $\eta^2 < .001$) were not significant as was the group x task interaction ($F(3.51, 168.29) = 1.60$, $p = .18$, partial $\eta^2 = .03$). Likewise for ratings of predicted performance, we also found no significant effect of group ($F(2, 96) = 1.59$, $p = .21$, partial $\eta^2 = .03$), task ($F(1.86, 178.39) = 2.12$, $p = .13$, partial $\eta^2 = .02$), or the group x task interaction ($F(3.72, 178.39) = 1.62$, $p = .18$, partial $\eta^2 = .03$). Lastly, with regard to ratings of importance of successful task completion, there was no significant effect of group ($F(2, 96) = .77$, $p = .47$, partial $\eta^2 = .02$) or the group x task interaction ($F(3.40, 163.14) = .19$, $p = .23$, partial $\eta^2 = .004$). However, the main effect of task on importance appraisals was significant ($F(1.70, 163.14) = 8.58$, $p = .001$, partial $\eta^2 = .08$), but subsequent paired t-tests indicated no significant differences in importance ratings between memory task levels ($p$'s > .05). Thus, we did not find between or within group differences in appraisals of task difficulty, predicted performance, and importance of successful performance on the memory task.

Finally, we assessed group differences in cognitive ability by comparing the number of correctly recalled letter strings. Working memory performance (measured by a composite mean score of correctly recalled letter strings) did not differ between the three groups ($F(2, 97) = .62$, $p = .54$), which suggests that individuals with elevated levels of social anhedonia do not have impaired working memory on a visual memory task relative to controls and individuals with elevated positive schizotypy.

**Exploratory analyses.** To assess whether cognitive ability and task appraisals play a role in effortful decision making within groups, we conducted exploratory partial correlations, controlling for age (Table 6). Correlations between working memory on the memory task and the total proportion of hard tasks chosen on the EEfRT were not significant for the SocAnh, PerMag, or control groups ($r$'s = .08, .07, and .18, respectively, $p > .05$). Thus, working memory ability did not appear to impact the extent to which participants made more effortful decision on the EEfRT. Next, we conducted correlations between the total proportion of hard tasks chosen on the EEfRT and memory task appraisals of difficulty, predicted performance, and importance averaged across the three task levels. In the PerMag group, participants who perceived the memory task as being more difficult displayed more effortful decision making on the EEfRT ($r = .41$, $p = .03$), which may reflect an adaptive choice to expend more effort if PerMag participants perceive a greater need to do so. We also evaluated relationships between working memory and task appraisals within groups. Working memory was only associated with task appraisals in the PerMag group. In the PerMag group, greater working memory ability was correlated with greater predicted performance (r = .56, p = .002) and rating the memory task as less

difficult (r = -.45, p = .01). Lastly, the SocAnh, PerMag, and control groups demonstrated a relationship between perceived task difficulty and predicted performance in that the more difficult the memory task seemed, the less well participants expected to perform (r's = -.48, -.60, and -.60, respectively, p's < .01). No additional correlations between memory task appraisals and hard tasks chosen on the EEfRT were significant. In our sample, cognitive ability was related to appraisals of task difficulty and predicted performance in the PerMag group, and perceiving the memory task as more difficult was correlated with more frequent decisions to expend greater effort for monetary reward. However, it is unclear why the above relationship would appear only in the individuals with elevated positive schizotypy and not across all participants.

**Symptom Measures and Functional Impairment**

To test our hypothesis that the SocAnh group would be characterized by deficits in anticipatory and consummatory pleasure (TEPS), higher depressive scores (BDI-II), and greater social functioning impairment (SAS) compared to controls and the PerMag groups, we used a series of one-way ANOVAs (Table 2). Unexpectedly, there were no group differences in anticipatory ($F(2, 97) = 2.35$, $p = .10$) or consummatory pleasure ($F(2, 97) = 1.07$, $p = .35$, but differences in depressive symptoms ($F(2, 97) = 7.44$, $p = .001$) and social functioning ($F(2, 97) = 6.78$, $p = .002$) surfaced between the three groups. Individuals in the SocAnh group had significantly higher depression scores than individuals in the control ($t(40.68) = 3.36$, $p = .002$) and PerMag ($t(50.24) = 2.27$, $p = .03$) groups. The control and PerMag groups did not display significantly different depressive scores ($t(68) = -1.24$, $p =$

.22). Additionally, greater impairment in social functioning was evident in the SocAnh group compared to controls ($t(68) = 3.26$, $p = .002$) and the PerMag group ($t(48.09) = 2.67$, $p = .01$). The control and PerMag groups demonstrated similar levels of social functioning ($t(68) = -.66$, $p = .51$). Though our findings do not support our hypothesis that anticipatory and consummatory pleasure would be disrupted in the SocAnh group, they do provide evidence for our hypotheses that individuals high in social anhedonia experience more depressive symptoms and greater social functioning impairment in comparison to controls and individuals high in positive schizotypy.

**Correlations**. To assess the relationship between the self-report measures above and 1) effortful decision making and 2) physiological measures of effort mobilization, we conducted a series of partial correlations. Controlling for age, we examined partial correlations between anticipatory pleasure, depression, and functional impairment and effortful decision making (proportion of hard tasks chosen); correlations are presented in Table 7. In the SocAnh and PerMag groups, we found no significant correlations between the proportions of hard tasks chosen on the EEfRT with the self-report measures ($p$'s > .05). However, in the control group, there was an unexpected significant negative relationship between consummatory pleasure and overall effortful decision making on the EEfRT, indicating that greater effort in the context of monetary reward is associated with less consummatory pleasure ($r = -.34$, $p < .05$).

