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Effort-Based Decision-Making in Schizotypy

Jessica Elaina McGovern
Louisiana State University and Agricultural and Mechanical College, jemcgovern210@gmail.com

EFFORT-BASED DECISION-MAKING IN SCHIZOTYPY

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Jessica Elaina McGovern
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ABSTRACT

Avolition/apathy, defined as reduced initiation of or persistence in goal-directed behavior, is a pernicious, core negative symptom of schizophrenia. While deficits in effort-based decision-making have been proposed to underlie negative symptom deficits, it remains unknown whether subjective or objective motivation deficits are evident in individuals with elevated *schizotypy*, a trait associated with putative latent liability of developing psychosis. Thus, the present study examined whether and how objective and subjective motivation deficits manifest in individuals high (n = 57) versus low (n = 58) in schizotypy traits (based on a median-split of total experience scores on the Schizotypal Personality Questionnaire –Brief Revised Impact) using an objective performance-based effort task and subjective measures of state and trait motivation. Compared to the low schizotypy group, the high schizotypy group self-reported lower trait but not state motivation. Counter to expectations, groups did not differ in willingness to exert higher effort for higher rewards on the effort task. Subjective ratings of state motivation were related to objective performance on the effort task in the low schizotypy group, but not in the high schizotypy group. Implications for this dysjunction between subjective and objective performance in relation to the schizophrenia spectrum are discussed.

CHAPTER 1. INTRODUCTION

Schizophrenia is a chronic and debilitating disorder most often recognized for its positive symptoms (e.g., hallucinations and delusions); however, the negative symptoms (i.e., deficiencies in normal behavior; e.g., anhedonia, avolition, alogia, and blunted affect) are often the most disabling (Kirkpatrick, Fenton, Carpenter, & Marder, 2006). One particularly deleterious symptom is *avolition*, defined as lacking initiation and/or persistence in goal-directed behavior. Avolition has been recognized as a core clinical feature of schizophrenia since the disorder's original description by Kraepelin (1919/1971) as "a weakening of those emotional activities which permanently form the mainsprings of volition." A person with this symptom may appear passive, withdrawn, asocial, apathetic, and, at extremes, inert or catatonic.

Regarding psychotherapy, avolition has been associated with worse engagement in treatment, poorer maintenance of goals, less persistence in tasks, reduced attendance, delays in treatment seeking, more relapses, and lower treatment and medication compliance in a variety of disorders (Altamura, Bassetti, Sassella, Salvadori, & Mundo, 2001; Malla, et al., 2002; Ryan & Deci, 2008; Ryan, Plant, & O'Malley, 1995; Tattan & Creed, 2001). Moreover, there are currently no FDA-approved treatments for avolition or any other negative symptom of schizophrenia (Kirkpatrick, Fenton, Carpenter, & Marder, 2006), and current medications designed to treat the positive symptoms can actually induce secondary negative symptoms (Artaloytia et al., 2006; Carpenter, Heinrichs, & Wagman, 1988; Voruganti & Awad, 2004). Regarding real-world implications, avolition accounted for 70% or more of the variance in functional outcomes in two separate studies of schizophrenia populations (Foussias et al., 2011; Konstantakopoulos et al., 2011). Therefore, finding ways to better treat, identify, or prevent this symptom could substantially improve functional outcomes.

Avolition is not merely a withdrawal reaction to the development of psychosis since it is prevalent across the schizophrenia illness course from the pre-psychotic ("prodromal") phase to first-episode and chronic phases (Faerden et al., 2010; Konstantakopoulos et al., 2011; Piskulic et al., 2012; Yung & McGorry, 1996). In fact, a 12-month prospective study of individuals in the prodromal phase of illness found that elevated baseline avolition was significantly associated with converting to psychosis within 60 days of study entry (Yung et al., 2003). Moreover, avolition was the second most commonly described prodromal feature (behind reductions in attention and concentration) among individuals who experienced their first episode of psychosis (Yung & McGorry, 1996). This evidence suggests that early identification and treatment of this symptom could attenuate, delay, or even prevent onset of psychosis in some individuals. Although the potential for treatment and prevention gains appears large, evidence regarding the causes of avolition is lacking.

Since avolition has such detrimental effects from early on in the course of illness, it is pertinent to examine how this symptom may manifest in individuals with *schizotypy,* a trait that reflects putative latent liability to decompensation into schizophrenia-spectrum disorders (Lenzenweger, 2006; Meehl, 1962, 1990). Individuals with schizotypy demonstrate several deficits in common with individuals with schizophrenia, including reward-related deficits such as reduced anticipatory pleasure (for review, see Nelson, Seal, Pantelis, & Phillips, 2013). Despite some overlap in biopsychosocial abnormalities, only a small percentage of those with schizotypy, and especially those with negative schizotypy, decompensate into a schizophrenia-spectrum disorder, such as schizophrenia or paranoid, schizoid, or schizotypal personality disorders (Meehl, 1990; Kwapil, 1998; Kwapil, Gross, Silvia, & Barrantes-Vidal, 2013). Thus,

examining individuals with schizotypy may reveal certain protective and risk factors relevant to the development of psychosis and its symptoms within schizophrenia spectrum disorders.

Aberrant cost-effort computations have been demonstrated in individuals with schizophrenia and have been suggested as a mechanism that underlies decisions to initiate and persist in preferred activities (Fervaha, Graff-Guerrero, et al., 2013; Gold et al., 2013); however, whether this deficit is evident in individuals with schizotypy has not yet been examined. Moreover, it has been suggested that the relationship between self-reported intrinsic motivation and cognitive performance is disrupted in individuals with schizophrenia, compared to healthy controls (Barch, Yodkovik, Sypher-Locke, & Hanewinkel, 2008). Thus, there may be a disconnect between self-reported and behavioral performance within the schizophrenia spectrum. This thesis examined whether self-reported and/or behavioral indicators of motivation deficits were evident in a schizotypy population and whether self-reported indicators of motivation were less tied to objective performance, as has been suggested in individuals with schizophrenia.

Given the complexity of effort-based decision-making, a definition of schizotypy is first provided followed by a discussion/outline of how schizotypy studies may be utilized to explore reward-related deficits in schizophrenia. A brief review of the literature related to the neurobiology of motivated behavior that is relevant to this study follows. Lastly, an explanation/rationale is provided as to how the present study addressed current gaps in the literature related to avolition within the schizophrenia spectrum. More specifically, the study addressed whether state or trait deficits in motivation were evident in individuals high in schizotypy traits and whether self-reported motivation deficits translated to objective motivation deficits, operationalized as willingness to exert more effort to achieve a higher reward. This improved understanding may help elucidate whether avolition should be considered an explicit

part of the construct of negative schizotypy, and whether the presence of these deficits (or lack of them) may represent a vulnerability (or protective) factor toward developing schizophrenia spectrum disorders.

1.1 Why Study Individuals with Schizotypy?

Studying college-age individuals with schizotypy poses several advantages for examining factors that contribute to development and maintenance of symptoms of schizophrenia: 1) college-age students are within the peak age of onset of schizophrenia (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994), 2) confounds of many schizophrenia studies do not apply to this population (e.g., effects of medication, psychosis, chronic illness, repeated hospitalizations, stigma, previous treatments), and 3) there is the added convenience of a higher prevalence rate in the general population (about 10% for schizotypy [for theory, see Meehl, 1990; for empirical support, see Lenzenweger & Korfine, 1992] vs. 1 % [Regier et al., 1993] for schizophrenia) and thus provides a larger subject pool. According to Meehl, "schizotaxia" (i.e., genetic risk) is necessary but not sufficient to cause schizophrenia, is expressed in all or almost all schizotaxic individuals as a phenotype called "schizotypy," and interacts with environment and social learning influences to determine the degree of decompensation to schizophrenia spectrum disorders possible during one's lifetime (Lenzenweger, 2006; Meehl, 1962; 1990). Given that genetic, perinatal, and early childhood factors have been associated with schizophrenia (Cannon, Mednick, & Parnas, 1990; Raine, 2006; Walker, Grimes, Davis, & Smith, 1993; Zubin & Spring, 1977), it is likely that many neurobiological abnormalities already exist at the level of schizotypy relative to the "healthy" general population. Exploring additional risk factors or phenotypes may help identify those who are more likely to convert to psychosis.

Psychometric schizotypy studies have demonstrated that deviantly high schizotypy scores are associated with genetic risk and psychosis proneness (Docherty & Sponheim, 2008; Kwapil, 1998). Longitudinal studies using self-reports to identify members with schizotypy have demonstrated that deviant scorers are at increased risk of developing a schizophrenia-spectrum disorder (i.e., schizophrenia, schizoaffective disorder, or schizotypal, schizoid, or paranoid personality disorders) within 10 years (Kwapil, 1998). Moreover, first-degree family members of individuals with schizophrenia are also elevated in schizotypy traits; this evidence suggests schizotypy traits are heritable (Docherty & Sponheim, 2008). Lastly, individuals with schizotypy share certain deficit areas with individuals with schizophrenia, though notably to a lesser degree (Chun, Minor, & Cohen, 2013). Overall, evidence suggests that at least some abnormalities lie on a continuum between schizotypy and schizophrenia.

While individuals with schizotypy are at heightened risk of developing schizophrenia spectrum disorders, it is also important to recognize the continuities and discontinuities between schizophrenia and schizotypy as they may inform our understanding of risk and protective factors, respectively, for conversion to psychosis (Cannon, van Erp, & Glahn, 2002; Nelson et al., 2013). First, both individuals with schizophrenia and with schizotypy show persistent, elevated trait negative affect and diminished trait positive affect relative to their respective control groups (Horan, Blanchard, Clark, & Green, 2008). Second, as in schizophrenia, individuals with schizotypy have shown deficient performance on tasks of attention, working memory, set-shifting, and eye-tracking (for reviews, see Chun et al., 2013; Nelson et al., 2013). Although these deficits exist at a relatively smaller effect-size level in individuals with schizotypy, their existence illustrates the continuum across the schizophrenia spectrum (Chun et al., 2013; Nelson et al., 2013). That said, there are also a large number of cognitive domains

where individuals with schizotypy do not differ significantly from controls (e.g., memory, language, and visuospatial abilities; Chun et al., 2013), whereas there has been evidence of medium to large effect-size deficits in these areas at least as early as in first-episode schizophrenia samples (for meta-analytic review, see Mesholam-Gately, Giuliano, Goff, Faraone, & Seidman, 2009).

Another finding demonstrated in both individuals with schizotypy and with schizophrenia is reduced prefrontal cortex volume on MRI (Raine, Lencz, et al., 1992; Raine, Sheard, Reynolds, & Lencz, 1992; Weinberger, Berman, & Zec, 1986); thus, it is not surprising that both groups demonstrated deficits on tests requiring these brain areas, such as set-shifting in the Wisconsin Card Sorting Test (Raine, Lencz, et al., 1992; Raine, Sheard, et al., 1992). Converging evidence suggests that tasks requiring the prefrontal cortices may be a point of continuity across the schizophrenia spectrum. Furthermore, converging evidence from rodent, human fMRI, and human PET studies has demonstrated that the dopamine pathways linking the striatum to prefrontal cortices are involved in making decisions that require the integration of reward, probability, and effort information to evaluate options and translate a decision into an action (Burke, Brünger, Kahnt, Park, & Tobler, 2013; Prévost et al., 2010; Wardle, Treadway, Mayo, Zald, & de Wit, 2011). Accordingly, tasks which assess effort-based decision-making, should require the use of areas of the brain shown to be impaired (at least mildly) in schizotypy.

A particularly interesting point of divergence is that, while both schizophrenia and schizotypy groups underestimate the amount of pleasure/enjoyment they will receive from a stimulus, only the schizotypy group additionally demonstrates reduced enjoyment of that stimulus in the moment compared to healthy comparison participants (for reviews, see Cohen & Minor, 2010; e.g., Cohen, Callaway, Najolia, Larsen, & Strauss, 2012). This example illustrates

that not every deviation from control populations is necessarily more severe in schizophrenia compared to schizotypy; however, it is not always clear what that indicates about the pathophysiology of psychosis and, therefore, warrants further exploration. Importantly, these findings suggest that reward-related mechanisms, particularly those that require the prefrontal cortex, may be abnormal in individuals with schizotypy.

