Predictors of Motivational Deficits in Schizophrenia

BY

EMILY K. OLSEN

B.S., University of California Davis, 2005
M.A., University of Illinois at Chicago, 2013

THESIS

Submitted as partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Psychology
in the Graduate College of the
University of Illinois at Chicago, 2015

Chicago, Illinois

Defense Committee:

Ellen S. Herbener, Chair and Advisor
David E. Gard, San Francisco State University
Amanda Lorenz, Psychology
Robin Mermelstein, Psychology
Amy West, Psychology

This thesis is dedicated to my family, Chuck Olsen, Marcia Weber Olsen, Chris Olsen, and to my husband, Ryan Walter, as well as those who have inspired and supported me over the years.

ACKNOWLEDGEMENTS

I would like to thank my thesis committee-- Ellen Herbener, David Gard, Amanda Lorenz, Robin Mermelstein, Amy West-- for their tremendous support and assistance. They provided guidance in all areas that helped me accomplish this project. I would also like to acknowledge my graduate colleagues, Anjuli Bodapadi and Olivia Bjorkquist, who made contributions important to the study's design and implementation. Individuals collaborating on this study including Rajiv Sharma, Cherise Rosen, Kayla Chase, and Scot Hill were also critical to the success of the study. I would additionally like to acknowledge Leah Rubin and David Henry, who provided statistical consultation for the data analytic plan.

A number of individuals at the University of Illinois at Chicago, Department of Psychiatry, were extremely helpful to me during data collection, and I would like to thank them as well -- Michael Keutmann, Sushma Rameshkumar, and Stephanie Nereppil.

This study was partially supported by NIMH Grant 1R01MH094358-01A1 (awarded to Rajiv Sharma).

Last, I would like to acknowledge the individuals who participated in this study, without whom this research would not have been accomplished.

EKO

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BAS	Behavioral Approach System
BIS	Behavioral Inhibition System
DA	Dopamine
D2	Dopamine Receptors
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, 4th Edition
ESM	Experience Sampling Methodology
HC	Healthy Participants
HDRS	Hamilton Depression Rating Scale
HQLS	Heinrich's Quality of Life Scale
IAPS	International Affective Picture System
IMI-SR	Intrinsic Motivational Inventory for Schizophrenia Research
IQ	Intelligence Quotient
PANSS	Positive and Negative Syndrome Scale for Schizophrenia
PCS	Perceived Self Competency Scale
RatioMod	Proportions of Effort Choices Associated with Higher Levels of Difficulty for Moderate Trials
RatioHigh	Proportions of Effort Choices Associated with Higher Levels of Difficulty for High Trials
SZ	Schizophrenia Participants
TEPS	Temporal Experience of Pleasure Scale
WASI	Wechsler Abbreviated Scale of Intelligence
WRAT	Wide Range Achievement Test
WTAR	Wechsler Test of Adult Reading

SUMMARY

The present study utilized a novel task designed to assess hedonic response and expended effort (i.e., motivation) for naturalistic rewards. Twenty-four individuals with schizophrenia (SZ) and 27 control participants (HC) viewed humorous and non-humorous film scenes and performed an effortful task at varying degrees of difficulty in order view additional scenes from their preferred film. Participants rated their hedonic enjoyment to these stimuli including consummatory liking and anticipatory wanting. Relationships between task performance, clinical symptoms, and social-contextual variables were also examined.

SZ and HC reported similar levels of hedonic enjoyment to rewarding stimuli. Group differences in exerted effort were not observed at low to moderate levels of required effort. However, SZ chose to expend less effort than HC at higher levels of required effort. While ratings of anticipatory wanting to the stimuli were predictive of exerted effort among the HC, this was not true of SZ. General, depressive, and psychotic symptoms were negatively associated with hedonic responses among the SZ. Exploratory analyses revealed social-contextual variables including perceived task value and interest were positively associated with hedonic responses among a subset of study participants.

Results converge with literature showing that motivational impairments in SZ relate to difficulties modulating behavior to obtain reward, particularly when effort demands increase. This is also consistent with work demonstrating incongruence between hedonic drives and motivated behavior in SZ. Translated to daily life, people with schizophrenia may be biased in judging the positive outcomes associated with difficult or effortful behaviors.

I. Introduction

A. Background

Reductions in motivational and hedonic drive have long been considered a cardinal feature of schizophrenia (Kraepelin, 1919; Meehl, 1962; Rado, 1962). For instance, early conceptualizations of the disorder described volitional deficits in thought and action (Kraepelin, 1919) stemming from reduced emotional and intellectual capacities (i.e., avolition). Avolition was eventually classified with other negative symptoms including impairments in hedonic capacity, emotional expression, communication, social engagement, and goal driven behavior. Efforts to parse the heterogeneity of these symptoms have generally supported a distinction between reduced emotional expression (flat affect, alogia) and experiential impairment manifested as amotivation, anhedonia, and asociality (Messinger et al., 2010; Sayers, Curran, & Mueser, 1996; Strauss et al., 2013). As foretold by early accounts, the current literature suggests impaired motivational drive is central to negative symptomatology. For instance, it is likely that core deficits in motivation underlie apathy for personal goals, including decreased pursuit of social, vocational, and recreational activities (Foussias & Remington, 2010; Messinger et al., 2010). Supportive of this, motivational deficits are highly predictive of functional outcome (Foussias, Mann, Zakzanis, van Reekum, & Remington, 2009) and more so than reduced emotional expression (Galderisi et al., 2013; Strauss et al., 2013). Avolition is also more consistently related to social functioning than other negative symptoms (Kiang; Christensen, Remington, Kapur, 2003), suggesting a strong influence on engagement with the environment. Thus, reduced motivational drive may be an essential factor when defining the course of illness in individuals with schizophrenia (SZ).

The schizophrenia literature has increasingly focused on ways to better explain the nature of these motivational deficits in order to better inform clinical intervention. This has included methods to experimentally measure mechanisms underlying motivated behavior

including both social-contextual factors and neurobiological factors. However in understanding the etiology of motivational deficits in schizophrenia, a review of factors impacting motivation in non-clinical samples is warranted.

B. Understanding Motivation in Healthy Individuals

Social-contextual factors. A sizeable amount of the social and personality literatures have been devoted to social-contextual variables impacting motivated behavior in healthy individuals. Goal oriented theories examine how outcome expectancies predict behavior. Expectancy value theory (Wigfield & Eccles, 2000) has been used to demonstrate that the perceived value and competency in performing a task predicts motivational drive. For instance, activities that are deemed worthwhile and/or rewarding in some respect are more likely to be pursued (Medalia & Brekke, 2010). Also predictive of motivated behavior is goal orientation, or the extent to which behavior is intrinsically driven (i.e., engaging in activity because it is enjoyable and/or meaningful) or extrinsically driven (i.e., engaging to achieve tangible rewards). Intrapersonal factors are also found to heavily influence motivation. For instance, beliefs and attitudes about the self and the ability to accomplish goals in a given context are thought deterministic of behavior. Perceived self-efficacy is demonstrated to be a robust predictor of motivation (Bandura 1977, 1991), as this concept factors into several other theoretical perspectives. Self-determination theory (Ryan & Deci, 2000) highlights the extent to which tasks engender autonomy, competence, and well-being. Similarly, the theory of Reasoned Action (Ajzen 1991) posits that intention is the greatest predictor of behavior, with perceived controllability and attitude towards the behavior as influential factors. Self regulatory theories (e.g., Carver & Scheier, 2002; Higgins, 1987) explain how the desire to reduce or widen the discrepancy between goals and states of being drive motivated behavior. Social influences also factor into several theoretical perspectives. Societal norms and perceived expectations play a significant role in determining which activities and behaviors are valued and eventually pursued

by an individual. Furthermore, the need to affiliate and form interpersonal bonds (Baumeister & Leary, 1995; Gable & Gosnell, 2013) can be especially influential in motivated social behavior and may have a downstream effect on motivation for achievement goals.