Next, we conducted partial correlations, controlling for age, between the three self-report variables and cardiovascular measures of effort; correlations are presented

in Table 8. There were no significant relationships with systolic blood pressure within any of the three participant groups (p's > .05). There were significant correlations, however, between anticipatory pleasure and the diastolic blood pressure baseline ($r$ = -.39, $p$ = .04) and easy memory task performance ($r$ = -.47, $p$ = .01) measures in the PerMag group. This suggests that individuals high in positive schizotopy experienced lower levels of diastolic blood pressure with increased self-reported anticipatory pleasure. Relationships between the self-report measures and cardiovascular measures were also identified in the SocAnh and control groups. Individuals high in social anhedonia who had greater self-reported anticipatory pleasure exhibited decreased pulse rate during the baseline ($r$ = -.41, $p$ = .03) and hard memory task performance ($r$ = -.37, $p$ < .05) periods, indicating that lower pulse rates are related to better anticipatory pleasure functioning. In controls, social functioning was positively correlated with pulse rate during the easy memory task performance ($r$ = .38, $p$ < .05), which suggests that better social functioning is related to higher pulse rate in a low demand memory ask.

To further characterize the relationship between the self-report measures used in the study, we conducted partial correlations, controlling for age, between measures of schizotypy, anticipatory and consummatory pleasure, depression, and social functioning within each group; correlations are presented in Table 9.

In the SocAnh group, depressive symptoms on the BDI-II were positively associated with total schizotypy, negative schizotypy (interpersonal subscale of the SPQ), and positive schizotypy (cognitive perceptual subscale of the SPQ) ($r$'s = .59, .40, and .38, respectively, $p$'s < .05), indicating that elevated schizotypy is associated

with increased depressive symptoms. As expected, worse social functioning was also positively correlated with depressive symptoms ($r = .72$, $p < .001$), as well as total, positive, and negative schizotypy ($r$'s = .55, .38, .40, $p$'s < .05) in the SocAnh group. Anticipatory pleasure on the TEPS was negatively correlated with depression ($r = -.39$, $p = .04$), social functioning ($r = -.45$, $p = .02$), and negative schizotypy ($r = -.52$, $p = .004$) such that anticipatory pleasure deficits were related to higher rates of depressive symptoms, worse social functioning, and greater negative schizotypy (including social anhedonia). There were no significant correlations between consummatory pleasure and the other self-report measures. Interestingly, anticipatory and consummatory pleasure was not significantly correlated ($r = .17$, p = .39), possibly reflecting a decoupling of these hedonic experiences in individuals with elevated social anhedonia.

In the PerMag group, as expected, anticipatory and consummatory pleasure were significantly correlated ($r = .53$, $p = .003$). However, no other correlations between anticipatory or consummatory pleasure, schizotypal symptoms, depressive symptoms, or social functioning were significant within this group characterized by positive schizotypy. In the control group, anticipatory and consummatory pleasure also had a significant relationship ($r = .51$, $p = .001$) with each other. We found that total schizotypy was negatively correlated with anticipatory ($r = -.37$, $p = .02$) and consummatory pleasure ($r = -.36$, $p = .02$), and positive schizotypy was related to consummatory ($r = -.32$, p < .05) but not anticipatory pleasure ($r = -.30$, $p = .07$). Additionally, social functioning was positively correlated with total, positive, and negative schizotypy ($r$'s = .46, .47, .38, $p$'s < .05), indicating that worse social

functioning was related to higher levels of schizotypy. No other relationships among the self-report measures were significant.

Thus, in the SocAnh group, there were significant relationships between depression, schizotypy, anticipatory pleasure, and social functioning. Controls exhibited relatively similar significant relationships among the schizotypy, anticipatory and consummatory pleasure, and social functioning, whereas the PerMag group did not display significant associations between the self-report measures.

## Chapter 4: Discussion

This study sought to examine the nature of motivation and effort and individuals with social anhedonia by assessing behavioral, physiological, and self-report measures of effort. First, we hypothesized that, compared to controls and individuals with elevated positive schizotypy, individuals with social anhedonia would demonstrate diminished effortful decision making on the EEfRT by choosing a smaller proportion of hard tasks. Second, we hypothesized that individuals with social anhedonia would demonstrate less physiological effort mobilization compared to individuals in the PerMag and control groups, as measured principally by systolic blood pressure during a cognitively demanding memory task. Third, we hypothesized that individuals in the SocAnh group would exhibit greater anticipatory and consummatory pleasure deficits, higher depressive scores, and increased functional impairment, compared to the PerMag and control groups. Furthermore, we expected these variables to correlate with effortful decision making on the EEfRT and systolic blood pressure measures of effort mobilization on the memory task.

Our first hypothesis that the SocAnh group would display diminished effortful decision making on the EEfRT was not supported by our results. Individuals with social anhedonia displayed a distinct pattern of effortful decision making on the EEfRT compared to controls and individuals with positive schizotypy. However, this pattern was in an unexpected direction, namely, elevated social anhedonia was associated with more effortful decision making on the EEfRT, as indexed by the proportion of choosing to perform the hard task, rather than the easy task, in the face of monetary rewards. Particularly, in trials with a medium (50%) probability of

reward and the potential to earn a low to medium reward ($3.00 or less), the SocAnh group displayed more effortful decision making than both controls and individuals in the PerMag group. The SocAnh group also displayed more effortful decision making than the PerMag group in the low (12%) probability/low reward trials ($2.00 or less) as well as the medium probability/high reward trials ($3.01 or more). Within the control group, anhedonia (as measured by consummatory pleasure on the TEPS) was similarly related to a greater tendency to choose the hard task for rewards on the EEfRT.