Unfortunately, there is currently a dearth of knowledge examining apathy/avolition in schizotypy. One study found that schizotypy traits (and negative schizotypy traits in particular) were associated with self-reported apathy (Fervaha et al., 2014). Another study examined social apathy in schizotypy and found that negative schizotypy traits (defined by the "no close friends" and "constricted affect" subscales of the Schizotypal Personality Questionnaire – Brief Revised [SPQ-BR]) were associated with increased social apathy toward others (i.e., friends, family members, strangers, and authority figures; Cohen & Matthews, 2010). Although not synonymous with apathy/avolition, negative schizotypy traits have also been associated with increased negative affect, less enjoyment of pleasant stimuli, lower life satisfaction, and lower self-efficacy (Abbott, Do, & Byrne, 2012; Cassar, Applegate, & Bentall, 2013; Cohen, Callaway, et al., 2012). Beck and colleagues' cognitive model for the negative symptoms of schizophrenia suggests that such negative expectations regarding self, and life more generally, could contribute to the reduced engagement and withdrawal that is characteristic of avolition (Beck, Rector, Stolar, & Grant, 2009; Rector, Beck, & Stolar, 2005). Moreover, some theories suggest that negative symptoms of schizophrenia share a common underlying neurobiology (Kirkpatrick et al., 2006; Liddle et al., 1989), so it is possible that social anhedonia and blunted affect as assessed by the SPQ-BR negative schizotypy subscale may be related to self-reported deficits in motivation,

more broadly. Overall, there is reason to suspect that apathy, or perhaps beliefs about self or others that precede apathy, may be present in individuals high in negative schizotypy traits.

1.2 Subjective-Objective Dysjunction in Schizotypy

The *subjective-objective dysjunction* in schizotypy is the term given to an odd pattern of results wherein individuals with schizotypy tend to self-report significantly elevated pathology across a large number of domains (e.g., cognitive concerns, affective experiences, subjective quality of life, expressive/communicative abilities, and even olfactory experience) that, for the most part, are not consistent with objective measures of such domains (for review, see Cohen, Mitchell, Beck, & Hicks, 2014). This is unusual in that these individuals have grossly intact reality-testing skills, are well-functioning enough to successfully navigate academic and social college environments without major impairment, and are largely intact neurocognitively.

The first example of this subjective-objective dysjunction is in the domain of cognitive functioning. Specifically, individuals with schizotypy self-reported high levels of subjective cognitive complaints (two standard deviations higher than controls) regarding attention, memory, language and other basic neurocognitive abilities despite minimal differences relative to peers on actual performance (Chun, Minor, & Cohen, 2013). Second, individuals with schizotypy reported reduced experience of pleasant emotions during tasks that induce pleasant emotions at a level worse than college peers, as well as more severe than patients with chronic schizophrenia and/or mood disorders (Cohen, Calloway, Najolia, Larsen, & Strauss, 2012). Third, individuals with schizotypy self-report diminished facial, vocal, and hand gestural expressivity, yet do not demonstrate substantial expression deficits when assessed by objective raters or computer-based programs (e.g., Llerena, Park, Couture, & Blanchard, 2012; Cohen, Morrison, Brown, & Minor, 2012). Fourth, individuals with schizotypy reported significantly lower levels of subjective

quality of life (e.g., satisfaction with social, familial, money, health) relative to college peers and at a level similar to chronic outpatients with severe mental illness despite objective self-reports that the frequency of engaging in these activities is comparable to that of college peers (Cohen, Auster, MacAulay, & McGovern, 2014b). In this sense, across multiple domains, individuals with schizotypy self-report severe levels of pathology yet fail to demonstrate commensurate deficits on objective tests of these domains.

In the schizophrenia literature, some evidence suggests that individuals with schizophrenia may show a disruption in the normative relationship between self-rated motivation and objective performance. For instance, one study found that schizophrenia and control groups did not differ significantly in mean self-reported intrinsic motivation, although the control group but not the schizophrenia group showed significant associations between self-reported motivation and cognitive performance (Barch, Yodkovik, Sypher-Locke, & Hanewinkel, 2008). In this sense, subjective ratings of trait intrinsic motivation were not tied to objective performance in a schizophrenia population. One potential conclusion from the schizotypy and schizophrenia literature is that declines in objective performance or other areas may be preceded by development of negative beliefs about that performance or other areas. At the very least, a cognitive bias acting independent of their true abilities appears to be influencing their perceptions of self and their performance.

1.3 Neurobiology of Reward, Effort, and Motivation

While the psychological aspects of performance represent one pathway toward understanding motivation deficits in schizophrenia-spectrum disorders, neurobiological mechanisms offer a complimentary but convoluted pathway. The sheer number of complex independent and inter-dependent reward-related mechanisms complicates explanations of

avolition in schizophrenia in that numerous disruptions in normal functioning could individually, or in some combination, contribute to behavior that outwardly manifests as diminished initiation or maintenance of goal-directed behavior (for reviews, see Barch & Dowd, 2010; Der-Avakian & Markou, 2012).

As an example, consider some of the motivational processes involved in the simple observation that a person chooses to stay at home and watch television rather than attend a party. Assuming she enjoys parties when she does attend ("liking" or consummatory pleasure), there are many processes involved in "wanting" to go to the party that may impede her executing the behavior involved in getting *to* the party: she may perceive that she will not enjoy herself if she does go (anticipatory pleasure deficit); she may not remember how much she enjoyed a party the last time she went to one (memory encoding or retrieval deficit); she may overestimate how much effort it will take to shower, get ready, and commute to the party (effort valuation deficit); she may have difficulty weighing the costs versus benefits of attending the party are worth the effort it takes to attend the party (cost-benefit analysis deficit); or she may perceive that she does not have the energy and resources at this moment and choose to stay home instead (integrating computed effort required with available resources). This apparently simple behavior of choosing to watch television (a low effort/low reward [LE/LR] option) instead of attending a party (a high effort/high reward [HE/HR] option) can be caused by any number of mechanistic deficits.

Each deficit described in the above example is related to specific aspects of the cortico-striatal dopamine pathway (i.e., the interconnections between the prefrontal and anterior cingulate aspects of the cortex and the nucleus accumbens within the striatum), and each mechanism may be contributing to avolition in individuals with schizophrenia (Barch & Dowd, 2010; Fervaha, Foussias, et al., 2013). Importantly, individuals with schizophrenia prefer LE/LR

over HE/HR options more often than healthy controls, but only when the reward magnitudes are highest (i.e., when the payoff for selecting the HE/HR option is greatest) and/or the probability of reward receipt is greatest, a finding which has led some researchers to conclude that individuals with schizophrenia make aberrant cost-effort decisions (Fervaha, Graff-Guerrero, et al., 2013; Gold et al., 2013).

Impairments in the ability to evaluate the cost of effort and the value of the reward may undermine decisions to execute the goal-directed action. If an individual underestimates a reward's worth (anticipatory pleasure deficit), overestimates the effort or cost involved (effort computation deficit), and/or fails to integrate cost-benefit information optimally, she will likely anticipate the reward as being less pleasurable and will be less likely or "motivated" to execute the behavior required to obtain the reward (Treadway & Zald, 2013). However, it is presently unclear which aspects of this equation are abnormal in schizophrenia. It is also unclear whether this deficit extends to individuals with schizotypy.

Animal models and human neuroimaging studies have demonstrated how changes in dopamine signaling modulate avolition, which has been operationalized as willingness to expend effort to obtain higher, preferred rewards (i.e., preference for HE/HR over LE/LR options). For example, blocking or reducing ventral striatal dopamine (e.g., via dopamine depletion, dopamine antagonists such as haloperidol, or nucleus accumbens lesions) causes a shift in rodents' preferences from preferring to exert additional effort (e.g., scale a wall, make more lever presses) for a larger or more preferred reward to preferring lower effort options, despite intact "liking" and food preferences (Berridge, 1996; Salamone, Correa, Farrar, & Mingote, 2007; Salamone et al., 1991). In contrast, dopamine agonists such as amphetamine, which increase dopamine release, administered to the nucleus accumbens will increase the animal's preference for the

HE/HR option and increase the amount of effort an animal will exert to obtain a preferred reward (Wyvell & Berridge, 2000; Salamone et al., 2007).

In addition to increasing effort motivation, dopamine release in the nucleus accumbens has also been directly related to modulation of the probability of reward receipt and relative magnitude of reward; greater increases in sustained mesolimbic dopamine occur with anticipation of greater reward magnitude and maximal uncertainty of reward receipt (Fiorillo, Tobler, & Schultz, 2003; Schultz, 2002). Moreover, weighing effort, probability, and reward magnitude costs are each weighed in anatomically distinct areas (Prévost, Pessiglione, Météreau, Cléry-Melin, & Dreher, 2010), which are integrated via the frontal pole within the prefrontal cortex (Burke, Brünger, Kahnt, Park, & Tobler, 2013). As already stated, areas of the prefrontal cortex have been implicated in schizophrenia pathophysiology (for review, see Barch & Dowd, 2010; e.g., Weinberger et al., 1986), and some evidence suggests that individuals high in schizotypy traits may show hypofunctioning in these areas as well (e.g., Raine, Sheard, et al., 1992). If striatal dopamine is related to weighing effort, probability, and reward magnitude information in decision-making and is also dysfunctional in schizophrenia, it stands to reason that individuals with schizophrenia or high in anhedonia/avolition-type symptoms should show similarly reduced preferences for the HE/HR options in similar tasks, such as the Effort-Cost Computation Task (Gold et al., 2013).

The Effort-Cost Computation Task used in the present study, as well as a similar task, were developed as translational paradigms that similarly measure willingness to exert effort in humans (Gold et al., 2013;Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009). Just as in the animal paradigms, humans must make choices between HE/HR and LE/LR options wherein levels of effort, probability, and reward magnitude are varied. In a PET imaging study

that used dopamine D_2/D_3-specific ligand [^{18}F] fallypride and *d*-amphetamine (a dopamine agonist) to measure individual differences in dopamine responsivity in healthy adults, greater preference for the HE/HR option was associated with more dopamine in the left striatum and ventromedial prefrontal cortex whereas lower preference for the HE/HR option was associated with more DA in the bilateral insula (Wardle et al., 2011). Moreover, healthy individuals given low doses (10mg and 20mg) of *d*-amphetamine (a dopamine agonist) during an effort-cost computation task were more willing to work for rewards, especially during low probability trials (the opposite pattern seen in schizophrenia participants); thus, dopamine appears to mitigate response costs in humans, especially when costs are maximal.

1.4 Effort in Schizophrenia

Consistent with animal models where dopamine was blocked in the nucleus accumbens, human individuals with major depressive disorder (in whom anhedonia/avolition is a common symptom) (Treadway, Bossaler, Shelton, & Zald, 2012), healthy individuals with high trait anhedonia (Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009), and individuals with schizophrenia (Fervaha, Graff-Guerrero, et al., 2013; Gold et al., 2013) chose a significantly lower proportion of HE/HR choices compared to healthy comparison groups, particularly when reward magnitudes were highest and probability of receiving the reward was highest (i.e., in situations where it is most advantageous or most "worth the effort" to choose the HE/HR option). These authors concluded that these results suggest aberrant ability to make effort-cost computations in these populations. Moreover, in the schizophrenia studies, proportion of HE/HR choices was inversely related to negative symptoms. Since other schizotypy populations have been defined based on high trait anhedonia scores, it was expected that individuals with schizotypy in the present study, especially those high in negative traits, would show similar

reductions in preference for the HE/HR option in this EEfRT task, particularly when reward magnitudes and probability of reward receipt were highest. This finding would suggest an effort-cost computation deficit similar to that shown in individuals with schizophrenia and would suggest related pathophysiology.

1.5 Summary and Purpose

Avolition, a deficit in initiation of and persistence in goal-directed activities, is a deleterious symptom of schizophrenia that undermines treatment and functional outcomes. Pathophysiological explanations of this symptom have been complicated by the numerous potential mechanisms involved in goal-directed reward processes, many of which involve the cortico-striatal dopamine pathway. The Effort-Cost Computation Task (Gold et al., 2013) was designed to measure willingness to exert physical effort for rewards in humans based on translational work that has directly linked performance on a similar task in rodents to dopamine functioning in the prefrontal cortex and striatum (e.g., Wardle et al., 2011). Moreover, effort-cost computation deficits have been found in in individuals with schizophrenia (Fervaha, Graff-Guerrero, et al., 2013; Gold et al., 2013), with major depressive disorder (Treadway, Bossaler, et al., 2012), and higher in trait anhedonia (Treadway et al., 2009). However, it is presently unclear whether these deficits extend to individuals with schizotypy. The present study examined whether aberrant effort-cost computations deficits found in schizophrenia extended down the schizophrenia spectrum disorder continuum to individuals high in schizotypy traits.

Furthermore, examining whether individuals high in negative schizotypy traits also report deficits in motivation would provide support for the inclusion of apathy as part of the construct of negative schizotypy, since current schizotypy measures do not typically, or at least overtly, measure motivation deficits as a component of schizotypy traits. Moreover, some preliminary

evidence suggests individuals within the schizophrenia spectrum may show a dysjunction between subjective perception and objective aspects of their performance; however, it is presently unclear whether individuals with schizotypy self-report deficits in motivation consistent with their level of performance. Thus, this study examined whether schizotypy objective/subjective dysjunction extends to the domain of effort and motivation.