Emotional and biological factors. A number of theoretical accounts also surround emotional and biological processes underlying motivation. This is particularly relevant considering that emotion is a central, albeit non-explicit factor in most social-contextual theories. For instance, theories involving a need for achievement, self efficacy, and competency certainly carry emotional significance. The motivation to achieve desired versions of oneself (e.g., Carver & Scheier, 2002; Higgins, 1987), draws heavily on an affective commitment to one's life. Adherence to social norms and the desire for social affiliation also assume there are emotional consequences tied to certain outcomes and not others. Given that emotionally arousing material engages greater attentional allocation and mobilizes resources for coping (Lang & Bradley, 2013), motivation is likely influenced by similar physiological processes. The emotional valence of stimuli is also thought to differentially engage different modes of behavioral response (Gray, 1990), including motivation. For instance, the behavioral activation or approach system (BAS) is sensitive to reward and results in appetitive or goal directed behavior associated with positive emotion; while the behavioral inhibition system (BIS) is responsive to stimuli that are threatening or aversive, resulting in avoidance or withdrawal (Carver & White, 1994). Neurobiological accounts of motivational processes examine how rewarding stimuli are processed and then pursued. Initial appetitive or hedonic responses to rewarding stimuli, termed "liking" are behaviorally distinct from "wanting", or motivation to engage in behaviors that reinstate the initial hedonic experience (Berridge & Robinson 2003). Distinct neurobiological mechanisms underlie these drives as liking is related to the opioid system, while wanting is related to striatal dopamine (DA) receptors (D2) (Berridge & Kringelbach, 2008). Thus it would seem that emotion, specifically processing the hedonic value of stimuli, is inherent to motivated behavior.

C. Understanding Motivation in Schizophrenia

Social-contextual factors. Applications of these theoretical models have begun to shed some light on motivational deficits in schizophrenia. SZ also demonstrate expectations of success which predicts task persistence. For instance, self determination theory and expectancy value theory are operative in schizophrenia, as perceived self competence and task value has been found to predict engagement and success in cognitive remediation trials (Choi, Fiszdon, & Medalia, 2010; Silverstein, 2010). Moreover, perceived controllability predicted intention and greater engagement in daily functional behaviors among a SZ sample (Mausbach et al., 2013). Importantly, this demonstrates that SZ are sensitive to similar social-contextual factors as healthy individuals and failure to satisfy conditions may relate to motivational impairments. For instance, motivational deficits in SZ may arise from low self-efficacy due to real or perceived shortcomings (Beck, Rector, Stolar, & Grant, 2009). This has borne out by studies linking dysfunctional attitudes and functional outcome. For instance, low self efficacy seems to account for associations between capacity (potential functioning) and functional outcome (actual behavior) in SZ (Cardenas et al, 2013; Horan et al, 2010). In this model, defeatist attitudes caused by ineffectual (real or imagined) ability are proposed to perpetuate negative symptoms (Grant & Beck, 2010). Repeated failures in social or achievement domains may engender negative self beliefs which lead to low motivation and engagement with the environment. Consistent with this, dysfunctional beliefs have been found to associate with more severe symptoms of avolition, asociality, and anhedonia (Couture, Blanchard, & Bennett, 2011). Social factors also presumably play a role in motivational deficits; however, the specifics of this are unclear given pervasive social deficits in the disorder. On one hand, decreased social interest and social avoidance are key features of the illness. It may be that general motivational deficits (i.e., avolition, apathy) are simply expressed in social as well as non-social domains. On the other hand, SZ self-report similar levels of social motivation as healthy individuals (Tremeau,

Goldman, Antonius, & Javitt, 2013), and are cognizant of societal expectations in their intended daily activities (Mausbach et al., 2013). Given that dysfunctional attitudes are found to negatively impact self-efficacy in SZ, it may be that a long history of social failure reinforces low expectations of success in social situations (Grant & Beck, 2010). This is reminiscent of Paul Meehl's aversive drift hypothesis (Meehl, 1962; 1990) wherein some individuals are genetically predisposed to experience the environment as less rewarding and as a result, disengage. Therefore, failure to elicit positive outcomes from the environment may generalize across social and non-social domains. Although tentative, these studies suggest that SZ may not see their goals and their ability to accomplish them as tenable and therefore disengage from meaningful activities.

Emotional and biological factors. Much of the recent motivation research in schizophrenia has also focused on biological substrates of hedonic and emotional processing. This has evolved from what has been learned about basic emotional processing in the disorder. For instance, an exceedingly large body of evidence finds that SZ report similar emotional experiences as healthy individuals including, pleasure in response to experimentally based rewards (Heerey & Gold, 2007; Horan, Green, Kring, & Nuechterlein, 2006; Waltz et al., 2009), events in daily life (Gard, Kring, Germans Gard, Horan, & Green, 2007; McCormick Snethen, & Lysaker, 2012), and when rating the emotional content of laboratory based stimuli (Amnioff, Jensen, Lagerberg, Andreasen, & Melle, 2010; Cohen & Minor, 2010; Herbener, Song, Khine, & Sweeney, 2008). While SZ self report similar levels of intrinsic motivation as controls (Barch, Yodkovik, Sypher-Locke, & Hanewinkel, 2008), this is not entirely consistent with behavioral indicators. Thus, internal drives appear inconsequential in daily life, as reflected by clinical symptoms and level of functioning. This has led to efforts to reconcile spared emotional experience in schizophrenia in light of motivational deficits. An early and influential study (Gard et al., 2007) found evidence of preserved in-the-moment accounts of hedonic response in SZ