This is the first study using the EEfRT to compare a group of individuals high in social anhedonia with controls and a group characterized by elevated positive schizotypy, and we replicated Treadway and colleagues' (2009) general finding that individuals choose a higher proportion of hard tasks with increasing probability of reward and reward magnitude. Unexpectedly, our results are inconsistent with their prior finding that increased anhedonia was related to less effortful decision making in trials with the most uncertain of probabilities (50%) and high reward values (Treadway et al., 2009). However, our counterintuitive finding that social anhedonia was related to more effort is in line with recent reports that higher mean depressive scores on the BDI-II, often characterized by anhedonia, were related to more effortful decision making on the EEfRT within a group of patients with major depression (Treadway, Bossaller, Shelton & Zald, 2012). When analyzing individual items from the BDI-II, Treadway and colleagues (2012) also noted that specifically higher anhedonia scores that reflect a deficit in consummatory pleasure (as measured by item 4 of the BDI-II, loss of pleasure) were related to choosing the hard task more often.

On the other hand, they proposed that greater pessimism scores (as measured by item 2 of the BDI-II, pessimism) represented deficits in anticipatory pleasure, and they found that these deficits were associated with less willingness to work for reward on the EEfRT. Though Treadway and colleagues (2012) identified significant relationships between anticipatory and consummatory pleasure and effortful decision making, their analysis is limited by the use of individual items. In our study, we did not find significant correlations between measures of anticipatory pleasure using the TEPS in any of our three study groups, but less consummatory pleasure was significantly related to more willingness to work for reward on the EEfRT.

It may be that undergraduates with elevated social anhedonia are, in fact, responsive to probability and reward cues, but they may be using the cues and allocating their effortful resources less efficiently than controls and individuals with increased positive schizotypy. If people with social anhedonia tend to make more effortful decisions with less guarantee of reward outside of the laboratory, they may be at risk for constructing situations in which they learn over time with increased negative feedback that rewards are not worth the effort to pursue. If this were true, it would have implications for motivated decision making in academic, social, and work domains.

Alternatively, individuals with heightened social anhedonia may not lack the motivation to work for rewards when they are made available, as is the case in laboratory studies using a reward task, but instead they may potentially lack the opportunities or skill to gain access to rewards, especially social rewards. It is possible that when social rewards are not available, other types of rewards like money

may become more salient for people with social anhedonia, given that the SocAnh group in the current study responded with more effort than controls and the PerMag group to monetary rewards on the EEfRT. Therefore, we may not be able to assume that monetary rewards are equivalently valued across groups or that participants would respond similarly to monetary and social rewards. Overall, our findings indicate a unique effortful decision making profile in individuals with social anhedonia, but the nature of this profile warrants further investigation.

Our second hypothesis that individuals with social anhedonia would demonstrate less physiological effort mobilization compared to individuals in the PerMag and control groups was not supported by our data and may not have been possible to test in our study due to insufficient task manipulation. We describe our findings and, given the absence of predicted cardiovascular reactivity in controls, explain the limitations of testing group differences in cardiovascular reactivity below.

We did not find significant group differences with respect to absolute values or change scores (memory performance minus baseline) on measures of cardiovascular reactivity (systolic and diastolic blood pressure and pulse rate). Thus, individuals with social anhedonia did not display differential rates of systolic blood pressure or any collected measure of cardiovascular reactivity in response to a three-difficulty level memory task in our study. Our results are contrary to prior findings using a similar letter string memorization task in an undergraduate sample high in dysphoric symptoms that demonstrated greater mental effort as measured by systolic blood pressure reactivity compared to undergraduates low in dysphoric symptoms (Brinkmann & Gendolla, 2007). On the other hand, they are consistent with null

findings of group differences with respect to diastolic blood pressure and heart rate (Brinkmann & Gendolla, 2007, 2008). Of note, in the control group, there were significant gender differences with male participants displaying higher systolic blood pressure than females, but this does not seem to explain the lack of group differences, as main effects of gender were not present in the SocAnh and PerMag groups.

One explanation for why we did not find significant group differences in physiological measures of effort is that there were no within or between group differences in subjective appraisals of the memory task. Individuals in the SocAnh, PerMag, and control groups made similar ratings for the easy, medium, and hard levels (memorizing 4, 7, and 15 letter strings) of the memory task with respect to task difficulty, predicted performance, and importance of successful performance. Additionally, no group effects of cognitive ability on the memory task were evident in our findings, and all three groups were able to remember a similar amount of letter strings across all memory task conditions. Thus, participants did not perceive the increasingly difficult levels of the memory task as becoming significantly harder to complete, which is reflected by their minimal cardiovascular reactivity to the task, and they had comparable working memory abilities to do so.

This is the first study to date to examine physiological effort mobilization in individuals with elevated social anhedonia and positive schizotypy in an extreme groups design. We aimed to assess whether groups high in schizotypy differed in cardiovascular reactivity from controls. However, we were limited in our ability to detect group differences because neither the expected increase in effort mobilization in response to more difficult cognitive tasks nor increases in task difficulty appraisals

were significant across participant groups, suggesting a task manipulation failure. Our null findings may be due to differences in our study procedures and/or sample relative to those in prior studies using systolic blood pressure (as well as diastolic blood pressure and pulse rate) as a measure of cardiovascular reactivity. In terms of study procedure, the conditions of our experiment differed from a prior study that sampled cardiovascular data every minute (Richter & Gendolla, 2006), whereas we used a sampling rate of every two minutes to reduce the physical burden on participants. Perhaps collecting more frequent data points would allow for a more accurate and sensitive measure of cardiovascular reactivity. Additionally, the parameters of our cognitive task may not adequately elicit group differences in cardiovascular reactivity, possibly, as a result of the type of incentive manipulation, clarity of instructions, or task difficulty. Our task may have lacked a sufficient manipulation of incentive or success importance by using entries into a $50.00 raffle as an incentive for performance rather than a potential monetary reward without the added probability of a raffle (e.g., Brinkmann et al., 2009). We used clear task instructions in which we specified how many letter strings participants were to memorize to better understand their appraisals of a range of task difficulties, but other researchers have reported greater reactivity with the use of unclear (participants told to memorize letter strings without knowing how many) instead of clear task conditions (Richter & Gendolla, 2006). Our memory task which has been used in prior studies (e.g., Gendolla & Krüsken, 2002, Richter & Gendolla, 2006) was selected to allow for the assessment of task appraisal, reduce metabolic effects of movement on cardiovascular reactivity, and create a task that tapped a range of