Overall, the present study assessed had two primary aims: 1) Examine whether individuals with high (HIGH SZT) relative to low schizotypy (LOW SZT) traits demonstrated subjective deficits in state and trait motivation. 2) Examine whether HIGH SZT demonstrated objective deficits on a cost-effort computation task. Exploratory and post-hoc analyses examined whether negative schizotypy traits and self-reported trait and state motivation/apathy were related to each other and to specific aspects objective performance.

CHAPTER 2. METHOD

2.1 Participants

Participants were recruited via two methods and received either $20 USD or course credit toward their psychology course for participating. In the first method, undergraduates enrolled at Louisiana State University (LSU) were invited to participate in an online questionnaire sent via email as part of a larger study. The questionnaire included a consent form, demographic questions, Infrequency Scale Items (Chapman & Chapman, 1983), the modified Schizotypal Personality Questionnaire – Brief Revised Impact (SPQ-BRI; Cohen, 2014), and Brief Symptom Inventory (BSI; Derogatis & Melisaratos, 1983). Consistent with prior studies, individuals scoring in the 90th percentile on the positive (i.e., ideas of reference, suspiciousness, magical thinking, and unusual perceptions), negative (i.e., constricted affect and no close friends), and/or disorganization (i.e., odd speech and eccentric behavior) SPQ-BRI subscales (based on gender and ethnicity means), were invited to participate in the laboratory phase of the study. In order to address concerns related to overlap between negative schizotypy and depressive symptoms, individuals with elevated negative schizotypy traits were only included if they a) also showed elevation on the positive or disorganization scales (and thus reflected more of a "schizophrenia-like" presentation), or b) had a BSI depression subscale score below their gender- and ethnicity-determined mean. Of the 728 participants who completed the surveys, 73 participants formed the top 10% of scorers and nine high scorers participated in the laboratory portion of the study.

In the second method, participants were recruited through the psychology department's online research participation system (SONA). To decrease the putative genetic loading of schizophrenia-spectrum disorders on the control group, low schizotypy group participants with a family member with schizophrenia were also excluded. Two low schizotypy participants

endorsed having a family member with schizophrenia and were thus excluded. Two high schizotypy participants also endorsed this criterion and were retained in analyses. No participants endorsed personal history of schizophrenia or mania. There were no other exclusion criteria. The recruitment strategy described above has been successfully employed in previous studies (Cohen, Callaway, et al., 2012; Cohen, Morrison, Brown, & Minor, 2012). This study was approved by the LSU Human Subjects Review Board and all participants provided informed consent at both the survey and laboratory phases.

Due to a lacking number of extreme scorers to form the high schizotypy group, a median split of the total sum of the SPQ-BRI experiences scores (SPQ-BRI total M = 13.37; Med = 14; SD = 6.03) from all the laboratory participants was used to determine group status. This grouping procedure has been used in numerous previous studies (e.g., Hori et al., 2008; Jolley, Jones, & Hemsley, 1999).There were 57 participants in the LOW SZT group (M = 8.44, SD = 3.55) and 58 participants in the HIGH SZT group (M = 18.22, SD = 3.46). These groups significantly differed on SPQ-BRI total experience scores, $t(113) = 14.97$, $p < .001$, $d = 2.82$ (see Table 1). Of the nine high schizotypy participants recruited via the email method, one individual fell one item short of the median-split cut-score when the SPQ-BRI was re-administered in the laboratory and was subsequently analyzed as part of the LOW SZT group. Of note, the mean SPQ Total Experience score from the top 10% of scorers (n = 73) was 28.81 (SD = 1.45) whereas the mean for the high schizotypy group was only 18.22 (SD = 3.46).

2.2 Measures

2.2.1 Schizotypal symptoms. The Schizotypal Personality Questionnaire – Brief Revised Impact (SPQ-BRI; see Appendix A; Cohen, 2014) is a modified version of the SPQ-Brief Revised (Cohen, Matthews, Najolia, & Brown, 2010) and an abbreviated version of the SPQ

(Raine, 1991). The SPQ and its variants were designed to mirror the nine DSM-III-R criteria for schizotypal personality disorder. The SPQ-BRI is a self-report with 32 items and seven subscales (ideas of reference/suspiciousness, magical thinking, unusual perception, constricted affect/no close friends, social anxiety, eccentric behavior, and odd speech), which roughly map onto the positive, negative, and disorganized symptoms of schizophrenia (Liddle et al., 1989). Higher scores indicate more severe symptom traits. The SPQ-BRI employed in the present study employed the same questions as those from the SPQ-BR but changed the format from the original 5-point Likert scale (strongly disagree to strongly agree) to a dichotomized yes/no format (Experience score) with an additional sub-question related to perceived distress caused by that symptom (Distress score). For the present study, all 32 SPQ-BRI Experience items were summed to create a total Experience Score (Cronbach's $\alpha = .849$) and used to determine group status from the median split of these scores. Distress total and subscale scores were also computed although not incorporated to determine group status. The Cronbach's α values for the Experience and Distress subscales (positive, negative, and disorganized traits) as well as the SPQ-BRI Total Distress Score ranged from .73-.91, indicating good to excellent internal consistency.

There are several reasons to suggest that the SPQ-BRI may be equivalent to or better than its predecessors. First, the original versions of the SPQ and SPQ-Brief were administered and validated in a dichotomous (true/false) format (Raine, 1991; Raine & Benishay, 1995). Moreover, a similar modification of adding a "Distress Score" to the Brief Prodromal Questionnaire (PQ-B), an alternative to the SPQ, resulted in similar sensitivity (89 to 88%) and increased specificity (58% to 68%) over the dichotomous version in detecting individuals who met prodromal syndrome and psychotic syndrome diagnoses on the Structured Interview for

Prodromal Syndromes, a popular and well-validated interview for detecting individuals at ultra-high risk of converting to psychosis (Loewy, Pearson, Vinogradov, Bearden, & Cannon, 2011). In addition, another instrument, the CAPE, found that risk for conversion to a psychotic disorder within four years was four to five times higher when individuals were distressed by their psychotic experiences compared to those who were not distressed (Hanssen, Bijl, Vollebergh, & van Os, 2003). Thus, there is evidence to suggest this response format may improve predictive validity in detecting individuals at greater risk of conversion to psychosis or another schizophrenia-spectrum disorder.

Moreover, the SPQ-BRI is preferred here over other schizotypy scales due to evidence that schizotypy is a heterogeneous construct, as is schizophrenia (Liddle et al., 1989), and the SPQ-BRI covers this breadth of traits more so than the majority of other measures. Loewy et al. (2005) note that the presence of distress and/or effects on role functioning distinguish the presence of unusual experiences from true symptoms or disorder. Consistent with this notion, the initial validation study of the SPQ-BRI, which surveyed over 600 undergraduate students at LSU, found that each the positive, negative (no close friends and constricted affect subscales only) and disorganization experience and distress subscales were associated with lower satisfaction and quality of life across multiple domains including school, transportation, home life, recreational activities, sleep and others (Cohen, 2014).

2.2.2 Depressive symptoms. The Brief Symptom Inventory (BSI; Derogatis & Melisaratos, 1983) was administered, although only the depression subscale was of interest in the present study. The BSI is a commonly used self-report wherein individuals rate their symptoms on a 5-point Likert scale regarding how distressed by certain symptoms they have felt in the last

month. Internal consistency for the depression scale in the present study was good (Cronbach's α = .87)

2.2.3 Estimated intelligence. The Wechsler Reading Achievement Test – 4th Edition (WRAT-4) - Word Reading Subtest (Wilkinson & Robertson, 2006), was used to estimate intelligence. The WRAT-4 Word Reading Subtest is a norm-referenced test of the ability to decode letters and words that is frequently used as an estimate of intelligence.

2.2.4 Trait motivation: avolition/apathy. The Apathy Evaluation Scale – self-report version (AES; see Appendix B; Marin, Biedrzycki, & Firinciogullari, 1991) was used to quantify severity of apathy, as there is no existing measure of avolition. The AES is among the most widely used assessment tools for apathy across disorders from dementia and brain injury to schizophrenia (Andersson, Krogstad, & Finset, 1999; Clarke et al., 2007; Faerden et al., 2008). It was developed as a measure of primary motivational loss that is not attributed to emotional distress, intellectual impairment, or diminished level of consciousness (Marin, 1991). Items are rated on a 4-point Likert scale (1 = not at all true, 2 = slightly true, 3 = somewhat true, 4 = very true) with higher scores representing greater apathy. Items were answered with regard to experiences during the past four weeks. Internal consistency for the self-report version used in the present study was good (Cronbach's α = .85), and nearly identical to that found in the validation study (α = .86, Marin et al., 1991).

2.2.5 Reward valuation. The reward valuation questions (Appendix C) were designed to assess how much participants valued different amounts of monetary reward and were used in a previous study (Fervaha, Graff-Guerrero, et al., 2013). In that study, there were no differences between schizophrenia and control participants, which strengthened their confidence in concluding that performance differences on that effort task were attributable to differences in

perception of effort costs or in ability to integrate effort-cost/reward-value information rather than differences in how much individuals valued monetary reward. Internal consistency in the present study was good (Cronbach's $\alpha = .85$).

2.2.6 State motivation. The State Effort Questionnaire (Appendix D) utilized a Likert-scale format to assess state motivation aspects of behavior and consisted of the items that make up the "Effort" subscale of the Intrinsic Motivation Inventory (Choi, Mogrami, & Medalia, 2009; Plant & Ryan, 1985), which was also designed to be administered immediately after a test or task of interest. Lower scores indicate lower self-ratings of effort put into the just-completed task. Internal consistency in the present study was good (Cronbach's $\alpha = .84$).

2.2.7 Effort–Cost Computation Task. The Effort-Cost Computation Task (Gold et al., 2013) is a multi-trial, button-pressing game designed to measure individual differences in willingness to expend effort to obtain monetary rewards (see Figure 1 for schematic representation of each trial). On each trial, participants were asked to make a choice between a high-effort/high-reward (HE/HR; 100 button presses) and low-effort/low-reward (LE/LR; 20 button presses) option under varying levels of monetary reward for the HE/HR option ($3, $5, or $7) and probability of reward receipt (50% and 100%). The reward for the LE/LR option was always $1. There were 10 trials of each combination of probability and HE/HR type for a total of 60 trials. The trials were administered to all participants in the same pseudorandom order. The probability and reward values were displayed on the screen for each trial. After making their choice, participants had an unlimited time to make the button presses to inflate a balloon until it popped on the pin at the top of the screen; the mean time to pop the balloon was 5.26 seconds (*SD* = 1.1) for LE/LR choices and 30.45 seconds (*SD* = 6.7) for HE/HR choices. After the balloon popped, participants were told how much money they had won (range: $0-$7). A running

tally of their total winnings was displayed on the screen. To incentivize optimal performance, participants were told that each dollar they earned would count as one ticket toward their chance of winning one of four $50-dollar gift cards that would be raffled off at the end of the study. This incentive was meant to reduce the likelihood that lack of effort was related to insufficient reward valuation (i.e., extrinsic motivation) and make more compelling any finding of reduced effort performance. Willingness to expend effort was operationalized as proportion of HE/HR choices. Total task time (in seconds) as well as measures of response vigor, calculated based on average number of presses per second for HE/HR and LE/LR options, were also collected as secondary measures of effort.