via experience sampling methodology (ESM). However, when asked to predict their pleasure for events that had not occurred, SZ reported decreased anticipated pleasure compared to healthy individuals. This distinction between in-the-moment, *consummatory pleasure* and future-oriented or *anticipatory pleasure*, led to anhedonia being conceptualized as a deficit imagining and predicting the hedonic impact of future pleasurable experiences (Gard et al., 2007). Thus, if anticipation of pleasure is impacted, motivational deficits would likely follow (Heerey & Gold 2007; Schmidt et al., 2001). This work converged with other theoretical perspectives and also with well documented cognitive impairments found in schizophrenia. For instance, ineffective memory for affective and hedonic material (Herbener, Rosen, Khine, & Sweeney, 2007; Horan, et al., 2006), could also result in motivational deficits given that activities associated with positive hedonic states in the past are thought to motivate pursuit of similar activities in the present (Berridge and Robinson, 2003). Notably, SZ do not show the enhanced memory for positive stimuli as do control participants (Calev & Edelist, 1993; Herbener, et al., 2007; Koh, Grinker, Marusarz, & Forman, 1981). Deficits are also found in generating mental imagery for past and future events (D'Argembeau, Raffard, & Van der Linden, 2008) so it is likely that representations of affective experience (past or future) may be similarly impaired. The animal literature has also provided clarity into the neurobiological nature of motivational deficits. For instance, distinctions between consummatory and anticipatory pleasure, are analogous to "liking" and "wanting" behavior observed in rodents and primates (Barch & Dowd, 2010; Berridge & Robinson 2003; Berridge, 2004). Animal models of schizophrenia involving over expression of D2 receptors have also demonstrated associations with reduced effort to earn progressively larger rewards (wanting), despite spared appetitive behavior (liking) (Simpson, Waltz, Kellendonk, & Balsam, 2012). Similar results have been replicated in human samples with healthy participants (Treadway, et al., 2012). Taken together, motivational deficits

potentially stem from neurobiological processes underlying “wanting” behavior despite intact “liking” behavior.

Behavioral measures of motivation. Accordingly, a number of studies have sought to examine the relationships between hedonic experience (liking) and motivated behavior (wanting) in schizophrenia. Most employ effort based decision making tasks designed to elicit an effortful response in exchange for a rewarding stimulus as a proxy of motivation. Generally, SZ show decrements in the ability to earn rewards rather than a lack of sensitivity to rewards. This has been tied to difficulties representing value associated with effortful actions (Gold, Waltz, Prentice, Morris, & Heerey, 2008), using positive outcome information to guide decisions (Waltz, Frank, Wiecki, & Gold, 2011), computing effort-reward costs (Gold et al., 2013), and predicting the impact of future rewards (Heerey, Robinson, McMahon, & Gold, 2007). Reinforcement paradigms also reveal deficits in effortful behavior among SZ through the use of primary rewards such as juice (Waltz et al., 2009) and secondary rewards such as money (Koch et al., 2010). However, these rewards may not be akin to everyday behavior in schizophrenia given that gainful employment (i.e., exerting effort for monetary reward) is often impaired. Therefore, the application of these findings to everyday behavior is somewhat tentative.

Increasingly, study designs have begun to use emotionally evocative stimuli as a means of eliciting motivated behavior. For instance, Heerey and Gold (2007) examined how hedonic response (i.e., liking) to images from the International Affective Picture System (IAPS) (Lang, Bradley, Cuthbert, 2005), predicted subsequent effort (i.e., “wanting”) to prolong or decrease exposure to these stimuli. While all groups demonstrated similar intensity of hedonic response to the stimuli, SZ demonstrated a weaker correspondence between hedonic response and effort than did controls. This was especially pronounced when stimuli were not visible and participants had to rely on internal representations of previously seen images. Somewhat similarly, Tremeau et al., (2010) measured anticipatory, consummatory, and remembered pleasure of positive and

negative IAPS images. Although SZ did not differ from controls in any of these domains, consummatory pleasure was predictive of their self reported willingness (measured by a single question) to repeat the task in the future, among controls but not SZ. This latter index of motivation was inversely correlated with negative symptoms. Collectively, studies support an atypical separation between emotional and motivational processes in schizophrenia.

D. Convergence of Theoretical Perspectives

Taken together, motivational deficits in schizophrenia appear to be multi-determined with social-contextual and emotional/neurobiological factors playing key roles. However, these literatures are considerably distinct and it is unclear which framework is most appropriate in conceptualizing motivational impairment. Much of the social contextual literature centers around associations between attitudes and behavior assumed to reflect motivational drives. However, outcome variables used to reflect motivation are generally clinician rated symptoms or indices of functional performance and thus not reflective of internal drives. Although SZ are shown to report internal experiences in a similar fashion to controls (Bell, Fiszdon, Richardson, Lysaker, & Bryson, 2007; Kring, Barrett, & Gard, 2003), these scales may not necessarily reflect behavior associated with hedonic and motivational drives, such as effort expended to reach a goal.

In contrast, effort based decision making tasks focus primarily on emotional and cognitive mechanisms, but may be limited their ecological validity. Namely, many experimental paradigms fail to consider how psychological constructs relevant to motivation (i.e., self-efficacy, task value, etc) factor into task performance. First, it is unclear if IAPS stimuli are adequately motivating and relevant to typical emotional experiences outside of a laboratory setting. The perceived value of the task based on interest and utility is also unclear. Although IAPS stimuli are effective in eliciting emotional response, it is unlikely that individuals encounter static emotional images in their daily lives, and would be compelled to exert effort to view them several times. Therefore, it is unclear if more evocative and ecologically valid affective stimuli

would produce similar results. Second, previous behavioral studies did not assess expectations of success and competency, which are thought to be critical determinants of goal driven behavior as posited by numerous motivational theories. This issue may be particularly relevant for probabilistic reward tasks wherein participants are required to predict future outcomes (Heerey, Bell-Warren, & Gold, 2008), weigh rewards and punishments (Koch et al., 2010), and adapt to changes in reward contingencies (Waltz & Gold, 2007). Thus, it is unclear if motivational deficits would emerge when reward outcomes were definite and perceived as attainable due to low cognitive demand. Therefore, a present challenge is to merge the disparate aspects of the literature to clarify how social-contextual and behavioral methods predict motivated behavior in SZ.

Understanding these factors has many probable benefits. These include uncovering the etiology of these deficits, providing an additional means of parsing the heterogeneity in the illness, and informing the treatment of negative symptoms. Given that amotivation is central to functional outcomes and potentially causal of other negative symptoms (Foussias & Remington, 2010), targeting these core deficits may be a potentially robust form of treatment. Efforts to address low motivation may also have a cascading effect on other life domains such as persistence in work or school.

E. Purpose

The goal of the current study is to examine the nature of motivational deficits in SZ and healthy adult participants (HC). To accomplish this, participants performed a novel effort-reward task designed to assess emotional response and expended effort (i.e., motivation) to hedonic stimuli. Participants viewed humorous and non-humorous film scenes and performed an effortful task at varying degrees of difficulty to view additional scenes from their preferred film. Participants rated their consummatory liking and future-oriented anticipatory wanting of the stimuli throughout the task. Thus, a primary aim was to examine the association between

hedonic experience and motivated behavior when reward outcomes were definite, attainable, and more akin to rewards encountered in daily life. Measures of social-contextual variables shown to impact motivational drives (i.e., self-competency, perception of task value and interest) were collected after task completion.