cognitive demand to elicit changes in cardiovascular reactivity, but this is only one of many tasks used in studies of physiological measures of effort. Other studies have used tasks that include the d2 mental concentration task which encourages fast response times (Brinkmann & Gendolla, 2008), comparisons of number pairs of varying length to determine whether they are identical using both reward and punishment (Brinkman et al., 2009), and speaking about a recent life event that caused feelings of depression (Betensky & Contrada, 2010). These tasks are more anxiety provoking than the task used in the current study, and this anxiety may result in greater cardiovascular reactivity. This could have made it more challenging to replicate the effect of task difficulty on measures of cardiovascular reactivity, but given our use of a task that has elicited significant results in prior research (Gendolla & Krusken, 2002) differences in task related anxiety would not account for our null findings. With respect to sample characteristics, our sample was comprised of college students, similar to many studies investigating cardiovascular reactivity, but the studies using the memory task on which we based our task were conducted in European samples that did not describe racial or ethnic data for their participants (e.g., Gendolla & Krüsken, 2002; Richter & Gendolla, 2006). This difference in sample composition has the potential to introduce racial or ethnic differences that could impact comparisons between the studies, as racial differences have been noted in the cardiovascular literature (Anderson, 1989). Finally, our sample was likely underpowered given the small effect sizes of our main and interaction effects of group and task difficulty. In sum, although all participants rated that the easy, medium, and hard stages of the memory task were increasingly difficult, individuals

high in social anhedonia displayed similar levels of cardiovascular reactivity compared to controls and individuals high in positive schizotypy.

Our third hypothesis that individuals with elevated social anhedonia would exhibit decreased anticipatory and consummatory pleasure, higher depressive scores, and increased functional impairment compared to the control and PerMag groups was partially supported by our findings. Prior studies using similar undergraduate samples have also reported worse depression and social functioning in individuals with heightened social anhedonia than controls (Llerena, Park, Couture, & Blanchard, 2012). As expected, we found higher depressive scores and more impaired social functioning in the SocAnh group compared to controls and individuals in the PerMag group who displayed similar levels of depressive symptoms and social functioning with each other. However, we did not find significant group differences in anticipatory or consummatory pleasure.

When assessing correlates of effortful decision making, controlling for age, we also found non-significant correlations between the overall proportion of hard tasks chosen on the EEfRT and the three self-report measures (BDI-II, SAS, TEPS) in the SocAnh and PerMag groups. This is inconsistent with other reports of significant correlations between higher total depressive scores on the BDI/BDI-II and choosing the hard task on the EEfRT more frequently (Treadway et al., 2009, 2012); we cannot make comparisons of our correlations with the SAS or TEPS, as these studies have not assessed the relationship between the EEfRT and social functioning or comprehensive assessments of anticipatory and consummatory pleasure. Also, one correlation was significant in the control group with higher rates of consummatory

pleasure being related to less effortful decision making. This may be a function of the different reward stimuli presented in the TEPS (physical and social experiences) and the EEfRT (money), but it is consistent with the SocAnh group, lower in consummatory pleasure demonstrating more willingness to work for reward. In terms of correlates of physiological effort mobilization, controlling for age, anticipatory pleasure was negatively correlated with cardiovascular measures of effort in the SocAnh and PerMag groups. The finding that greater effort was associated with less anticipatory pleasure may also be related to the different reward stimuli present in the TEPS and the memory task. Furthermore, anticipation of reward may not be directly connected to physiological effort mobilization, because measures of effort require the choice to first engage in effortful tasks. Lastly, in controls, greater physiological measures of effort were associated with better social functioning which may reflect a greater ability to engage in goal-directed activities that might promote better functioning, including functioning in the social realm.

Regarding correlations among the self-report measures of schizotypy, depression, anticipatory/consummatory pleasure, and social functioning, controlling for age, the SocAnh group demonstrated a significant relationship between higher rates of schizotypy and more depressive symptoms as well as less anticipatory pleasure. Other studies examining elevated social anhedonia in undergraduate samples have also reported correlations between increased rates of depression on the BDI and anhedonia (Kerns et al., 2008). Additionally, greater anticipatory pleasure was related to fewer depressive symptoms and lower social functioning. Also, worse social functioning was also related to elevated schizotypy and depressive symptoms

in this group. Our findings are consistent with studies that have reported that anticipatory pleasure deficits were related to higher levels of social anhedonia in individuals with schizophrenia (Favrod, Ernst, Giuliani, & Bonsack, 2009; Gard et al., 2007), and that increased social anhedonia was correlated with worse social functioning (Gard et al., 2007). Our results are contrary, though, to other findings that found no significant correlations between anticipatory pleasure and depression in people with schizophrenia (Strauss et al., 2011b). Interestingly, anticipatory and consummatory pleasure was not significantly correlated in the SocAnh group, whereas in individuals with schizophrenia, correlations between the TEPS subscales have been reported (e.g., Lee, Chun, J. Kang, D. Kang, Park, Kim, 2012). However, in the control and PerMag groups, as predicted, anticipatory and consummatory pleasure were significantly correlated which is in line with other reports of samples that included controls and individuals with schizophrenia and (Strauss et al., 2011b). In controls, we also found that greater schizotypy was related with less anticipatory and consummatory pleasure, and, like the SocAng group, worse social functioning was connected to higher rates of schizotypy.