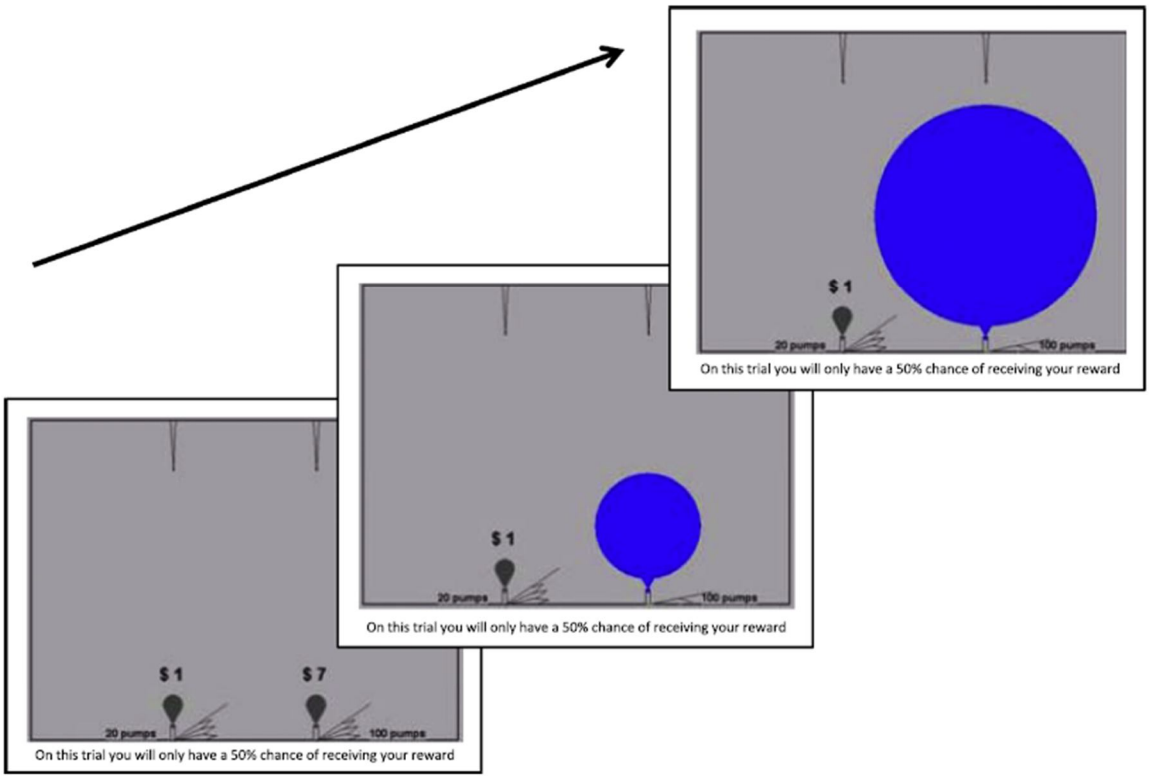

Figure 1. Effort-cost task trial sequence. Participants initially select which balloon they want to pop. The easy selection always offers $1 for 20 button presses. The hard selection offers $3–$7 for 100 presses. After each press the size of the balloon increases in proportion to how many presses are needed to reach the pin at the top of screen.

Figure 1. Schematic of Effort-Cost Computation Task.[1]

[1] Adapted from Gold et al. (2013).

A few modifications from the procedure described by Gold et al. (2013) were made in consultation with the second author on that publication (G. P. Strauss, personal communication, February 22, 2014) to adapt the task for our lab's purposes and to reduce participant time burden. First, whereas Gold et al. (2013) varied the high effort reward value at 5 levels ($3, $4, $5, $6, and $7), the present experiment only used 3 levels ($3, $5, $7). This modification reduced task time by 40% and maintained the power to detect differences per condition as well as paradigm design properties of interest. Namely, it enabled qualitative analysis of response strategies apparent from the three levels of HE/HR employed in the present study. For example, participants basing effort allocation purely on maximizing total reward should always choose the high effort option. By contrast, participants who choose based on the ratio of rewards to presses (i.e., to maximize the reward value per press), should 1) always choose the LE/LR option for $3 trials (where payoff is only 3 cents/press on the HE/HR choices vs. 1/20 or 5 cents/press on LE/LR choices), 2) be equally likely to choose the LE/LR or HE/HR condition for $5 trials (both 5cents/press), and 3) always choose the HE/HR condition for $7 trials (7 cents/press).

In the second modification, while the response for all trials in the original task required alternating left and right button-presses on a game controller, the present task required that responses be made by alternating pressing the "1" and "2" buttons on the keyboard. Participants were instructed that they could use whichever hand they preferred on a single trial but may not switch hands mid-trial. The measures of response vigor were one source for comparing task difficulty and fatigue effects in the present task compared to the original task, although participants in the original task were significantly older (*M* age = 39.4, *SD* = 11.0; Gold et al., 2013).

The third modification was that we incentivized performance with a chance at winning one of four $50 gift cards whereas the original task said that a task bonus would be provided based upon their choices when, in actuality, all participants were paid a $5 bonus. We reasoned that a good chance at winning $50 should be sufficiently motivating and should still incentivize participants to exert effort across all trials. The crucial similarity between task versions was that participants were led to believe that bonus rewards were based upon better performance; thus, less willingness to exert effort should not be related to lack of valuing good task performance. Given that we anticipated 100-120 participants for the present study, paying each participant $5 (study total: $500-$600) was not feasible in the present study.

2.3 Procedure

As part of this study, all participants who participated in the laboratory phase of this study reviewed and signed a consent form. Next, participants were provided with abbreviated instructions for the Effort-Cost Computation Task and then completed a pre-task questionnaire (only the subpart titled "Reward Valuation Questionnaire" was part of the present study). Following the questionnaire, participants received the full instructions and then completed the task (estimated duration: 18 minutes). Immediately following the task, participants completed the post-task questionnaire (only the subpart titled "State Effort Questionnaire" was part of the present study). Next, participants completed the WRAT-4 Word Reading test and all additional self-report measures. Finally, participants were debriefed regarding the purpose of the study.

2.4 Aims, Hypotheses, and Statistical Analyses

2.4.1 Statistical analyses. Group differences were examined using *t* tests, chi-square analyses, mixed-model ANOVAs, and Fisher's *r*-to-*z* transformation analyses. Correlations were used to explore relationships between variables of interest. Data were checked for violations of

normality, homogeneity of variances, skewness, and kurtosis and statistical corrections or non-parametric tests were employed, as appropriate. When Levene's test of homogeneity of variances was violated, adjusted degrees of freedom were reported. When Mauchly's test of sphericity was rejected in the repeated-measures ANOVAs, Greenhouse-Geisser corrections were applied. All tests had statistical significance set at $\alpha < .05$ (two-tailed) and were analyzed using IBM SPSS Statistics 20.

2.4.2 Preliminary analyses. Potential group differences on demographic variables were assessed using independent-sample *t* tests or chi-square tests for continuous (e.g., age, years of education, WRAT-4 Word Reading IQ estimate, BSI depression) and categorical (e.g., gender, ethnicity) data, respectively. Any significant differences in demographic characteristics were statistically controlled via appropriate modifications.

To minimize fatigue, the task used by Gold and colleagues (2013) was shortened by removing the $4 and $6 trials. Previous work with tasks of similar length (about 20 minutes) failed to find significant fatigue effects in either clinical or nonclinical groups (Fervaha, Graff-Guerrero, et al., 2013; Treadway et al., 2009; Treadway et al., 2012). An additional check for fatigue effects was to include trial number in the ANOVA analyses. To examine whether groups valued monetary reward differently, averaged reward valuation scores were computed. Lack of significant group differences in monetary valuation would suggest any group differences in effort-cost computation performance are less likely to be related to differences in the way participants valued money and more likely related to differences in the perception of effort costs.

2.4.3 Manipulation checks. To ensure that participants were sensitive to the changing demands of the task, it was anticipated that there would be significant main effects of high-effort

reward magnitude and probability, such that higher high-effort reward magnitudes and higher probability of reward receipt would be related to a higher proportion of HE/HR choices.

2.4.4 Aims and hypotheses. The Effort-Cost Computation Task or a similar version has been proposed as a behavioral test of reward motivation, has been used to demonstrate cost-effort computation deficits in individuals with schizophrenia and major depression, and has been related to avolition/anhedonia. The present study aimed to determine whether individuals with schizotypy demonstrate similar cost-effort computation deficits and whether their subjective reports of trait and state motivation are related objective performance on an effort task.

Aim One examined whether individuals with the HIGH SZT group (relative to LOW SZT group) demonstrated subjective deficits in state and trait motivation. The following hypotheses were assessed via independent samples *t* tests and correlations. It was hypothesized that:

1. The HIGH SZT group would have lower trait motivation (higher AES total score).
2. The HIGH SZT group would have lower state motivation (lower scores on State Effort Questionnaire).

Aim Two examined whether the HIGH SZT group (versus LOW SZT group) demonstrated objective deficits on a cost-effort computation task. These factors were assessed via a 2 (group: HIGH SZT vs. LOW SZT) x 3 (reward magnitude of high-effort option: $3, $5, $7) x 2 (probability: 50%, 100%) mixed-model analysis of variance (ANOVA) with post-hoc one-way ANOVAs and/or *t* tests to explore significant relationships. It was hypothesized that:

1. Consistent with reports using effort-cost computation tasks in schizophrenia (Fervaha, Graff-Guerrero, et al., 2013, Gold et al., 2013), there would be a significant two-way interaction between group and reward magnitude on the Effort-Cost Computation Task such that the

HIGH SZT group would make a lower proportion of HE/HR choices for large magnitude rewards ($7 trials), but not for small magnitude rewards ($3 trials).

2. Consistent with reports using the effort-cost computation tasks in schizophrenia (Fervaha, Graff-Guerrero, et al., 2013, Gold et al., 2013), there would be a significant two-way interaction between group and probability such that the HIGH SZT group would make a lower proportion of HE/HR choices on the 100% trials but not the 50% trials.

2.4.5 Exploratory analyses examined whether negative schizotypy traits and self-reported trait motivation/apathy were related to each other and to specific aspects objective performance. The following hypotheses were assessed via correlational analyses, combining groups as well as examining groups separately, with group differences in associations compared via Fisher's r-to-z transformations:

1. High trait apathy (AES total score) would correlate with negative schizotypy traits (SPQ-BR negative symptom subscale).
2. There would be a significant negative correlation between negative schizotypy traits and proportion of HE/HR choices on the 100% probability trials in the high reward magnitude ($7) condition.
3. There would be a significant negative correlation between trait apathy (AES total score) and proportion of HE/HR choices on 100% probability trials in the high reward magnitude ($7) condition.

2.5 Power Analysis

G*Power 3.1.5 (Faul, Erdfelder, Lang, & Buchner, 2009) was used in order to compute the minimum number of participants to be recruited for the present study to detect the expected correlations and two-way interactions with power $(1 - \beta)$ of .80, two-tailed tests, and $\alpha = .05$.

The closest model of a relationship between schizotypy traits and proportion of HE/HR choices in a non-clinical sample came from Treadway et al.'s (2009) finding of a significant relationship between proportion of HE/HR choices and a composite sum of two Chapman anhedonia scales, r = -0.28, p < .05. To match this small-to-medium effect size, a minimum of 97 participants were required. The group x probability interaction in the Gold et al. (2013) article was estimated to be in the large range ($F_{4,78}$ = 7.20, p < .001, η_p^2 = .27), and the group x reward magnitude interaction was only marginally significant ($F_{2.5,78}$ = 2.71, p = .058, η_p^2 = .08). Because that study compared schizophrenia to control participants, it was likely that the effect sizes would be smaller in a schizotypy population. To err on the side of caution, power was computed for a medium effect size according to Cohen's (1988) guidelines (phi = .25). This resulted in a minimum total sample size of 28 participants ($F_{critical}$ = 3.17). Thus, in order to adequately power all planned analyses, a minimum sample of 97 participants needed to be recruited. In total, 115 participants had data suitable for inclusion in analyses.

CHAPTER 3. RESULTS

3.1 Demographics and Preliminary Analyses

See Table 1 for descriptive statistics. There were no differences between the LOW SZT and HIGH SZT groups on gender, ethnicity, WRAT-4 Word Reading score, or age. As expected, there were significant group differences on SPQ-BRI Total Experience score as well as the SPQ-BRI Total Distress Score and on each of the positive, negative, and disorganized symptom scales. The HIGH SZT group was significantly higher than the LOW SZT group on the BSI

Table 1. Demographic Variables for the Low and High Schizotypy Groups

	Low Schizotypy (n = 57)	High Schizotypy (n = 58)	Statistic	Significance	Effect Size
	%	%	χ^2	*p*	Phi
Female	71.9	72.4	0.00	0.95	0.01
Caucasian	70.02	75.9	0.47	0.49	0.06
	Mean (SD)	Mean (SD)	*t*		*d*
WRAT-4 Word Reading (max 75)	60.59 (4.66)	61.02 (9.23)	0.31	0.76	0.06
Age	20.37 (2.67)	20.05 (2.07)	-0.71	0.48	-0.13
BSI Depression	10.39 (4.01)	15.33 (6.11)	5.01	< .001	0.97
SPQ-BRI Experience Scores					
Total	8.44 (3.55)	18.22 (3.46)	14.97	< .001	2.82
Cognitive Perceptual	2.72 (1.79)	6.09 (2.61)	8.08	< .001	1.61
Interpersonal	2.67 (2.10)	5.64 (2.06)	7.67	< .001	1.44
Disorganized	3.05 (1.86)	6.50 (1.35)	11.36	< .001	2.25
SPQ-BRI Distress Scores					
Total	56.51 (14.56)	82.67 (18.91)	8.30	< .001	1.56
Cognitive Perceptual	21.11 (6.15)	28.86 (7.94)	5.86	< .001	1.13
Interpersonal	19.81 (7.71)	29.81 (9.33)	6.26	< .001	1.18
Disorganized	15.60 (4.77)	24.00 (6.74)	7.73	< .001	1.53

depression subscale; thus, subsequent analyses repeated analyses in order to examine the effect of depressive symptoms.