F. Study Aims

1. A preliminary aim of this study was to examine the validity of the novel effort reward task. As such, we examined task parameters to ensure participants were sufficiently motivated by the hedonic rewards.
2. Examine group differences in hedonic experience and exerted effort. Consistent with research finding spared emotional responses to hedonic rewards (Heerey & Gold, 2007; Horan et al., 2006; Waltz et al., 2009) we predicted SZ would not differ from healthy participants in their hedonic responses (liking or anticipatory wanting) to the stimuli presented during both the Preference task and in the context of the Effort-Reward task. With regard to exerted effort, we predicted SZ would not differ from healthy participants when the effort-to- reward cost ratio was low to moderate. However, consistent with research showing SZ discount reward values more steeply (Gold et al., 2013; Heerey, Mateeva, & Gold, 2011), we expected SZ to demonstrate reduced effort when the effort-to- reward cost ratio is high.
3. Examine the correspondence between hedonic experience and exerted effort. We predicted correspondence between hedonic response and exerted effort would vary as a function of both group and the effort-to- reward cost ratio. Specifically, when effort costs were low to moderate, we expected SZ and controls to demonstrate a high degree of correspondence between their hedonic responses and exerted effort. That is, the degree of immediate liking/anticipatory wanting would predict the degree effort exerted to view those stimuli. However, we expected SZ to demonstrate less correspondence between

hedonic responses and effort when effort costs were higher given that SZ show poor correspondence between internal states and motivated behavior (Heerey & Gold, 2007; Treadway 2010), particularly when demands for effort allocation are high (Barch, Treadway, & Schoen, 2014; Treadway, Peterman, Zald, & Park, 2015).

4. Examine the relationship between task performance and traditional assessments of hedonic drives. These included self-report questionnaires measuring anticipatory and consummatory pleasure (Temporal Experience of Pleasure Scale) trait anhedonia (Physical and Social Anhedonia Scales), and behavioral approach motivation (BIS/BAS). In order to assess the predictive validity of the task, we also examined associations with clinical symptoms and measures of goal directed activity (i.e., Heinrich's Quality of Life Scale) and among the SZ. Specifically, we hypothesized that exerted effort would be predicted by lower levels of negative symptoms and higher levels of psychosocial functioning. Results supporting these predictions would suggest the ability to assess the value of environmental rewards and the behavior required to obtain them, are relevant to social and motivational drives in daily life.
5. A final exploratory aim was to examine the relationship between hedonic response and exerted effort with social contextual variables. Given that task value and perceived self-efficacy impact persistence of goal-driven behavior in schizophrenia (Choi et al., 2010; Medalia & Brekke, 2010), we expected these variables to be positively associated with effort exerted to view hedonic stimuli. Results supporting these predictions would suggest that perceptions of task value and self-efficacy impact general motivation.

II. Methods

A. Participants

Twenty-eight clinically stable outpatients with a schizophrenia (SZ) spectrum diagnosis were recruited at the University of Illinois at Chicago Medical Center, by physician referral and advertisements. Twenty-eight control participants (HC) were recruited through the community with advertisements. Exclusionary criteria for all participants included history of head trauma resulting in loss of consciousness, history of neurological injury or impairment, current substance abuse, and scoring lower than 70 on an abbreviated measure of intellectual ability (see below). Control participants were excluded for having a lifetime history of Axis I disorder or family history of schizophrenia in first degree relatives. Clinicians blind to individuals' task performance made diagnoses according to the Structured Clinical Interview for DSM-IV (First, Spitzer, Gibbon, & Williams, 2002). All procedures were approved by the local institutional review board.

B. Assessments and Measures

Neuropsychological Assessment. Cognitive ability was estimated with use of one of three abbreviated measures of intellectual ability (The Wechsler Abbreviated Scale of Intelligence (WASI), Wechsler Test of Adult Reading- Second Edition (WTAR-2), and the Wide Range Achievement Test, Reading Subscale (WRAT-3)). The frequency of participants assessed with these measures were as follows, WRAT: 2 (3.8%), WTAR: 33 (63.5%), WASI: 17 (32.7%).

Clinical Symptom Measures. Severity of symptoms in individuals with schizophrenia was assessed with the Positive and Negative Syndrome Scale (PANSS) (Kay, Fiszbein, & Opler, 1987), and the Hamilton Depression Rating Scale (HDRS) (Hamilton, 1960).

Measures of Goal Directed Activity. The Heinrich's Quality of Life Scale (HQLS) is a clinician rated measure used to assess pursuit of occupational and recreational activities,

functional outcome, interpersonal relationships, intrapsychic factors, and participation in activities required for daily living in the SZ sample (Heinrichs, Hanlon, & Carpenter, 1984). The intrapsychic subscale reflects aspects of cognition and affectivity often impaired in the disorder (i.e., sense of purpose, motivation, curiosity, empathy, hedonic capacity, time utilization, and emotional engagement).

Trait Anhedonia. The Physical and Social Anhedonia Scales (Chapman et al., 1976), is a true/false self-report measure assessing enduring attitudes towards pleasurable experiences in physical and social domains.

Anticipatory & Consummatory Pleasure. The Temporal Experience of Pleasure Scale (TEPS) is composed of 18-items rated on a Likert scale which yields two subscales measuring anticipatory and consummatory pleasure (Gard et al., 2007).

Behavioral Approach and Avoidance Motivation. The BIS/BAS Scale is composed of 24-items rated on a Likert scale measuring behavioral approach (BAS) and behavioral avoidance (BIS). The BAS subscale yields sub-scores for drive, fun-seeking, and reward responsiveness (Carver & White, 1994).

Intrinsic Motivational Inventory for Schizophrenia Research (IMI-SR). The IMI-SR assesses subjective experience of enjoyment/interest, perceived choice, and value/usefulness associated with performing an activity. Subscales are composed of seven items which are self rated on a 1 to 7 likert scale with higher scores indicating greater intrinsic motivation. The IMI-SR is demonstrated to have good internal consistency and test-retest reliability in SZ and HC samples (Choi, Mogami, & Medalia, 2009).

Perceived Self Competency Scale (PCS). The PCS scale is designed to measure self-competency for completing an activity (Williams & Deci 1996) and has been used with SZ samples (Choi & Medalia, 2010). The PCS consists of seven self report items on a 1 to 7 point Likert scale. Higher scores are indicative of greater perceived competency for a task.

C. Design and Procedure

Hedonic Stimuli. The hedonic stimuli in the Effort-Reward task included humorous clips from one of five possible movies shown during the Preference task. Humorous clips varied in length approximately 30 seconds – 2 minutes). Non-humorous movie clips were matched for duration and included mundane scenes from movies and instructional videos. Stimuli were presented on a 19-inch computer monitor equipped with speakers.

Preference Task. To familiarize participants to the hedonic stimuli and to assess personal preference for the stimuli, participants viewed previews from five popular movies: Airplane (Davison, Abrahams, Zucker, & Zucker, 1980), Dumb & Dumber (Wessler, Krevoy, Stabler, Farrelly, & Farrelly, 1994), The Jerk (Picker, McEuen, & Reiner, 1979), Nutty Professor (Grazer, Simmons, & Shadyac, 1996), and Rush Hour, (Birnbaum, Glickman, Sarkissian, & Ratner, 1998). Previews were approximately 2 minutes long. Immediate *liking* ("How much did you enjoy this preview") and *anticipatory wanting* ("How much would you like to see more of this movie") were assessed immediately after each preview using a 9 point likert scale. After all five previews were shown, participants were asked to rank their preference for the movies. The movie given the top ranking from the Preference task was designated as the source of the humorous clips shown during the Effort-Reward task.