**Limitations**

A limitation of our study that warrants consideration is that our extreme groups design yielded groups that were distinct in terms of social anhedonia; however, the SocAnh and PerMag groups were not significantly different in terms of positive schizotypy symptoms as measured by the cognitive-perceptual domain of the Schizotypal Personality Questionnaire (SPQ). We used the SPQ to measure levels of positive schizotypy to assess differences in the symptom levels between groups after

recruitment, because our screening questionnaire was based on abbreviated positive schizotypy measures (items from the Perceptual Aberration and Magical Ideation scales). Thus, because the two schizotypy groups were similar, it is difficult to assess the true character of effort related to social anhedonia and positive schizotypy. Furthermore, these SPQ symptom domains were correlated in the PerMag ($r = .62$, $p < .01$) and control groups ($r = .38$, $p < .05$), though not in the SocAnh group, which suggests that trying to establish "pure" samples of positive and negative schizotypy may have been unrealistic with the common co-occurrence of both positive and negative schizotypy triats, and if we had achieved such samples, generalizing our findings to populations that experience both positive and negative schizotypy symptoms would be limited.

Another limitation is the measure of cardiovascular reactivity that we chose to represent effort mobilization during cognitively demanding task. Recent studies (e.g., Richter & Gendolla, 2009) emphasize the need to collect beta-adrenergic reactivity data to ensure for quality measure of effort and to best reflect the underlying mechanisms behind resource recruitment. To address this issue, researchers have begun to collect preejection period data as a reliable measure of beta-adrenergic impact on the heart in addition to systolic blood pressure, dystolic blood pressure, and heart rate data (Richter & Gendolla, 2009). The preejection period is "the time interval between the onset of ventricular depolarization and the opening of the aortic valve," and a shorter preejection period represents greater reactivity (Richter & Gendolla, 2009). Although the preejection period is becoming a more frequently assessed cardiovascular variable in effort mobilization research, systolic blood

pressure remains one of the most reliable measures of cardiovascular reactivity and is generally collected in conjunction with preejection period data (Kemper et al., 2008). Thus, collecting additional measures of cardiovascular reactivity like the preejection period would likely offer a more comprehensive picture of the physiological effort mobilization above and beyond data provided by systolic blood pressure measures that we collected in the present study.

**Conclusions**

This study shed light on the nature of motivation and effort in undergraduate students high in social anhedonia compared to controls and individual with elevated positive schizotypy. Though previous studies have examined effortful decision making in undergraduates (Treadway et al., 2009), the present study aimed to expand our understanding of effortful choices made across groups of students with social anhedonia, positive schizotypy, and controls. Our results suggest that there were significant group differences in how individuals chose to engage in goal-directed behavior with social anhedonia being related to actually more effortful decision making to gain monetary rewards when compared to controls and individuals characterized by positive schizotypy. Although the increase in decision making within the SocAnh group was unexpected, it did lend support for the idea that decreased enjoyment of social interactions is associated with reward and probability processing that is distinct from controls and individuals with greater positive schizotypy. Additionally, our findings reflected greater depressive scores, worse social functioning, and anticipatory pleasure deficits as well as relationships among

these variables in the SocAnh group compared to the other study groups, further characterizing this participant group and supporting results from prior research.

However, our physiological effort mobilization findings were not significantly different between groups or across levels of difficulty on the memory task. We had aimed to assess an objective measure of cardiovascular reactivity to complement our self-report and behavioral assessments of motivation and effort, but our results did not support our hypothesis that social anhedonia would be related to diminished cardiovascular measures of effort. Perhaps, the task that we used was not appropriate to test this hypothesis, given that it did not produce the expected effects of task difficulty in the control group. Alternatively, we may not have had the power to detect main effects in our repeated measures ANOVA analysis. Although our research design is not without limitations, the present study is the first to our knowledge to examine differences in groups of individuals with social anhedonia, positive schizotypy, and controls with respect effortful decision making and physiological effort mobilization. Our findings have helped to continue our growing understanding of how motivation and effort function in individuals with social anhedonia.

To promote the ongoing pursuit of clarifying the nature of and mechanisms behind motivation and effort in individuals with social anhedonia, further research is required. Specifically, to strengthen the link between differences in motivation and effort to achieve reward in the laboratory and real world social functioning, future research would benefit from incorporating social stimuli or real social interaction in reward tasks, as well as including participant appraisals of the reward task. Though

monetary rewards have been used in a number of reward paradigms in the schizophrenia literature (e.g., Heerey et al., 2007), there may be differences in the way patient populations respond to social vs. monetary rewards; such differences have already been cited in individuals with autism (Lin, Rangel & Adolphs, 2012). To clarify the specific of findings in individuals with social anhedonia, more clearly distinguishing those individuals from extreme groups of positive schizotypy would likely aid interpretation of results. Additionally, understanding physiological measures of effort, (e.g., PEP in addition to systolic blood pressure and the role of neurotransmitters like dopamine in reward functioning), is important in the continued study of social anhedonia, because such data are more objective and may contribute to the biological mechanisms behind self-reported and observed differences in motivated behavior. Finally, both effortful decision making and cardiovascular reactivity warrant further research in ultra-high risk populations that more closely approximate individuals with schizophrenia, so that we may come to identify how motivation and effort impact people's social lives early in the course of this condition.