Table 2 presents the data regarding monetary valuation and response vigor. Groups did not differ on average reward valuation or on total money won on the task, which suggested groups did not differ in the way they valued the monetary rewards. Groups did not differ on mean time to decide whether to make the low- vs. high-effort choice. In terms of fatigue effects, groups did not differ on average presses per second for either hard or easy trials, suggesting that neither group responded less vigorously during each trial type.

Table 2. Response Vigor and Reward Valuation Variables for the Low and High Schizotypy Groups

	Low Schizotypy (n = 57)	High Schizotypy (n = 58)	Statistic	Significance	Effect Size
	Mean (SD)	Mean (SD)	*t*	*p*	*d*
Reward Valuation Avg.	4.97 (2.08)	5.52 (1.65)	1.57	0.120	0.13
Avg. Presses Per Second (Easy Trials)	3.94 (0.72)	4.03 (0.73)	0.62	0.537	0.12
Avg. Presses Per Second (Hard Trials)	3.44(0.67)	3.47 (0.68)	0.23	0.817	0.04
Mean Time To Make Choice (Seconds)	1.96 (0.64)	2.00 (0.56)	0.34	0.736	0.06
Total Money Won (Dollars)	138.00 (52.08)	144.03 (42.67)	0.68	0.499	0.13

Note. No group differences were statistically significant. Avg.=Average.

3.2 Manipulation Checks

A 2 (Probabilities: 50%, 100%) x 3 (High-Effort Reward: $3, $5, $7) x10 (Trial Numbers 1-10 of each type) mixed-model ANOVA was performed to examine sensitivity to task demands. Because Mauchly's Test of Sphericity was violated for the effects of high-effort reward, trial

number, high-effort reward x trial number, probability x trial number, and probability x high-effort reward x trial number (*p*s < .001), Greenhouse-Geisser-corrected values with adjusted degrees of freedom were reported in all subsequent analyses of these effects. As expected, results of the ANOVA revealed significant main effects of probability, $F(1,132) = 99.75$, $p < .001$, $\eta_p^2 = .43$, and of high-effort reward option, $F(1.65,264) = 106.08$, $p < .001$, $\eta_p^2 = .45$, which suggested participants were sensitive to changes in task demands, at a large effect-size level. Specifically, participants made a significantly larger proportion of HE/HR choices when the probability of winning the reward was 100% (vs. 50%) and when the high-effort reward was larger (i.e., $7 vs. $5 or $3). There was also a main effect of Trial Number, $F(6.16,770.96) = 26.19$, $p < .001$, $\eta_p^2 = .17$, which suggested participants as a whole showed large effect-size levels of reduced willingness to select the HE/HR option over time.

Also consistent with expectations, there were significant 2-way interactions between probability and high-effort reward, $F(1.93,254.93) = 14.82$, $p < .001$, $\eta_p^2 = .10$, between probability and trial number, $F(7.3,963.56) = 2.70$, $p < .01$, $\eta_p^2 = .02$, and between high-effort reward and trial number, $F(1.88,1908.47) = 12.52$, $p < .001$, $\eta_p^2 = .09$. In addition, there was a 3-way interaction between probability, high-effort reward, and trial number, $F(1.33,1865.54) = 9.33$, $p < .001$, $\eta_p^2 = .07$. Inspection of the plots of estimated marginal means suggested that participants were most likely to select the HE/HR option when probability was most certain (i.e., in the 100% probability condition) and when reward values were highest (i.e., $7 > $5 > $3).

Tests of within-subjects contrasts for trial number were significant for linear, quadratic, and cubic effects (*p*s ≤ .005) suggesting a dramatic decrease in willingness to select the HE/HR option over time. As seen in Figures 2 and 3, the effects of trial number were less pronounced in the $7 high-effort reward conditions and when probability of winning was 100%.

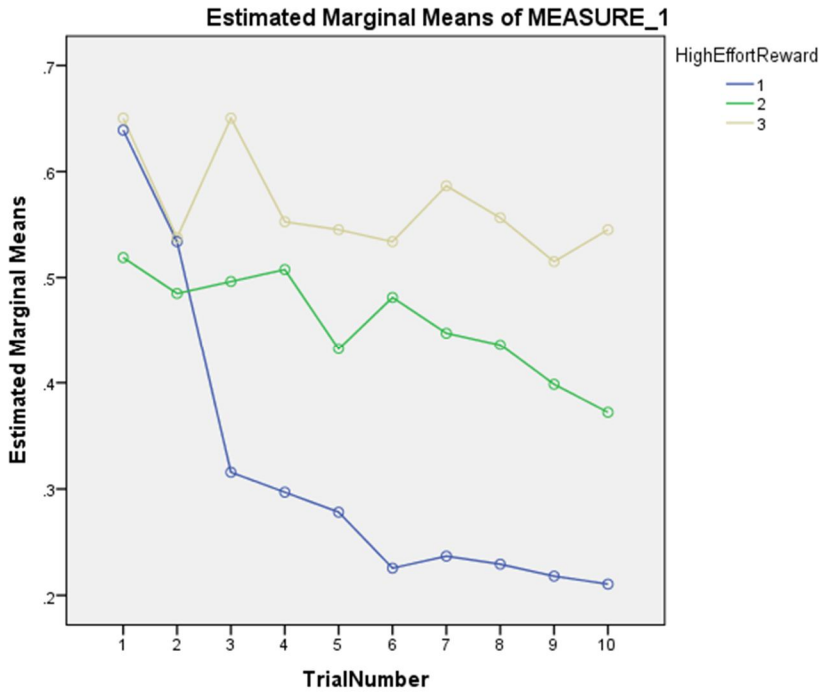

Figure 2. Effects of Trial Number on Proportion of High-Effort Choices, as a Function of High-Effort Reward Value (1 = $3 reward, 2 = $5 reward, and 3 = $7).

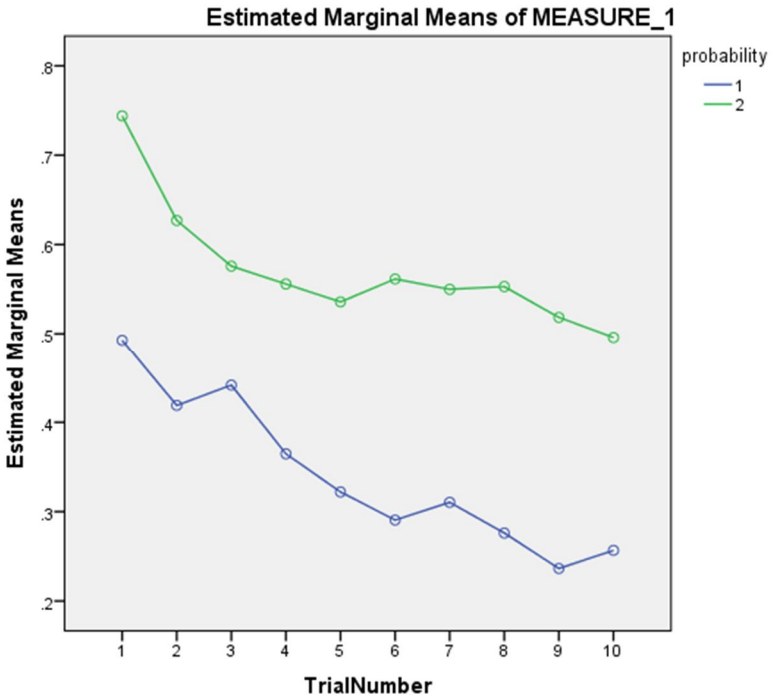

Figure 3. Effects of Trial Number on Proportion of High-Effort Choices, as a Function of Probability of Winning the Reward (1 = 50%, 2 = 100%).

3.3 Aim One: Examining high- vs. low- schizotypy group differences in state and trait apathy

T tests were employed to examine hypotheses one and two. As hypothesized, the HIGH SZT group was higher in self-rated trait apathy (i.e., lower in trait motivation) (M = 29.19, SD = 7.65) than the LOW SZT group (M = 25.56, SD = 6.18), $t(109) = 2.75$, $p = .007$, $d = 0.52$, 95% CI [-0.78, 1.82]. Given that depressive symptoms were significantly higher in the high schizotypy group, an exploratory ANCOVA with depression as the covariate was employed. The relationship between schizotypy group and trait motivation/apathy was no longer significant after entering depression as a covariate, $F(1,110) = 0.31$, $p = .58$, $\eta_p^2 = .003$, which suggested that schizotypy and apathy share significant variance with depression. In the present study, depression was significantly correlated with trait apathy, $r(111) = .57$, $p < .001$, and with SPQ-BRI Total Experience score, $r(111) = .58$, $p < .001$. Overall, the HIGH SZT group had elevated trait apathy (lower trait motivation), so hypothesis one was supported.

Contrary to the second hypothesis, groups did not differ on state motivation/apathy (HIGH SZT M = 26.22, SD = 5.60; LOW SZT M = 26.16, SD = 6.02), $t(113) = 0.06$, $p > .95$, d = .01, 95% CI [-1.06, 1.08]. Overall, groups did not differ on state motivation, but did differ on trait motivation (trait apathy); however, the trait apathy scores shared significant variance with depression scores.

3.4 Aim Two: Examining high- vs. low-schizotypy group differences on the effort-cost computation task

Given the significant main effect of (and interaction effects with) trial number, trial number was included as a within-subject factor in the mixed-model ANOVAs. That said, the ANOVAs were re-run without trial number included in the model, and the results were unchanged. A 2 groups (low v. high schizotypy) x 2 probabilities (50% and 100%), x 3 high-

effort reward values ($3, $5, and $7) x 10 trial number mixed-model ANOVA was employed to examine whether there were significant 2-way interactions between group and probability or group and high-effort reward value (see Figure 4). Inconsistent with expectations, neither the group x probability nor the group x high-effort reward interactions was significant, $F(1,113) = 0.60$, $p = .44$, $\eta_p^2 = .005$, 95% CI [.000, .061], or $F(1.63,188.56) = 0.37$, $p = .65$, $\eta_p^2 = .003$, 95% CI[.000, .031]. As expected, the main effect of group was not significant, $F(1,113) = 0.40$, $p = .53$, $\eta_p^2 = .004$, 95% CI[.000, .015]; thus, neither group was more likely to make HE/HR choices across any of the condition types. As with the within-subjects ANOVA mentioned in the manipulation checks section above, the main effects of probability, high effort reward, and trial

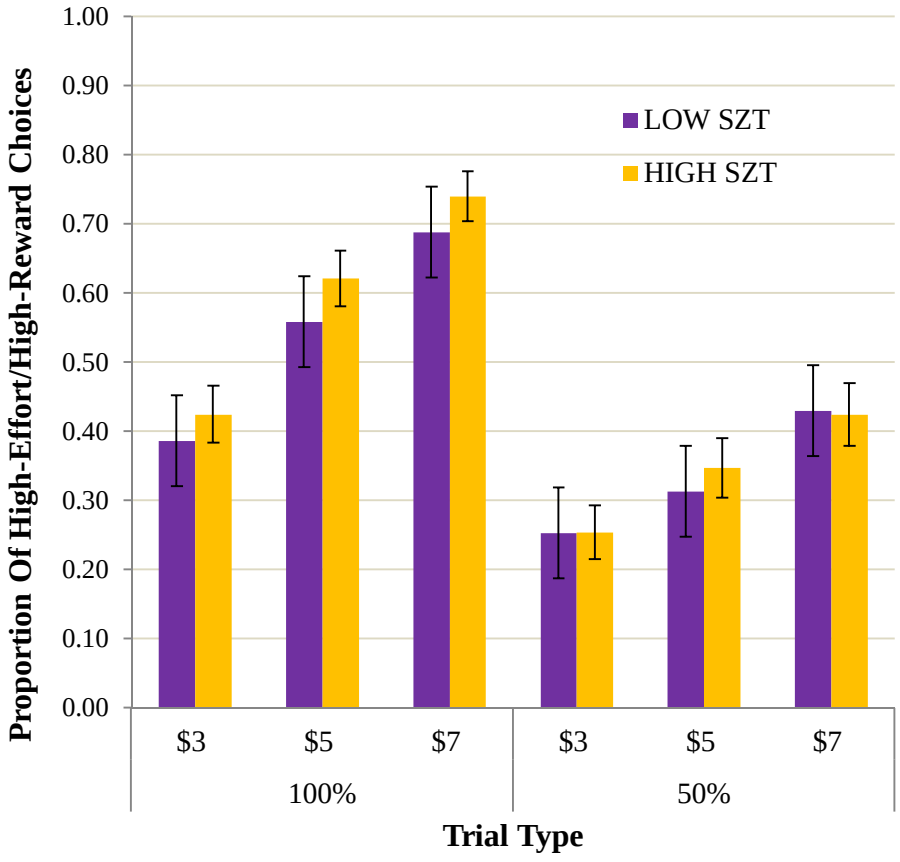

Figure 4. Mean (±SEM) Proportion of High Effort Choices by Trial Type for Low Schizotypy Group (LOW SZT; n = 57) and the High Schizotypy Group (HIGH SZT; n = 58).

number were each significant, as were all 2-way, and 3-way interactions with these variables (*ps* < .001, η_p^2s ranged from .023 - .467). Overall, neither hypothesis of Aim two was supported; groups did not differ in performance on the objective effort-cost computation task.