Effort-Reward Task. Immediately following the Preference task, participants completed the Effort-Reward paradigm (adapted from Sherdell, Waugh, & Gotlib, 2012; Waugh & Gotlib, 2008). Participants completed 18 trials of an effortful task followed by either a rewarding (i.e., humorous) or non-rewarding (i.e., non-humorous) movie clip. The number of humorous/non-humorous clips was determined by the participants' effort choices. As shown in Figure 1, at the onset of each trial, participants were given the choice between 2 movies associated with various levels of difficulty in an effortful task. Humorous movie clips were always associated with higher levels of effort/difficulty while non-humorous movies were associated with lower levels of

effort/difficulty. Participants were told they would view movie clips similar to those shown in Preference task (humorous clips from the movie given the top ranking from the Preference task) or they would view an alternate movie clip (i.e., mundane, non-humorous clips), dependent upon their choosing. Movie clips from the humorous collection were denoted with image from the movie; clips from the non-humorous collection were denoted with a picture of a film reel. Beneath each choice was a verbal descriptor of the effort task ("Easy", "Medium", or "Hard") associated with that movie clip. The effort task was a self-paced, simple visual search paradigm which required participant to click on the target letter (T) amongst a visual array of distracters (L, F, I). Task difficulty varied both in the number of distracters (Easy: 5, Medium: 10, Hard: 20) and the number of targets or mouse clicks required to complete the task (Easy: 5, Medium: 10, Hard: 20). A mildly aversive sound (i.e., buzzing) was played when participants missed the target response. After participants completed the effort task, the movie clip from the chosen category (humorous or non-humorous) was presented. Participants were then asked to rate their hedonic responses to the clip before the initiation of the next trial. Indices of *immediate liking* ("How much did you enjoy this movie") and *anticipatory wanting* ("How much would you like to see more of this movie") were collected using a 9-point likert scale.

Perceived Task Value & Self Efficacy. Immediately after completion of the effort-reward task, participants completed the PCS and IMI-SR measures.

D. Data and Analysis

As shown in Table I, four types of hedonic responses were analyzed including, ratings of immediate liking and anticipatory wanting from both the Preference and Effort-Reward tasks. Hedonic responses to the humorous and non-humorous film clips shown during the Effort Reward task were first examined separately to ensure participants were sufficiently motivated by the hedonic rewards (i.e., humorous clips). Participants who reported greater hedonic responses to the non-humorous stimuli versus humorous stimuli were excluded from all

analyses. When examining the correspondence between hedonic responses and exerted effort, only responses to the rewarding stimuli (i.e., humorous clips) were utilized. To increase power, hedonic responses to humorous clips across the entire Effort-Reward task were averaged for indices of immediate liking and anticipatory wanting.

Exerted effort was operationalized in two ways. The first variable was defined as the mean proportion of hard-task choices across task conditions. As seen in Table II, six of the total trials were high cost (Easy vs. Hard) and six were moderate cost (three Medium vs. Easy trials and three Hard vs. Medium trials). Therefore the proportions of effort choices associated with higher levels of difficulty were defined as:

RatioMod = (Number Moderate choices /Number. Moderate Cost trials)

RatioHigh = (Number Hard choices/ Number Hard vs. Easy trials)

The second effort variable was a categorical variable computed to capture the probability of choosing tasks with higher levels of difficulty on a majority of trials. If participants elected to play the more difficult task on more than 50% of trials, this variable was assigned a value of one; otherwise this variable was assigned a value of zero.

Moderate Choice 50%= 1 if (Number Moderate choices /Number Moderate cost trials) > 50%

High Choice 50% = 1 if (Number hard choices /Number Hard vs. Easy trials) > 50%

Statistical analyses were performed using SPSS (v22) (IBM Corp). All variables were evaluated for violations of the assumptions of parametric statistical analyses, and parametric tests were conducted when indicated.

Table I

Measures of Hedonic Response

Task	Question
Preference	
Immediate Liking	“How much did you enjoy this preview?”
Anticipatory Wanting	“How much would you like to see more of this movie?”
Effort-Reward	“How much did you enjoy this movie clip?”
Immediate Liking	“How much did you enjoy this movie?”
Anticipatory Wanting	“How much would you like to see more of this movie?”

Table II

Trial Types for the Effort Reward Task

Trial Type	Frequency	Effort Choice A	Effort Choice B
Equivalent	2	Easy	Easy
Equivalent	2	Medium	Medium
Equivalent	2	Hard	Hard
Moderate Cost	3	Medium	Easy
Moderate Cost	3	Medium	Easy
High Cost	6	Hard	Easy
Total	18	-	-