Table 1: Demographic Data for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| | **SocAnh (*n* = 30)** | **PerMag (*n* = 30)** | **Control (*n* = 40)** | **F/ $\chi 2$** |
|---|---|---|---|---|
| | **M (SD)** | | | |
| **Age** | 20.40 (3.35) | 18.77 (.97) | 20.35 (2.47) | $F$ = 4.45* |
| **Gender** | **% (N)** | | | |
| Male | 26.7 (8) | 23.3 (7) | 27.5 (11) | $\chi 2$ = 0.17 |
| Female | 73.3(22) | 76.7 (23) | 72.5 (29) | |
| **Race** | **% (N)** | | | |
| Caucasian | 40.0 (12) | 46.7 (14) | 67.5 (27) | |
| African-American | 33.3 (10) | 20 (6) | 7.5 (3) | |
| Hispanic | 10.0 (3) | 3.3 (1) | 2.5 (1) | $\chi 2$ = 14.79 |
| Asian | 16.7 (5) | 26.7 (8) | 15 (6) | |
| Other | 0 (0) | 3.3 (1) | 7.5 (3) | |
| **Handedness** | **% (N)** | | | |
| Right-handed | 86.7 (26) | 86.7 (26) | 80 (32) | $\chi 2$ = 0.79 |
| Left-handed | 143.3 (4) | 13.3 (4) | 20 (8) | |

*$p < 0.05$

Table 2: Clinical and Social Functioning Data for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| | **SocAnh (*n* = 30)** | **PerMag (*n* = 30)** | **Control (*n* = 40)** | ***F*** | **Effect Size ($\eta^2$)** |
|---|---|---|---|---|---|
| **SPQ Total** | 27.10 (13.09) | 23.37 (14.96) | 11.18 (7.60) | 17.52** | 0.27 |
| Cognitive-Perceptual | 9.30 (6.87) | 11.30 (7.69) | 3.70 (3.01) | 15.60** | 0.24 |
| Interpersonal | 8.47 (3.85) | 4.87 (3.85) | 3.48 (3.14) | 17.13** | 0.26 |
| **BDI-II** | 6.90 (6.18) | 3.83 (4.08) | 2.75 (3.21) | 7.44** | 0.13 |
| **SAS** | 28.37 (9.80) | 22.77 (6.00) | 21.68 (7.40) | 6.78** | 0.12 |
| **TEPS Total** | 79.23 (9.03) | 84.93 (10.15) | 81.33 (11.32) | 2.35 | 0.05 |
| Anticipatory | 42.43 (6.50) | 45.83 (5.29) | 43.78 (6.44) | 2.35 | 0.05 |
| Consummatory | 36.80 (5.33) | 39.10 (6.34) | 37.55 (6.79) | 1.07 | 0.02 |

*$p < 0.05$
**$p < 0.01$
SPQ = Schizotypal Personality Questionnaire; SAS = Social Adjustment Scale; TEPS = Temporal Experience of Pleasure Scale; BDI-II = Beck Depression Inventory

Table 3: Proportion of Hard Tasks Chosen on the EEfRT for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| | **SocAnh (*n* = 30)** | **PerMag (*n* = 30)** | **Control (*n* = 40)** |
|---|---|---|---|
| | Estimated Marginal Means[1] (SE) | | |
| **Total % of Hard Tasks Chosen** | .58 (.04) | .47 (.04) | .50 (.03) |
| **Probability** | | | |
| 12% | .31 (.04) | .19 (.03) | .24 (.03) |
| 50% | .64 (.05) | .45 (.05) | .49 (.05) |
| 88% | .78 (.04) | .79 (.03) | .76 (.02) |
| **Reward Level** | | | |
| Low | .39 (.04) | .23 (.03) | .28 (.03) |
| Medium | .60 (.04) | .54 (.05) | .50 (.04) |
| High | .73 (.05) | .66 (.04) | .71 (.04) |
| **Probability x Reward** | | | |
| **12%** | | | |
| Low | .22 (.03) | .08 (.02) | .16 (.02) |
| Medium | .30 (.04) | .23 (.04) | .24 (.03) |
| High | .42 (.06) | .30 (.05) | .35 (.05) |
| **50%** | | | |
| Low | .40 (.05) | .24 (.04) | .24 (.04) |
| Medium | .68 (.05) | .49 (.06) | .53 (.05) |
| High | .80 (.05) | .62 (.06) | .71 (.06) |
| **88%** | | | |
| Low | .61 (.05) | .48 (.05) | .50 (.04) |
| Medium | .79 (.06) | .84 (.05) | .75 (.05) |
| High | .88 (.04) | .91 (.02) | .91 (.02) |
| | M (SD) | | |
| **Total Trials** | 52.03 (7.92) | 52.13 (7.30) | 54.5 (7.09) |
| **% of Invariant Responders** | 3% (*n* = 1) | 0% (*n* = 0) | 2.5% (*n* = 1) |
| **% Trials Completed** | .99 (.02) | .98 (.05) | .95 (.16) |

[1]Estimated Marginal Means are adjusted for the covariate of age for variables included in GEE analyses.