3.5 Exploratory and Post-hoc Analyses: What is the nature of the relationship between schizotypy traits, objective effort task performance, and subjective assessments of effort?

It was hypothesized that trait apathy would be associated with negative schizotypy traits. This hypothesis was supported, $r(113) = .304$, $p = .001$. As was the case when looking at total schizotypy scores, the correlation was no longer significant after using partial correlations with depression as the covariate, $r(110) = .097$, $p = .31$.

It was additionally hypothesized that there would be a negative correlation between each negative schizotypy and trait apathy with proportion of HE/HR choices in the 100% probability x high reward magnitude ($7) condition (i.e., in the condition where it is most "worth the effort" to select the high-effort option); neither the association with negative schizotypy nor with trait apathy was significant, $r(117) = .141$, $p = .16$ and $r(113) = .059$, $p = .54$, respectively. Overall, objective performance was not associated with trait levels of negative schizotypy or trait apathy.

Previous studies have related performance on a similar effort-cost computation task to anhedonia, which is considered a negative symptom of schizophrenia spectrum disorders. To examine whether this particular facet of schizotypy, as opposed the more heterogeneous schizotypy construct (which includes positive and disorganized as well as negative schizotypy traits), was related to objective effort task performance, a median split of the negative schizotypy experience subscale score across all participants was employed (*M* = 4.17, *SD* = 2.55, *Med* = 4.00, *Min* = 0, *Max* = 9). The median resulted in 59 participants being placed into the low negative schizotypy group (LOW NEG SZT; negative SPQ Negative Experience score *M* = 2.05, *SD* = 1.40) and 56 in the high negative schizotypy group (HIGH NEG SZT; *M* = 6.39, *SD* =

1.26). Compared to the SPQ Total Experience score median split, 13 of the 57 (23% of) participants from the low SPQ total group were in the high negative schizotypy group and 15 of 58 (26% of) participants in the high SPQ total group were in the low negative schizotypy group (for a total of 28/115 = 24% of participants whose high versus low group membership changed); thus, the groups compared using a median split for each the SPQ total versus SPQ negative subscales did not appear to be a completely redundant measure of the same participants.

Then a 2 groups (LOW NEG SZT vs. HIGH NEG SZT) x 2 probabilities (50% and 100%), x 3 high-effort reward values ($3, $5, and $7) x 10 trial number mixed-model ANOVA was employed to examine whether there were significant 2-way interactions between group and probability or group and high-effort reward value (see Figure 5). Results revealed that neither the probability x group nor high-effort reward x group interactions was significant, $F(1,113) = 2.40$, $p = .12$, $\eta_p^2 = .021$, 95% CI [.000, .097], and $F(2,185.28) = 0.32$, $p = .68$, $\eta_p^2 = .003$, 95% CI [.000, .029]. Moreover, the near trend-level interaction between probability and group suggested that the HIGH NEG SZT group selected a higher proportion of HE/HR choices in the 100% probability condition (LOW NEG SZT: $M = .54$, $SD = .29$ vs. HIGH NEG SZT: $M = .60$, $SD = .25$; Cohen's $d = .22$, 95% CI[.017, .272]) although no differences in the 50% probability condition (LOW NEG SZT: $M = .34$, $SD = .31$ vs. HIGH NEG SZT: $M = .33$, $SD = .30$; Cohen's $d = -.033$, 95% CI[-.088,.022]). Overall, the high trait negative schizotypy group did not perform differently than the low trait negative schizotypy group on the Effort-Cost Computation Task.

3.5.1 Do high vs. low schizotypy groups differ in their relationship between objective and subjective performance? Although self-report measures of trait motivation / apathy and schizotypy did not appear to associate with objective aspects of effort task performance, it was unclear whether measures of state motivation / apathy might better predict performance. Given

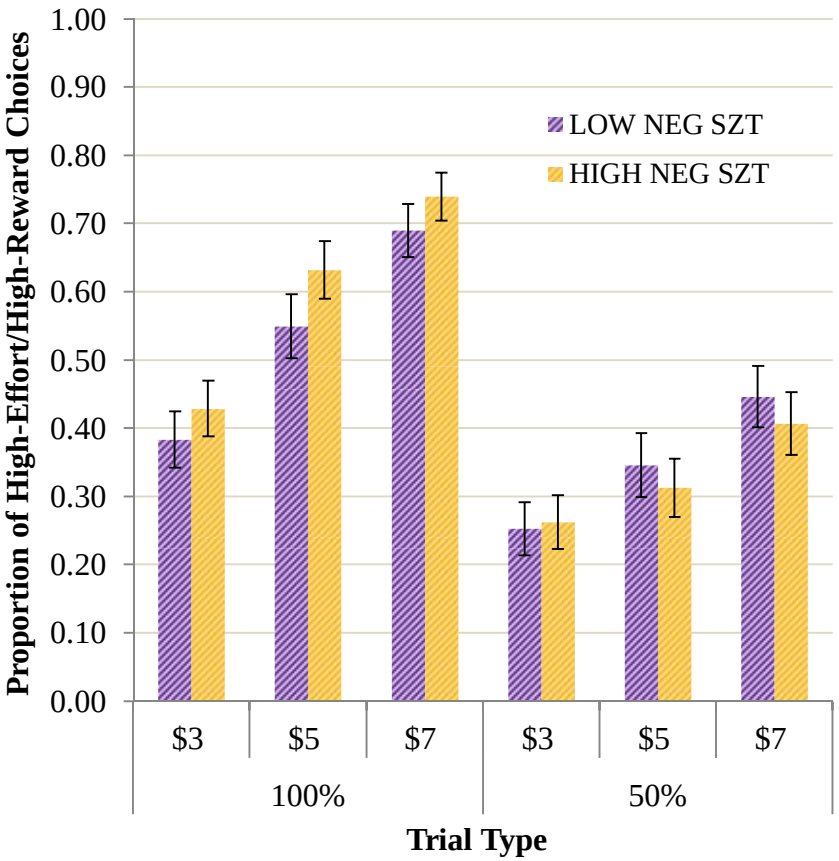

Figure 5. Mean (±SEM) Proportion of High Effort Choices by Trial Type for Low Negative Schizotypy Group (LOW NEG SZT; n = 59) and the High Negative Schizotypy Group (HIGH NEG SZT; n = 56).

previous reports of discrepancies between objective and subjective aspects of cognitive performance and quality of life in individuals with schizotypy, correlations within each the low and high schizotypy groups between state motivation and proportion of HE/HR choices in each of the 6 (i.e., 2 probability x 3 high-effort reward) conditions was employed. Interestingly, in the LOW SZT group, state motivation was significantly associated with proportion of HE/HR choices in each condition on the task at a trend level or better (*p*s < .10), with one exception (the 100% probability x $3 high-effort reward condition, $r[57] = .294$, $p = .112$) (see Table 3). By contrast, none of these associations was significant in the HIGH SZT group, *p*s > .50. Fisher's *r*-to-*z* transformation tests indicated that the LOW SZT group showed trend-level significantly

stronger correlations than the HIGH SZT group between state motivation and proportion of HE/HR choices for the $5 x 100% probability and $5 x 50% probability conditions as well as when combining proportion of HE/HR choices across all trial types (*p*s < .10). Of note, due to the exploratory, post-hoc nature of these analyses, corrections for multiple comparisons were not applied and all results should be interpreted with caution.

Table 3. Correlations Between State Effort and Proportion of High-Effort Choices on the Effort Task for Low vs. High Schizotypy Groups

	Low Schizotypy		High Schizotypy		Fisher's r-to-z transformation		95% Confidence Interval
	r	*p*	*r*	*p*	*Z'*	*p* (two-tailed)	[LL, UL]
100% Probability							
$7	.246†	.065	-.013	.924	1.379	0.168	[1.195, 1.563]
$5	.294*	.027	-.017	.898	1.670	0.095†	[1.486, 1.854]
$3	.204	.112	-.041	.760	1.294	0.197	[1.110, 1.478]
Across All $	.276*	.038	-.029	.829	1.630	0.103	[1.446, 1.814]
50% Probability							
$7	.294*	.026	.083	.535	1.147	0.250	[0.963, 1.331]
$5	.236†	.077	-.017	.898	1.344	0.090	[1.160,1.528]
$3	.262*	.049	-.071	.596	1.772	0.077	[1.588, 1.956]
Across All $	.289*	.029	.002	.986	1.542	0.124	[1.358,1.726]
Across All Probabilities							
$7	.305*	.021	.050	.710	1.383	0.168	[1.199,1.567]
$5	.302*	.022	-.021	.876	1.737	0.082†	[1.553,1.921]
$3	.247†	.064	-.061	.650	1.635	0.101	[1.451,1.819]
Across All 6 Conditions	.306*	.021	-.014	.918	1.969	0.085†	[1.785,2.153]

† $p < .10$. * $p < .05$. LL = Lower Limit. UL = Upper Limit.

CHAPTER 4. DISCUSSION

The present study had two primary aims: 1) to examine whether individuals high in schizotypy traits demonstrated elevated trait and/or state apathy/motivation, and 2) to examine whether deficits in effort-cost computations extend from individuals with schizophrenia to individuals high in schizotypy traits). Lastly, exploratory and post-hoc analyses were utilized to examine whether there were any discrepancies between objective and subjective effort in either the high or low schizotypy groups. Overall, the first aim was partially supported, and the second aim was not supported. That is, the high schizotypy group was higher than the low schizotypy group in trait but not state apathy / lower motivation, and there were no group differences on the Effort-Cost Computation Task. Post-hoc analyses revealed that there were relationships between objective task performance and self-reported state effort for the low but not high schizotypy groups.

4.1 Examining high- vs. low- schizotypy group differences in state and trait motivation/apathy

As hypothesized, individuals in the high schizotypy group were significantly higher in trait apathy (i.e., lower in trait motivation) than those in the low schizotypy group. This suggests that apathy/avolition may be an important though largely ignored aspect of the schizotypy construct, and is consistent with the schizophrenia literature which recognizes apathy/avolition as a core negative symptom of schizophrenia (Kirkpatrick et al., 2006). This is consistent with previous research which has shown that higher schizotypy traits, particularly negative schizotypy traits, correlated with higher levels of trait apathy at a moderate effect size level (Fervaha et al., 2014). Moreover, another study showed that social apathy was associated with negative schizotypy traits (Cohen & Matthews, 2010). Overall, examination of trait apathy in schizotypy warrants further exploration in future studies.

Of note, the association between schizotypy traits and trait apathy was no longer significant after entering depression severity as a covariate, which suggests that the construct of apathy as assessed by the AES shares significant variance with the construct of depression as assessed by the BSI. This was not surprising because apathy is a symptom of both depression and schizophrenia spectrum disorders, apathy likely shares similar neurobiological mechanisms in both disorders, and depression is frequently comorbid with schizophrenia. Alternatively, although not mutually exclusive, depression or a construct underlying both depression and schizotypy (e.g., negative affect) may mediate and/or moderate the relationship between schizotypy and apathy traits. Such a mediator may represent a shared vulnerability factor for these disorders. For example, elevated trait negative affect and low trait positive affect have been shown in schizotypy, depression, and schizophrenia and have associated with a broad range of psychological and physical problems (Horan et al., 2008).

Unexpectedly, groups did not differ on subjective/self-reported levels of state effort following the task. This suggested that individuals high in schizotypy traits did not indiscriminantly endorse higher psychopathology across all self-reports.