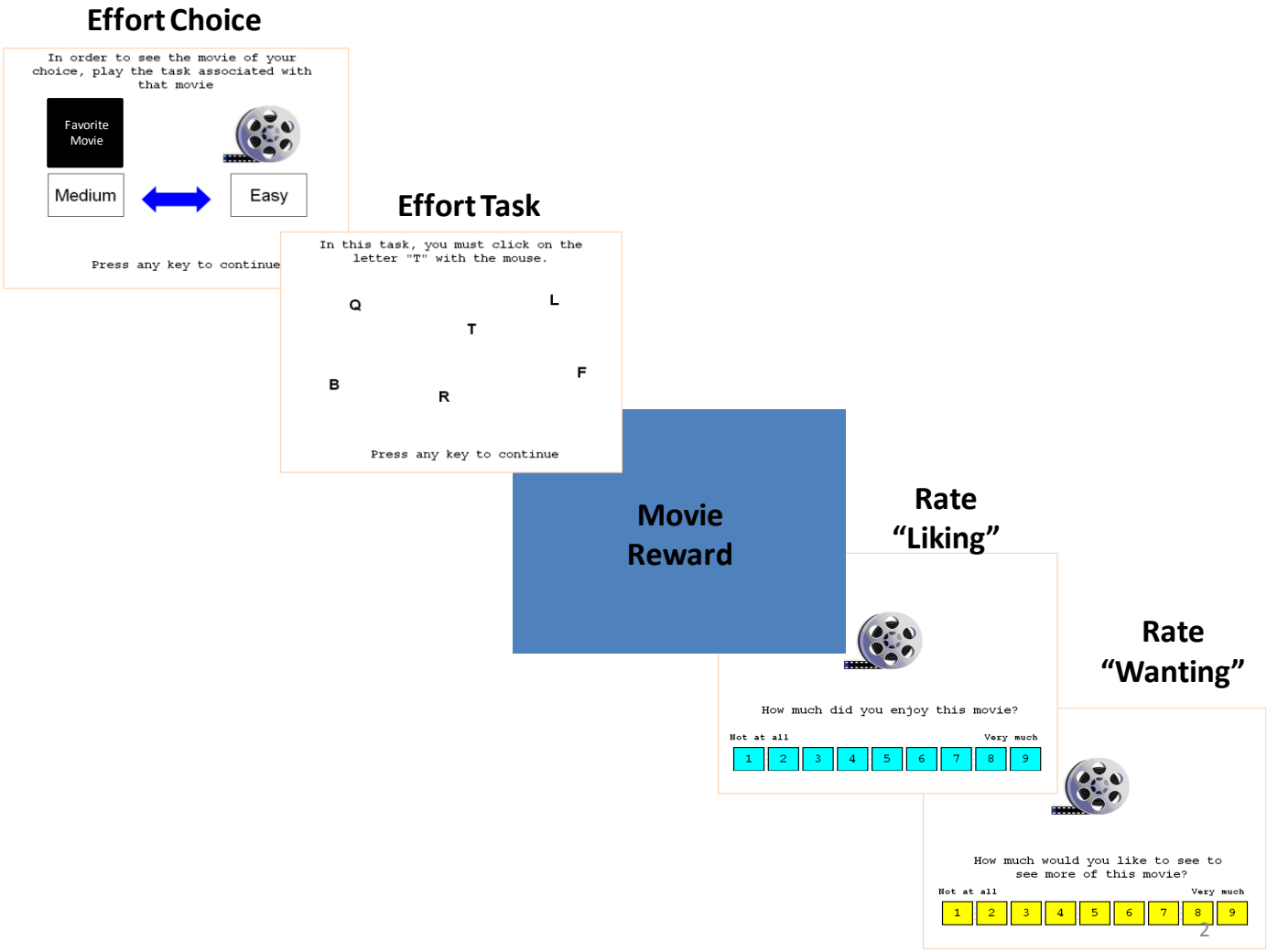

Figure 1. Diagram of a single trial on the Effort-Reward Task

III. Results

A. Demographic and Clinical Characteristics

Four SZ participants and one control participant reported greater hedonic responses to the non-humorous stimuli versus humorous stimuli and thus were excluded from subsequent analyses. This resulted in a final sample of 27 HC and 24 SZ.

To test for group differences in sociodemographic, clinical, and questionnaire data, analyses of variance (ANOVA) were conducted. Kruskal-Wallis tests were performed for demographic variables that were not normally distributed. Due to experimenter error, the Chapman Scales were not collected for one HC and two SZ participants. The BIS/BAS was not collected for one SZ participant. Three SZ participants had incomplete clinical ratings data.

Controls demonstrated higher scores than SZ on measures of estimated IQ, $H(1) = 7.55$, $P = .006$, and educational attainment, $H(1) = 13.48$, $P = .001$ (see Table III). SZ reported higher levels of physical anhedonia, $H(1) = 4.97$, $P = .03$, and a trend for lower levels of consummatory pleasure, $H(1) = 3.54$, $P = .06$, than HC. The two groups did not differ on age, gender, nor on other self-report questionnaires. Clinical characteristics for the schizophrenia participants are displayed in Table IV. No significant Spearman correlations were found between demographic variables (i.e., age, education, IQ, gender) and task variables for both HC and SZ participants and thus were not used as covariates in subsequent analyses (see Table V).

B. Aim 1: Examination of Task Parameters

Parameters of the Preference and Effort-Reward tasks were examined to ensure participants were sufficiently motivated by the hedonic rewards. First, participants' average responses to the five movie previews shown in the Preference Task were analyzed. Next, given that the movie given the top ranking during the Preference Task was designated as the source of the humorous clips in the Effort Reward task, we examined the frequency distribution of the movie ranked as "1" (i.e. the favorite movie). Third, we examined if participants' hedonic

responses during the Preference Task differed between their favorite movie and the remaining four movie previews. Last, we examined participants' responses to the two types of stimuli (i.e., humorous versus non-humorous movie clips) shown during the Effort Reward Task.

Preference Task Stimuli. Mixed-design ANOVAs were used to assess effects of movie preview and group and on hedonic responses during the Preference Task. In each analysis, diagnostic group (SZ, HC) was the between-subjects factor and movie preview was the within-subjects factor. Results revealed significant a main effect of preview indicating that participants' ratings of immediate liking varied in response to the particular preview shown, $F(4, 196) = 4.99$, $P = .002$. Follow-up analyses indicated that participants reported the strongest immediate liking to preview 5 in comparison to all other previews shown (P's <.01) (see Table VI). The group × preview interaction was not statistically significant, $F(4, 196) = 1.84$, $P = .14$.

Analogous analyses compared ratings of the intensity of anticipatory wanting among the two groups. A significant main effect of movie preview indicated that across groups, intensity of anticipatory wanting varied in response to the particular preview shown, $F(4, 196) = 4.11$, $P = .006$. Follow-up analyses indicated that participants reported stronger anticipatory wanting to Preview 5 in comparison to 3 of the other previews (Previews 1-3) (P's <.01). Participants also reported stronger anticipatory wanting to Preview 4 in comparison to Preview 2 (P=.003). The group × preview interaction trended towards statistical significance, $F(4, 196) = 2.34$, $P = .07$. While the intensity of participants' hedonic responses to movie previews varied, this pattern was similar across groups.

Fisher's exact test was used to examine group differences in the movie preview given the highest preference rating (i.e. favorite movie). Results indicated a nonsignificant relationship between group and favorite movie preview, χ^2 (4, N = 51) = 1.37, $P = .91$. However, as can be seen by the frequencies tabulated in Table VII, χ^2 (4, N = 51) = 12.04, $P = .02$, participants' selection of favorite movie varied significantly among the five previews shown.

Mixed-design ANOVAs were then used to determine if participants' hedonic responses differed between their favorite movie and the remaining four movie previews. Ratings of immediate liking and anticipatory wanting were collapsed into a single hedonic response variable. Mean hedonic responses were computed for the four non-preferred movies (i.e., those not given the highest ranking). Diagnostic group (SZ, HC) was the between-subjects factor and preview (favorite vs. non-preferred) was the within-subjects factor. A main effect of preview, $F(1, 48) = 81.39$, $P = .000$, indicated that participants' intensity of hedonic response were higher for the favorite versus non-preferred previews (Figure 2). Effects of group, $F(1,48) = .48$, $P = .49$, and the group × preview interaction, $F(1,48) = .20$, $P = .89$, were not significant.

Effort-Reward Task Stimuli. Due to several non-normally distributed variables, non-parametric statistics (i.e., Wilcoxon signed-rank tests) were used to determine if participants were ambivalent to the humorous versus non-humorous movie clips shown during the Effort Reward Task. Within group analyses compared participants' responses to the humorous versus non-humorous movie clips. Results indicated that HC reported higher levels of immediate liking, $z = -4.54$, $P = .000$, and anticipatory wanting, $z = -4.54$, $P = .000$, for humorous in comparison to non-humorous films (Figure 3). A similar pattern emerged among the SZ with participants reporting higher levels of immediate liking, $z = -4.29$, $P = .000$, and anticipatory wanting, $z = -4.20$, $P = .000$, for humorous in comparison to non-humorous films. Thus, both HC and SZ participants perceived the humorous clips as more hedonically rewarding than non-humorous clips.