Table 4: Baseline and Cardiovascular Reactivity Measures for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| **Memory Task Difficulty** | **SocAnh (*n* = 30)** | **PerMag (*n* = 30)** | **Control (*n* = 40)** |
|---|---|---|---|
| | M (SD) | | |
| **Systolic BP** | | | |
| Baseline | 109.01 (11.94) | 105.33 (8.70) | 106.28 (10.38) |
| Easy | 110.44 (12.85) | 107.66 (11.19) | 108.05 (11.02) |
| Medium | 110.92 (12.33) | 109.06 (10.76) | 109.08 (12.70) |
| Hard | 112.99 (12.77) | 110.84 (10.74) | 109.66 (13.06) |
| Easy_change | 1.43 (5.42) | 2.32 (6.66) | 1.77 (6.35) |
| Medium_change | 1.91 (5.19) | 3.72 (6.11) | 2.81 (7.17) |
| Hard_change | 3.98 (5.82) | 5.51 (5.55) | 3.39 (8.22) |
| **Diastolic BP** | | | |
| Baseline | 65.21 (6.95) | 61.23 (5.19) | 60.44 (5.63) |
| Easy | 65.11 (7.08) | 62.23 (6.20) | 63.27 (7.37) |
| Medium | 66.62 (7.93) | 62.71 (6.02) | 64.77 (8.06) |
| Hard | 67.42 (7.42) | 63.22 (6.67) | 65.02 (8.85) |
| Easy_change | -0.09 (5.22) | 1.00 (4.00) | 2.83 (4.40) |
| Medium_change | 1.42 (5.40) | 1.48 (4.65) | 4.33 (5.26) |
| Hard_change | 2.21 (4.15) | 1.99 (4.50) | 4.58 (6.09) |
| **Pulse Rate** | | | |
| Baseline | 76.92 (13.22) | 74.74 (12.01) | 73.33 (13.25) |
| Easy | 79.62 (13.41) | 78.99 (12.47) | 76.33 (11.11) |
| Medium | 81.12 (13.17) | 79.17 (11.42) | 76.09 (10.16) |
| Hard | 81.84 (14.56) | 79.47 (12.00) | 77.85 (11.50) |
| Easy_change | 2.70 (3.52) | 4.24 (6.83) | 3.01 (6.33) |
| Medium_change | 4.20 (7.76) | 4.42 (5.90) | 2.77 (6.34) |
| Hard_change | 4.92 (6.93) | 4.72 (6.91) | 4.52 (7.29) |

BP = blood pressure; X_change = change from baseline to X condition

Table 5: Memory Task Appraisals and Cognitive Ability for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| | | **SocAnh (*n* = 30)** | **PerMag (*n* = 30)** | **Control (*n* = 40)** |
|---|---|---|---|---|
| | | M (SD) | | |
| **Memory Task Appraisals** | Difficulty | | | |
| | Easy | 3.7 (1.58) | 3.93 (1.72) | 2.98 (1.40) |
| | Medium | 4.7 (1.21) | 4.4 (1.43) | 4.25 (1.28) |
| | Hard | 5.77 (1.43) | 5.63 (1.30) | 5.73 (1.52) |
| | Mean difficulty | 4.72 (1.06) | 4.66 (1.10) | 4.32 (1.10) |
| | Predicted Performance | | | |
| | Easy | 5.00 (1.02) | 4.57 (1.59) | 5.48 (1.15) |
| | Medium | 4.50 (0.94) | 4.30 (1.37) | 4.48 (1.09) |
| | Hard | 3.63 (1.40) | 3.40 (1.40) | 3.68 (1.37) |
| | Mean performance | 4.38 (0.83) | 4.09 (1.24) | 4.54 (0.91) |
| | Importance | | | |
| | Easy | 4.87 (1.25) | 4.23 (1.57) | 4.50 (1.72) |
| | Medium | 4.90 (1.27) | 4.30 (1.62) | 4.45 (1.68) |
| | Hard | 4.70 (1.51) | 4.23 (1.74) | 4.38 (1.55) |
| | Mean importance | 4.82 (1.25) | 4.26 (1.59) | 4.44 (1.63) |
| **Cognitive Ability** | Working memory | | | |
| | Easy | 3.70 (0.70) | 3.97 (0.18) | 3.75 (0.63) |
| | Medium | 5.83 (1.72) | 6.03 (1.54) | 6.43 (1.30) |
| | Hard | 7.27 (3.40) | 8.03 (2.87) | 7.43 (3.10) |
| | Mean working memory | 5.60 (1.68) | 5.87 (1.35) | 5.87 (1.35) |

Easy = memorizing 4 letter strings; Medium = memorizing 7 letter strings; Hard = memorizing 15 letter strings

Table 6: Partial Correlations[12] of Effortful Decision Making, Working Memory, and Memory Task Appraisals for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| | **EEfRT** | | **Memory Task Appraisal** | | |
|---|---|---|---|---|---|
| | **Total % Hard Task** | **Working Memory** | **Difficulty** | **Predicted Performance** | **Importance** |
| **Total % Hard Task** | | .18 | -.20 | .24 | .31 |
| **Working Memory** | .08 | | .06 | .16 | .13 |
| **Difficulty** | -.07 | .09 | | -.60** | -.05 |
| **Predicted Performance** | .07 | -.24 | -.48** | | .15 |
| **Importance** | .02 | .07 | .13 | .25 | |
| **Total % Hard Task** | | | | | |
| **Working Memory** | .07 | | | | |
| **Difficulty** | .41* | -.45* | | | |
| **Predicted Performance** | -.21 | .56** | -.60** | | |
| **Importance** | .22 | .31 | .08 | .22 | |

*$p < .05$
**$p < .01$
EEfRT = Effort Expenditure for Rewards Task
[1]Correlations for controls are above the gray diagonal, correlations for the SocAnh group are below the gray diagonal, and correlations for the PerMag group are below the black diagonal.
[2]Correlations are controlling for age.

Table 7: Partial Correlations[1] of Proportion of Hard Tasks Chosen on the EEfRT and Self-Report Measures for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| | | | | **TEPS** | |
|---|---|---|---|---|---|
| | | **BDI-II** | **SAS** | **Antic** | **Consum** |
| **EEfRT Total % Hard Tasks Chosen** | **SocAnh (*n* = 30)** | -.17 | -.09 | -.24 | .12 |
| | **PerMag (*n* = 30)** | .32 | .03 | .19 | -.07 |
| | **Controls (*n* = 40)** | -.13 | -.02 | -.09 | -.34* |

*$p < .05$

EEfRT = Effort Expenditure for Rewards Task; BDI-II = Beck Depression Inventory II; SAS = Social Adjustment Scale; TEPS = Temporal Experience of Pleasure Scale (Antic = Anticipatory Pleasure; Consum = Consummatory Pleasure)

[1]Correlations are controlling for age.