4.2 Examining high- vs. low-schizotypy group differences on the Effort-Cost Computation Task

Both the high and low schizotypy groups appeared sensitive to changing demands of the Effort-Cost Computation Task (i.e., changes in probability and high-effort reward value); that is, they made a higher proportion of high-effort/high-reward (HE/HR) choices when the probability of receiving the reward was 100% (vs. 50%) and when the payoff for the HE/HR choice was greatest ($7 > $5 > $3). However, there was no objective evidence that the high schizotypy group was less willing to exert effort in any of the conditions. This is particularly interesting since the high schizotypy group was elevated in self-reported apathy and depression yet did not

demonstrate lack of willingness to exert extra effort for higher rewards on the objective effort-based decision-making task.

This result contradicts a previous study that used a non-clinical undergraduate sample examining trait anhedonia dimensionally on a similar effort-cost computation task. In that study, results suggested that trait anhedonia significantly predicted high-effort choices at higher reward values but not lower reward values and significantly predicted trials at the lower probability levels but not on the highest probability level (Treadway et al., 2009). There are several potential differences between these studies which may help explain this discrepancy. First, it may be that individuals high in schizotypy traits are not impaired on objective effort-based decision-making tasks. There is a large body of evidence which suggests that individuals with schizotypy are largely unimpaired relative to peers on objective measures neurocognitive functioning (Chun et al., 2013).

Another potential reason for the discrepancy may be due to construct differences in the way that schizotypy traits were measured. Whereas Treadway et al. (2009) used a composite score of higher physical and social anhedonia, which is sometimes used to determine schizotypy group, the present study used a more heterogeneous measure of schizotypy traits that assessed positive, negative, and disorganized traits. However, when using a median split of negative schizotypy scores, a construct slightly more similar to that assessed in the Treadway et al. (2009) study, the results were unchanged and suggested, if anything, that the high negative schizotypy trait group was more willing to exert higher effort for higher reward in some conditions.

A third explanation for the discrepancy between the Treadway et al. (2009) and present studies is in the approach to statistical analyses. The present study took a condition-level approach to analyses (i.e., examining proportion of high effort choices made in each of the 6

conditions [2 probability x 3 high-effort reward], which has been used in some studies (Fervaha, Graff-Guerrero, et al., 2013; Gold et al., 2013). By contrast, the Treadway et al. (2009) study took a trial-by-trial generalized estimating equation (GEE) modeling approach to predicting probability that an individual would make a high effort choice on any given trial. By looking at the trial level, power and thus sensitivity to detecting differences is greatly enhanced because N is computed by the number of samples involved in predicting the relationships of interest (i.e., 50-60 trials x N participants).

Related to this issue of power, it is also possible that the use of a median split to determine schizotypy status was a less sensitive and, potentially, overly conservative way to examine the influence of schizotypy traits. Accumulating evidence suggests schizotypy is non-taxonic (i.e., non-categorical; e.g., Rawlings, Williams, Haslam, & Claridge, 2008a, 2008b) and thus a median-split to form groups may be somewhat arbitrary; however, the taxonic nature of schizotypy has been hotly debated (e.g., Beaucharine, Lenzenweger, & Waller, 2008; Horan, Blanchard, Gangestad, & Kwapil, 2004; Korfine & Lenzeweger, 1995; Rawlings et al., 2008b) and some suggest separate taxons for negative and positive schizotypy traits (Horan, Blanchard, Gangestad, & Kwapil, 2004). SPQ-BRI scores were normally distributed in the present study, which is consistent with the idea that schizotypy is non-taxonic. Moreover, median splits on schizotypy measures have been used in previous studies (e.g., Hori et al., 2008; Jolley et al., 1999). Importantly, the lack of objective cost-effort computation deficits in the high schizotypy group does not appear to be a power issue since, if anything, the high schizotypy group tended to make more high-effort/high-reward choices in the hypothesized conditions (see Figures 4 and 5).

Other studies using this exact task or one very similar in psychiatric populations known to possess reward-related deficits found group interactions with probability and high effort

reward in individuals with schizophrenia (vs. non-psychiatric controls; Fervaha, Graff-Fuerrero, et al., 2013; Gold et al., 2013) and in individuals with major depressive disorder (Treadway, Bossaller, et al., 2012), such that those psychiatric groups were less willing to exert effort in the conditions where it would seem most "worth the effort" to exert extra effort to obtain larger rewards (i.e., they made inefficient cost-effort computations). It may be the case that such deficits are not present at the level of high trait schizotypy. Alternatively, it may be that selecting individuals because they have more extreme schizotypy traits or who are at "ultra-high risk" of conversion to psychosis (e.g., Woods et al., 2009) may have produced the predicted relationship.

4.3 What is the nature of the relationship between schizotypy traits, objective effort task performance, and subjective assessments of effort?

As already mentioned, the present study failed to find objective evidence that individuals high in schizotypy traits made aberrant cost-effort computations on the effort task. While this was unexpected, it is consistent with a line of research that has found a dysjunction between subjective and objective performance in individuals with schizotypy. For instance, schizotypy traits did correlate with trait apathy, and trait apathy was elevated in the high schizotypy group relative to the low schizotypy group. That these relationships shared significant variance with depression suggests that they should be less likely to sustain effort. However, it appeared that despite having elevated self-report ratings of depression and apathy, they were equally willing to exert higher effort for higher rewards on the objective effort task.

Interestingly, exploratory analyses revealed that only in the low schizotypy group, and not in the high schizotypy group, was state effort (i.e., state motivation) associated with objective performance on the Effort-Cost Computation Task across almost all condition types, with the exception of the $3 high-effort reward x 100% probability condition. Moreover, there were trend-level significant group differences in the relationship between state effort and objective

performance in all of the $5 high-effort reward conditions and in the $3 x 50% probability condition; thus, state effort mattered most when it was not clearly "worth the effort" to make the HE/HR choice. In other words, if reward trials are broken up into cents per press (i.e., how much reward can I can get for how little effort?), the effort maximization ratio is always in favor of the high effort choice when the high-effort reward is $7 ($7 per 100 presses = 7 cents per press for the high-effort choice vs. $1 per 20 presses = 5 cents per press for the low-effort choice), is equally "worth it" in the $5 conditions (also 5 cents per press), and never "worth it" in the $3 condition (i.e., 3 cents per press). Participants who took a pure reward maximization approach should choose the HE/HR choice every time regardless of condition; nine participants in the present study took this approach. Participants who took a pure effort sparing approach would never choose the HE/HR choice; two participants took that approach. However, the majority of participants generally favored the effort maximization approach. That there were trend-level group differences in each of the $5 conditions, and not the $7 conditions, makes sense since the $5 conditions are the ones where effort maximization versus reward maximization strategies compete. In this regard, it appeared that higher state motivation was associated with biasing participants away from a pure effort sparing approach (i.e., with participants demonstrating greater willingness to exert higher effort for any higher reward). In the low schizotypy group, across all condition types (except one), state motivation appeared to play a role in predicting willingness to exert higher effort for higher reward, and even appeared to bias people away from a pure effort sparing approach. This relationship was not evident in the high schizotypy group. In this sense, it appeared that effort-based decisions were less tied to subjective assessment of their efforts in the high schizotypy group.

A similar dysjunction between objective and subjective performance was found in a study examining presence and associations of intrinsic motivation in individuals with schizophrenia. Specifically, while individuals with schizophrenia did not differ from controls on a self-report scale of intrinsic motivation (the Motivation Trait Questionnaire [MTQ]), controls but not individuals with schizophrenia evidenced associations between personal mastery and competitive excellence subscales of the MTQ and measures of intellectual functioning, working memory, and attention (Barch et al., 2008). The authors suggested that the lack of association may be related to individuals with schizophrenia having difficulty representing the value of rewarding stimuli in a way that is sufficient to drive behavior toward those desired goals or activities. In other words, the desirability or value of a potential reward from a previous experience does not appear to be salient enough when the individual is considering whether to exert the effort to obtain the present goal.

In another study in a schizophrenia sample examining state intrinsic motivation, the authors found that perceived competency as assessed by the MTQ mediated the relationship between intrinsic state motivation (to perform well on a cognitive task) and trait motivation (Choi, Saperstein, & Medalia, 2012). Lastly, a study examining defeatist performance beliefs (which may be construed as an extreme lack of perceived competency) in schizophrenia patients found that defeatist beliefs mediated the relationship between cognitive impairment and both negative symptoms and functioning (Grant and Beck, 2009). Taken together, it may be that beliefs about self and others influence the relationship between how motivated individuals generally are and how motivated they are in the moment and such beliefs may mediate the relationship between objective and subjective motivation. Thus, future studies should explore

psychological variables that may mediate or moderate the relationship between self-reported state effort and objective effort-based performance in schizophrenia-spectrum disorders.

Accumulating evidence suggests that individuals high in schizotypy traits tend to demonstrate large discrepancies between their objective performance and subjective experiences across a number of domains, including quality of life, cognitive functioning, and even olfaction (Auster, Cohen, Callaway, & Brown, 2014; Cohen, Auster, et al., 2014b; Chun et al., 2013). These dysjunctions tend to be biased toward reporting subjective experiences at a level more severe than their objective performance or ratings would suggest. This pattern of findings has been termed the "subjective-objective dysjunction" in schizotypy (Cohen, Mitchell, et al., 2014), and the authors suggest that certain underlying dysfunctional beliefs about oneself and others may mediate the relationship between subjective and objective experience. For example, most people tend to overestimate their positive qualities and underestimate their negative qualities. Cohen, Auster, et al. (2014a) found that when college undergraduates compare their experience to others' in reaction to expressing emotional narratives, individuals with schizotypy do not rate themselves as having a different level of reaction than others would whereas controls rate themselves as having more positive and less negative reactions than others would report in that situation. In this sense, individuals with schizotypy appear to lack the illusory superiority bias that is protective in "healthy" populations (Cohen, Mitchell, et al., 2014).

In the present study, individuals high in schizotypy traits rated themselves as more apathetic and more depressed than those low in schizotypy traits, which would suggest they would be less willing to exert extra effort; however, they self-reported similar levels of state motivation compared to individuals low in schizotypy traits and did not show deficits in effort-based decision-making on the task. It may be that individuals low in schizotypy traits were over-

reporting their amount of intrinsic motivation in this task, but that it was adaptive in the sense that it increased their willingness to exert extra effort on the objective effort task. Future studies should further examine these relationships.

4.4 Additional Limitations

Several limitations to the present study which warrant mention. The chief limitation was the use of a median split because the present study was unable to employ an extreme groups design. The use of a median split to create groups was likely an overly conservative test of the relationship between schizotypy traits and effort task performance, as evident in the lower mean SPQ total score in the high schizotypy group in the present sample relative to the top 10% of scorers on the email survey (had this been an extreme groups design). Moreover, dichotomizing continuous predictor variables underestimates the strength of relationships and reduces statistical power to detect differences by as much as 38% to 60% (Cohen, 1983).

One way to conserve power without reducing the number of participants included in analyses would be to examine SPQ Total Experience scores dimensionally. For example, use of Generalized Estimating Equations (GEE) to predict probability of making a high-effort choice as per Treadway, Bossaller, et al. (2012) and Treadway, Buckholtz, et al. (2009) may have been a more appropriate statistical method for examining these relationships, because of the additional flexibility of assumptions in "generalized" regression models; that is, GEEs can model multiple different distribution types (e.g., normal, dichotomous, Poisson) and may be used to model time-varying (e.g., trial-by-trial changes in probability and reward magnitude of the high effort option) as well as time-invariant parameters (e.g., schizotypy scores). That said, inspection of mean plots from the present study (see Figures 3 and 4) indicated that the relationships of interest were in the opposite direction of those hypothesized, which suggests this was not a power issue and, if

anything, the high schizotypy group was more willing to exert additional effort than the low schizotypy group. Moreover, if the high schizotypy group was more willing to exert additional effort than the low schizotypy group, it would make even more discrepant the association found in the present study between their objective and subjective performance.

In addition, the present study employed a novel version of the SPQ-BRI, which has not yet been published nor used in previous studies. The preliminary validation study for this measure suggested that it had good reliability and was related to important domains of functioning (i.e., quality of life). The modification to the SPQ-BR was done as part of a larger study in effort to improve potential predictive validity of the measure to detect traits that may increase risk of conversion to a schizophrenia-spectrum disorder. Given that other variations of the SPQ have also utilized a dichotomous (Yes/No) format (Raine, 1991; Raine & Benishay, 1995) and other schizotypy measures have demonstrated improved predictive validity by adding a "distress" score (Loewy et al., 2011), there is strong reason to suspect that this was a valid (and potentially improved) way of detecting schizotypy traits.

Another potential limitation is the use of the SPQ Experience scores without the Distress scores to create groups. For simplicity and because the dichotomous subscales were used in the validation study to generate cut-scores, the median split was computed from the dichotomous yes/no experience questions from the SPQ-BRI and did not take into account whether distress questions interacted with the experience questions in any way that may have influenced effort task performance. Future studies should examine this possibility.