Summary of Aim 1 Results. Taken together, results suggest participants were sensitive to hedonic stimuli used on both tasks. Participants found certain previews during the Preference Task as more enjoyable and ranked the previews accordingly. However, the lack of significant group differences indicates HC and SZ responded similarly to each of the previews. Participants

were also sensitive to experimental manipulation of hedonic rewards in the Effort Reward task. Both SZ and HC reported higher hedonic responses to humorous versus non-humorous films.

Table III

Demographic Characteristics

	HC [M ± S.D.]	SZ [M ± S.D.]	Statistics
Age (years)	43.85 ± 13.90	46.08 ± 9.46	$H(1) = .35$, $P = .55$ [b]
Female N (%)	17 (63%)	12 (50%)	χ^2 (1, N = 51) = .87, $P = .35$ [c]
Education (years)	15.15 ± 2.32	12.17 ± 2.58	$H(1) = 13.48$, $P = .001$ [b]
Estimated IQ	101.56 ± 14.05	91.38 ± 8.65	$H(1) = 7.55$, $P = .006$ [b]
Chapman Anhedonia			
Total	24.15 ± 20.64	25.05 ± 11.97	$H(1) = 1.16$, $P = .28$ [b]
Social	12.35 ± 9.01	11.86 ± 5.14	$H(1) = .18$, $P = .67$ [b]
Physical	12.19 ± 13.12	15.05 ± 7.93	$H(1) = 4.97$, $P = .03$ [b]
TEPS			
Anticipatory	45.30 ± 8.54	44.09 ± 7.78	$F(1, 49) = .27$, $P = .61$ [a]
Consumatory	37.85 ± 8.80	35.17 ± 6.69	$H(1) = 3.54$, $P = .06$ [b]
BIS/BAS			
Drive	11.96 ± 2.98	11.91 ± 3.68	$H(1) = .11$, $P = .75$ [b]
Reward Responsiveness	18.37 ± 1.39	18.09 ± 1.93	$H(1) = .03$, $P = .87$ [b]
Fun Seeking	11.89 ± 2.39	11.74 ± 2.88	$F(1, 49) = .04$, $P = .84$ [a]
BIS	19.37 ± 4.05	20.43 ± 3.82	$F(1, 49) = .90$, $P = .35$ [a]

Note. Estimated IQ = (WRAT-III Reading, Wechsler Test of Adult Reading- Second Edition, Wechsler Abbreviated Scale of Intelligence). TEPS = Temporal Experience of Pleasure Scale, BIS = Behavioral Avoidance, BAS = Behavioral Approach. SZ = schizophrenia, HC = control participants. [a] ANOVA significance level, [b] Kruskal-Wallis significance level, [c] Chi-Square significance level.

Table IV

Clinical Characteristics for the Schizophrenia Group

	n	M ± S.D.	(min-max)
Schizophrenia	16	-	-
Schizoaffective	8	-	-
Clinical Ratings			
HDRS	22	13.18 ± 9.78	0 - 32
PANSS Positive	22	16.45 ± 5.24	8 - 27
PANSS Negative	22	17.68 ± 7.31	10 - 41
PANSS General	22	32.32 ± 9.47	20 - 49
PANSS Total	22	66.45 ± 18.20	41 - 113
HQLS Instrumental Role	21	11.60 ± 5.49	3 - 24
HQLS Interpersonal	21	24.71 ± 10.66	6 - 42
HQLS Intrapsychic	21	28.76 ± 7.60	14 - 47
HQLS Total	21	65.08 ± 18.15	24 - 93
Medication (N)			
Atypical Antipsychotics	18	-	-
Typical Antipsychotics	3	-	-
Antidepressants	9	-	-
Mood Stabilizers	4	-	-
Sedative/Hypnotics	10	-	-
Stimulants	0	-	-

Note. HDRS = Hamilton Depression Rating Scale; HQLS = Heinrich Quality of Life Scale; PANSS = Positive and Negative Syndrome Scale.

Table V

Correlations between Demographics and Task Variables

	HC						SZ					
Task	Preference Hedonic		Effort-Reward Hedonic		Effort-Reward Cost		Preference Hedonic		Effort-Reward Hedonic		Effort-Reward Cost	
Variable	Like	Want	Like	Want	Ratio Mod	Ratio High	Like	Want	Like	Want	Ratio Mod	Ratio High
Age (years)	0.30	0.06	0.16	0.15	0.09	0.04	-0.34	-0.28	-0.10	-0.05	0.11	0.07
Education (years)	-0.24	-0.12	0.00	0.10	0.09	0.23	-0.19	0.04	-0.07	0.07	0.07	0.05
Estimated IQ	-0.23	0.02	-0.18	-0.11	-0.09	-0.05	-0.08	0.08	-0.22	-0.01	0.17	0.20
Female	-0.01	-0.11	-0.02	-0.01	-0.05	-0.07	-0.30	-0.33	-0.13	-0.11	-0.22	-0.14

Note. SZ = schizophrenia; HC = control participants; Preference Hedonic = response to the movie preview given the highest preference ranking; Effort-Reward Hedonic = responses during effort-reward task; Effort Reward Cost = effort exerted to view hedonic stimuli; Like = immediate liking; Want =anticipatory wanting; Ratio Mod = proportion of moderate cost effort choices; Ratio High = proportion of high cost effort choices; Estimated IQ = (WRAT-III Reading, Wechsler Test of Adult Reading- Second Edition, Wechsler Abbreviated Scale of Intelligence). Spearman significance level, *$p < .05$, **$p < .01$.

Table VI

Hedonic Responses to Movie Previews

	HC [M ± S.D.]		SZ [M ± S.D.]	
Movie	Like	Want	Like	Want
1. Airplane	6.74 ± 2.47	6.30 ± 2.71	4.79 ± 2.47	4.67 ± 2.58
2. Dumb & Dumber	6.00 ± 3.01	5.11 ± 3.21	6.29 ± 3.09	6.25 ± 3.08
3. The Jerk	6.07 ± 2.70	5.22 ± 3.30	5.54 ± 2.98	5.75 ± 3.04
4. Nutty Professor	6.89 ± 2.53	6.48 ± 3.02	6.25 ± 2.57	6.50 ± 2.57
5. Rush Hour	7.56 ± 1.80	6.85 ± 2.55	7.25 ± 2.56	7.17 ± 2.16

Note. SZ = schizophrenia, HC = control participants, Like = immediate liking; Want =anticipatory wanting.