Table 8: Partial Correlations[1] of Cardiovascular Measures of Effort and Self-Report Measures for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| | | | | | TEPS | |
|---|---|---|---|---|---|---|
| | | | **BDI-II** | **SAS** | **Antic** | **Consum** |
| **Systolic** | **SocAnh (*n* = 30)** | Base | .29 | .23 | -.26 | -.19 |
| | | Easy | .24 | .11 | -.09 | -.04 |
| | | Med | .26 | .08 | -.16 | -.05 |
| | | Hard | .28 | .18 | -.21 | .04 |
| | **PerMag (*n* = 30)** | Base | -.09 | -.18 | .17 | .04 |
| | | Easy | .06 | -.19 | .20 | .04 |
| | | Med | -.05 | -.05 | .08 | .00 |
| | | Hard | -.04 | -.10 | .05 | -.03 |
| | **Controls (*n* = 40)** | Base | .03 | -.03 | -.18 | -.17 |
| | | Easy | -.03 | -.05 | -.13 | -.23 |
| | | Med | -.12 | -.07 | -.07 | -.16 |
| | | Hard | -.11 | -.09 | -.22 | -.26 |
| **Diastolic** | **SocAnh (*n* = 30)** | Base | .21 | .09 | -.04 | .02 |
| | | Easy | .25 | .11 | .09 | -.06 |
| | | Med | .19 | .07 | .07 | .05 |
| | | Hard | .26 | .13 | -.10 | .09 |
| | **PerMag (*n* = 30)** | Base | .12 | .18 | -.39* | -.27 |
| | | Easy | .19 | .08 | -.47* | -.25 |
| | | Med | .01 | .19 | -.21 | .03 |
| | | Hard | .04 | .12 | -.37[a] | -.17 |
| | **Controls (*n* = 40)** | Base | .06 | .05 | .07 | .29 |
| | | Easy | .00 | .06 | .02 | .09 |
| | | Med | -.10 | -.05 | .07 | .09 |
| | | Hard | -.07 | -.09 | -.05 | .01 |
| **Pulse Rate** | **SocAnh (*n* = 30)** | Base | .23 | .18 | -.41* | -.16 |
| | | Easy | .19 | .07 | -.30 | -.11 |
| | | Med | .20 | .06 | -.23 | -.12 |
| | | Hard | .18 | .09 | -.37* | -.07 |
| | **PerMag (*n* = 30)** | Base | -.08 | .13 | -.35 | -.19 |
| | | Easy | .00 | .03 | -.19 | -.16 |
| | | Med | -.08 | .14 | -.18 | -.18 |
| | | Hard | -.09 | .03 | -.26 | -.18 |
| | **Controls (*n* = 30)** | Base | .02 | .28 | -.16 | -.25 |
| | | Easy | -.01 | .38* | -.06 | -.16 |
| | | Med | -.02 | .22 | -.05 | -.19 |
| | | Hard | .01 | .21 | -.14 | -.26 |

*$p < .05$
[a]$p = .05$

BDI-II = Beck Depression Inventory II; SAS = Social Adjustment Scale; TEPS = Temporal Experience of Pleasure Scale (Antic = Anticipatory Pleasure; Consum = Consummatory Pleasure)
[1]Correlations are controlling for age.

Table 9: Partial Correlations[12] of Self-Report Measures for Social Anhedonia (SocAnh), Perceptual Aberration and Magical Ideation (PerMag), and Control Groups

| | | | SPQ | | | TEPS | |
|---|---|---|---|---|---|---|---|
| | **BDI-II** | **SAS** | **Total** | **Positive** | **Negative** | **Antic** | **Consum** |
| **BDI-II** | | .24 | .27 | .22 | .27 | .05 | .30 |
| **SAS** | .72** | | .46** | .47** | .38* | -.12 | -.07 |
| **Total** | .59** | .55** | | .84** | .74** | -.37* | -.36* |
| **Positive** | .40* | .38* | .80** | | .38* | -.30 | -.32* |
| **Negative** | .38* | .40* | .60** | .12 | | -.19 | -.20 |
| **Antic** | -.39* | -.45* | -.28 | .02 | -.52** | | .51** |
| **Consum** | -.07 | -.16 | -.15 | -.29 | .05 | .17 | |
| **BDI-II** | | | | | | | |
| **SAS** | .28 | | | | | | |
| **Total** | .04 | -.02 | | | | | |
| **Positive** | -.08 | -.06 | .93** | | | | |
| **Negative** | .10 | -.09 | .83** | .62** | | | |
| **Antic** | -.01 | .01 | -.16 | -.19 | -.08 | | |
| **Consum** | .06 | .07 | .09 | .13 | .01 | .53** | |

*$p < .05$
**$p < .01$
BDI-II = Beck Depression Inventory II; SAS = Social Adjustment Scale; SPQ = Schizotypal Personality Questionnaire (Positive = Cognitive Perceptual subscale; Negative = Interpersonal subscale); TEPS = Temporal Experience of Pleasure Scale (Antic = Anticipatory Pleasure; Consum = Consummatory Pleasure)
[1]Correlations for controls are above the gray diagonal, correlations for the SocAnh group are below the gray diagonal, and correlations for the PerMag group are below the black diagonal.
[2]Correlations are controlling for age.

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