It is possible that the demand characteristics created by the nature of requiring the participants to exert the effort required to come into the laboratory may have dissuaded more severely apathetic students from being included and may have lowered the ceiling on the range

of trait apathy severity that was observed in the present study. For example, in a recent study which administered the SPQ and AES to a nonclinical undergraduate sample via online self-reports, they reported a total sample mean AES score that was significantly higher (M = 32.6, SD = 7.5) than the total sample mean score found in the present study (M = 27.4, SD = 7.1), at a large effect-size level, $t(249) = 5.58$, $p < .001$, $d = .71$. One possible interpretation of these mean sample differences is that the lower task demands associated with being able to complete the study measures from home, or the most convenient location of their choice, encouraged more severely apathetic undergraduates to participate in the study who might not have been "motivated enough" to come into the laboratory for the experiment. This potential study difference has important implications for future studies examining apathy or avolition in undergraduate or other populations because laboratory studies may be unintentionally creating sampling bias by recruiting participants who are less severe on the trait of interest. One potential response to this concern would be to add sufficient extrinsic motivation to motivate more severely apathetic individuals to participate in more highly effort-demanding studies. Moreover, any significant or trend-level relationships with other study variables in the present study may be an underestimate of their true relationship in the population.

Lastly, several modifications (see Methods) were made to the original paradigm used in Gold et al.'s (2013) study, which may reduce the ability to compare results across studies. However, the adjustments to task duration are more comparable to a similar task, Treadway et al.'s (2009) Energy Expenditure for Rewards Task, which also took roughly 20 minutes and resulted in a similar pattern of results to those in the Gold et al. (2013) study. It is presently unclear as to how reducing the number of trials resulted in fatigue effects in this college sample, whereas similar tasks of this length, or longer, failed to demonstrate such effects. One potential

option is that the task demands were somehow higher in the present task. In the present study, participants used their index and middle fingers on the same hand to blow up the balloon whereas, in the Gold et al. (2013) study, participants used a game controller to make alternating thumb presses. That said, the Treadway et al. (2009) version of this task used single pinky finger presses yet did not demonstrate fatigue effect, their models included significant effects of trial number as well. Measures of response vigor indicated that there were no group differences in terms of amount of time taken to make hard versus easy choices nor in terms of average time taken to complete an easy versus hard trial. In addition, trial number effects did exist in the Treadway et al. (2009) and were not overtly reported in the Gold et al. (2013) study, and this did not appear to affect their pattern of results. Either way, there is little reason to suspect that group differences in fatigue effects affected the pattern of performance on the Effort-Cost Computation task.

4.5 Implications and Future Directions

Without motivation, a person is passive, apathetic, and, at extremes, inert or catatonic. Avolition is associated with worse treatment outcomes, worse quality of life, and less persistence in adaptive behaviors (Altamura et al., 2001; Malla, et al., 2002; Ryan & Deci, 2008; Ryan, et al., 1995), and there is currently no FDA-approved medication for this symptom, or any other negative symptoms of schizophrenia (Kirkpatrick et al., 2006). Moreover, avolition is prevalent across the schizophrenia spectrum continuum from the prodromal (Yung et al., 2003) to first-episode (Faerden et al., 2010) to chronic (Konstantakopoulos et al., 2011) phases of illness.

Given this particularly deleterious and prevalent symptom, it was of interest to explore how early these symptoms begin, how they might manifest in individuals with schizotypy, and which reward-related mechanisms are related to this symptom. The present study attempted to

address gaps within the literature regarding these potential continuities or discontinuities between schizotypy and schizophrenia. Overall, evidence suggested that individuals higher in schizotypy traits reported significantly higher trait apathy, but did not demonstrate decreased willingness to expend effort on the effort task. The apparent disconnect between objective and subjective effort-based performance in individuals with schizophrenia (Barch et al., 2008) was also found in individual high in schizotypy traits, and extends the subjective-objective dysjunction theory of schizotypy to the domain of effort-based performance. Further exploration to parse the neurobiological and psychological underpinnings of this discrepancy is warranted.

Future studies might employ an extreme groups or dimensional design rather than a median split design to discern whether the present study was underpowered to detect interaction effects. In addition, future work might consider whether these results generalize to other kinds of rewards (e.g., drugs, food, humor, praise, sex, social), as it may be the case that individuals with schizotypy may be willing to exert effort for monetary reward but value less other rewards. For example, social anhedonia is a defining characteristic of schizotypy (Chapman, Chapman, & Raulin, 1976), and some evidence suggests that individuals with schizotypy derive less pleasure from social relationships than do their peers (Quirk, Subramanian, & Hoerger, 2007). Furthermore, they may be even more sensitive than their peers to social rejection (Premkumar et al., 2012).

Future studies might also consider whether different psychological variables (e.g., defeatist beliefs and negative expectancies) also relate to willingness to exert effort in schizotypy and schizophrenia or, alternatively, whether these beliefs lead to more general approach or avoidant coping strategies; such beliefs could be important targets for treatment. Additionally, future studies may wish to monitor depression, schizotypy, trait motivation/apathy, and negative

affect over time to parse which symptoms tend to co-vary and account for the shared variance found in this study. The majority, if not all studies, which measure schizotypy traits and depression symptoms find elevated depressive symptoms in schizotypy groups (e.g., Rey, Jouvent, & Dubal, 2009). Studies have shown that whereas negative affect tends to increase with major depressive episodes and decrease between episodes in individuals with major depressive disorder (i.e., has a state-like quality), negative affect tends to be persistently elevated in schizophrenia and schizotypy samples (i.e., has a state-like quality) (Blanchard, Horan, & Brown, 2001; Horan et al., 2008). If the shared variance between schizotypy, depression, and trait motivation seems to change over time, it would shed light on whether findings such as elevations in depression symptoms reflect state-like patterns (and thus, possible comorbid depressive symptoms) or reflect trait-like patterns (and thus, these elevations reflect shared variance in the constructs of depression and schizotypy).

Lastly, future studies might examine whether individuals deemed at "ultra-high risk" (UHR) of converting to psychosis demonstrate effort-cost computation deficits. This subgroup meets a higher threshold of psychotic symptoms compared to an extreme groups, psychometric schizotypy design and requires that individuals demonstrate a recent deterioration in functioning (e.g., a drop of 30 points or more on the Global Assessment of Functioning scale). Moreover, this subgroup has a 30-40% probability of converting to a fully psychotic illness within 2.5 years (Woods et al., 2009; Yung, McGorry, McFarlane, Jackson, Patton, & Rakkar, 1996). Since avolition has been described as the second most commonly described prodromal feature among individual who went on to experience a first psychotic episode (Yung & McGurry, 1996) and avolition has been shown to predict conversion to psychosis within the next 60 days (Yung et al.,

2003), it may be useful to have an objective measure of this symptom and examine whether it may be an endophenotype that predicts risk of conversion to psychosis.

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APPENDIX A. SCHIZOTYPAL PERSONALITY QUESTIONNAIRE – BRIEF REVISED IMPACT (SPQ-BRI)

INSTRUCTIONS: Please read the following statements and answer them as honestly as possible, giving only your own opinion of yourself. Do not skip any items and answer them as honestly as possible, giving only your own opinion of yourself. When thinking about yourself and your experiences, do not count as important those attitudes, feelings, or experiences you might have had only while under the influence of alcohol or other drugs (e.g., marijuana, LSD, cocaine).

Each item is rated according to the following scale:

a) Do you experience this? 0 = no, 1 = yes

b) How often does this bother or cause problems for you? 1 = never, 2 = almost never, 3 = occasionally, 4 = sometimes, 5 = often, 6 = much of the time, 7 = most of the time

Positive symptoms:

Ideas of Reference

Do you sometimes feel that people are talking about you?

Do you sometimes feel that other people are watching you?

When shopping do you get the feeling that other people are taking notice of you?

Suspiciousness

I often feel that others have it in for me.

Do you sometimes get concerned that friends or co-workers are not really loyal or trustworthy?

Do you often have to keep an eye out to stop people from taking advantage of you?

Magical Thinking:

Do you believe in telepathy (mind-reading)?

Do you believe in clairvoyance (psychic forces, fortune telling)?

Have you had experiences with astrology, seeing the future, UFO's, Magical Thinking ESP, or a sixth sense?

Have you ever felt that you are communicating with another person telepathically (by mind-reading)?

Unusual Perception:

I often hear a voice speaking my thoughts aloud.

When you look at a person or yourself in a mirror, have you ever seen the face change right before your eyes?

Are your thoughts sometimes so strong that you can almost hear Unusual them?

Do everyday things seem unusually large or small?

Negative symptoms:

Constricted Affect:

I tend to keep my feelings to myself.

I rarely laugh and smile.

I am not good at expressing my true feelings by the way I talk and look.

No Close Friends

Do you feel that you cannot get "close" to people?

I find it hard to be emotionally close to other people.

Do you feel that there is no one you are really close to outside of your immediate family, or people you can confide in or talk to about personal problems?

Social Anxiety (SA)

Do you often feel nervous when you are in a group of unfamiliar people?

I get anxious when meeting people for the first time.

I feel very uncomfortable in social situations involving unfamiliar people.

I sometimes avoid going to places where there will be many people because I will get anxious.

Disorganization symptoms:

Eccentric Behavior

I am an odd, unusual person.

I have some eccentric (odd) habits.

People sometimes comment on my unusual mannerisms and habits.

Other people see me as slightly eccentric (odd).

Odd Speech

I sometimes jump quickly from one topic to another when speaking.

Do you tend to wander off the topic when having a conversation? Odd Speech

I often ramble on too much when speaking.

I sometimes forget what I am trying to say.

APPENDIX B. APATHY EVALUATION SCALE – SELF-REPORT (AES)

For each question, select the number (1-4) for each item that best describes your thoughts, feelings, and actions during the past 4 weeks. (1 = not at all true, 2 = slightly true, 3 = somewhat true, 4 = very true) (R) = indicates this is a reverse scored item

1. I am interested in things. (R)
2. I get things done during the day. (R)
3. Getting things started on my own is important to me. (R)
4. I am interested in having new experiences. (R)
5. I am interested in learning new things. (R)
6. I put little effort into anything.
7. I approach life with intensity. (R)
8. Seeing a job through to the end is important to me. (R)
9. I spend time doing things that interest me. (R)
10. Someone has to tell me what to do each day.
11. I am less concerned about my problems than I should be.
12. I have friends. (R)
13. Getting together with friends is important to me. (R)
14. When something good happens, I get excited. (R)
15. I have an accurate understanding of my problems. (R)
16. Getting things done during the day is important. (R)
17. I have initiative. (R)
18. I have motivation. (R)

APPENDIX C. REWARD VALUATION QUESTIONNAIRE

1. How much would you value winning 10 cents? 0 (no value) to 10 (extremely valuable)
2. How much would you value winning $1? 0 (no value) to 10 (extremely valuable)
3. How much would you value winning $10? 0 (no value) to 10 (extremely valuable)
4. How much would you value winning $100? 0 (no value) to 10 (extremely valuable)

APPENDIX D. STATE EFFORT QUESTIONNAIRE

*(R) indicates a reverse scored item

1. I put a lot of effort into this task. 1 (not at all true) to 7 (very true)
2. I tried very hard on this activity. 1 (not at all true) to 7 (very true)
3. It was important to me to do well at this task. 1 (not at all true) to 7 (very true)
4. I did not try very hard on this activity. (R) 1 (not at all true) to 7 (very true)
5. I put a lot of energy into this. 1 (not at all true) to 7 (very true)

VITA

Jessica Elaina McGovern is a student in the clinical psychology program at Louisiana State University (LSU), where she anticipates earning her Doctor of Philosophy in Psychology in 2017 under the mentorship of Dr. Alex Cohen. She received her Bachelor of Science degree in psychology with a minor in cognitive science from the University of California at San Diego (UCSD), graduating magna cum laude with a college honors distinction and induction into Phi Beta Kappa (honors society). During her senior year at UCSD, she completed her honors thesis under the mentorship of Dr. Eric Granholm exploring the relationship between attributions individuals with schizophrenia made about their voices (auditory hallucinations) and these individuals' feelings of depression, anxiety, and self-esteem. After graduating from UCSD, Ms. McGovern worked as a psychometrist on a longitudinal traumatic brain injury where she further developed her interests in brain-behavior relationships under the mentorship of Dr. John Dsurney. In her time at LSU, Ms. McGovern has further refined her research interests in brain-behavior relationships as they relate to symptomatology in schizophrenia spectrum disorders; in particular, her interests are in investigating disruptions to the normal functioning of the mesocorticolimbic dopamine pathway and how these may explain avolition and effort-based decision-making in schizophrenia spectrum disorders.