Table VII

Frequency Distribution of Preference Ranking by Movie Preview

Movie	HC *f* (%)	SZ *f* (%)
Airplane	6 (22.5)	4 (16.7)
Dumb & Dumber	4 (14.8)	2 (8.3)
The Jerk	3 (11.1)	2 (8.3)
Nutty Professor	5 (18.5)	6 (25)
Rush Hour	9 (33.3)	10 (41.7)

Note. Preference rankings denote movie previews assigned the highest ranking. SZ = schizophrenia participants; HC = control participants

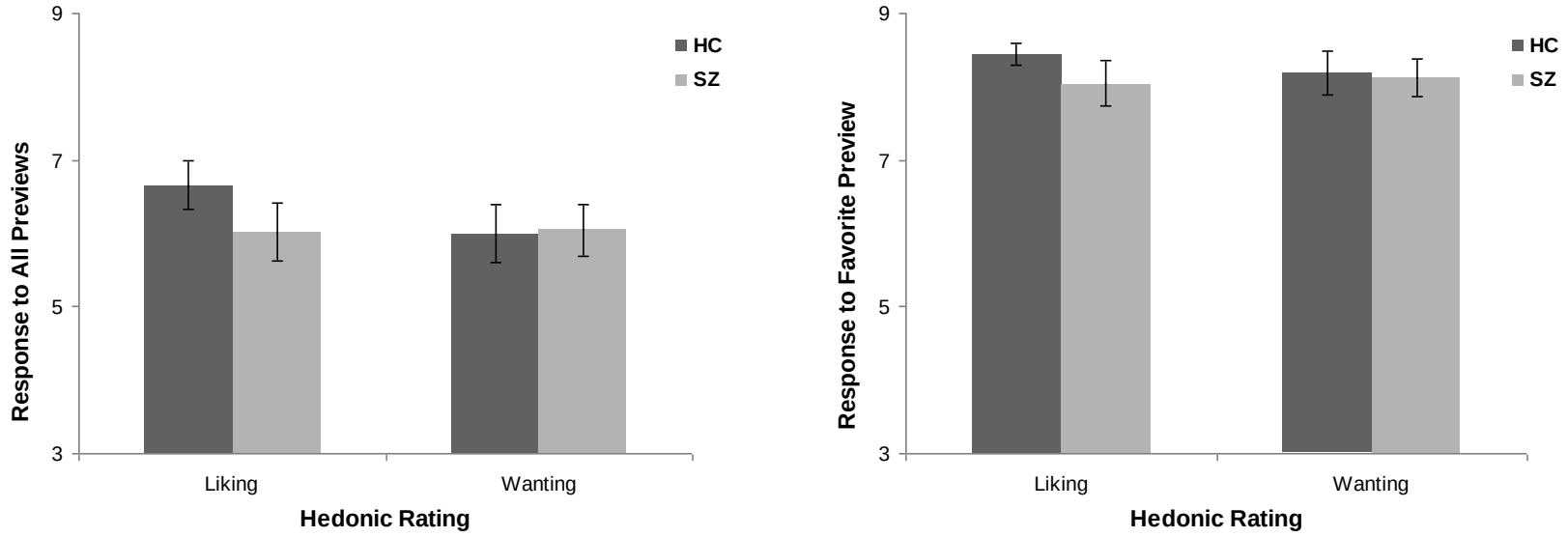

Figure 2A-B. Hedonic responses to all previews (2A) and to favorite film (2B) during the Preference Task as rated by schizophrenia (SZ) and control (HC) participants. Favorite Film denotes response to the movie preview assigned the highest preference ranking. Error bars depict standard error. *$P < .05$

C. Aim 2: Group Differences in Hedonic Experience and Exerted Effort

Hedonic Experience. Group differences in the intensity of hedonic responses were examined using ANOVA or non-parametric statistics (i.e., Kruskal-Wallis test) when indicated. Hedonic responses to 3 types of stimuli were examined: 1) average hedonic response to all previews shown during the Preference task, 2) responses to the movie preview assigned the highest/favorite ranking during the Preference task, and 3) and responses to the humorous and non-humorous film clips shown during the Effort Reward task. Measures of immediate liking and anticipatory wanting were examined separately.

Preference Task. Results of ANOVA indicated average hedonic responses during the Preference Task did not differ among groups. Controls and SZ participants reported similar levels of immediate liking, $F(1, 49) = 1.52$, $P = .22$, and anticipatory wanting, $F(1, 49) = .01$, $P = .92$, among all previews shown (see Figure 3).

Results of Kruskal-Wallis tests examining group differences in hedonic responses to the preview given the highest preference ranking indicated HC and SZ participants reported similar levels of immediate liking, $H(1) = .37$, $P = .54$, and anticipatory wanting, $H(1) = .62$, $P = .43$ (see Figure 2).

Effort Reward Task. Results of Kruskal-Wallis tests examining group differences in the intensity of hedonic responses indicated the SZ and HC participants reported similar levels of anticipatory wanting, $H(1) = .56$, $P = .46$, to humorous films (see Figure 3). However, HC reported higher levels of immediate liking to the humorous films than the SZ at a trend level of significance, $H(1) = 3.34$, $P = .07$. Groups did not differ in their immediate liking, $H(1) = 1.80$, $P = .18$, nor in their anticipatory wanting, $H(1) = 1.85$, $P = .17$, for non-humorous films.

Exerted Effort. Group differences in exerted effort were examined using two approaches. The first approach examined the proportion of effort choices (i.e., ModRatio, HighRatio) associated with higher levels of difficulty using non-parametric methods (i.e.,

Kruskal-Wallis tests). Analyses were limited to moderate and high cost trials, given that the rewards in the equivalent cost trials were predetermined. Moderate and high cost effort trials were examined separately. Results indicated groups did not differ in their effort exerted on moderate cost trials, $H(1) = 1.42$, $P = .23$. However, HC exerted more effort on high cost trials than the SZ participants, $H(1) = 3.99$, $P = .04$. That is, HC had a higher proportion of hard-task choices than SZ participants (see Figure 4).

The second approach utilized logistic regressions to predict the probability that participants would choose tasks with higher levels of difficulty on a majority of trials. Two logistic models were conducted to determine if participants elected to play the more difficult task on more than 50% of trials for each the moderate (Moderate Choice 50%,) and high (High Choice 50%) cost trials. In each analysis, diagnostic group (SZ, HC) was dummy coded using HC as the reference group. Separate analyses were conducted for the two effort cost conditions (moderate, high). Odds ratios were calculated according to Wuensch (2014). Standardized beta weights were calculated according to King (2007). Table VIII shows the logistic regression coefficient, Wald test, semi-standardized beta weights, and odds ratio for each of the predictors.

A test of the full model versus a model with intercept only was not statistically significant for moderate cost trials, χ^2 (1, N = 51) = 1.56, $P = .21$, indicating a non-significant main effect of group ($P = .21$).

In contrast, an analogous model predicting high cost trials was statistically significant, χ^2 (1, N = 51) = 6.46, $P = .01$, with a main effect of group observed ($P = .03$). The odds ratio for group indicates that SZ participants were 0.18 times less likely to choose the more effortful task. Inverted odds ratios for these dummy variables indicated that the odds of choosing the more effortful task were 5.71 times higher for HC participants than for SZ participants.

Summary of Aim 2 Results. Overall, results were generally consistent with hypotheses as SZ participants did not differ from healthy participants in their hedonic responses during the

Preference task. Ratings of anticipatory wanting during the Effort Reward task were equivalent among the groups for both humorous and non-humorous film clips. However, SZ participants reported lower immediate liking to the humorous film clips at a trend level of significance. Two separate analyses examining exerted effort revealed a consistent pattern of results. SZ did not differ from controls when the effort cost was moderate yet SZ demonstrated reduced effort when the effort cost was high.

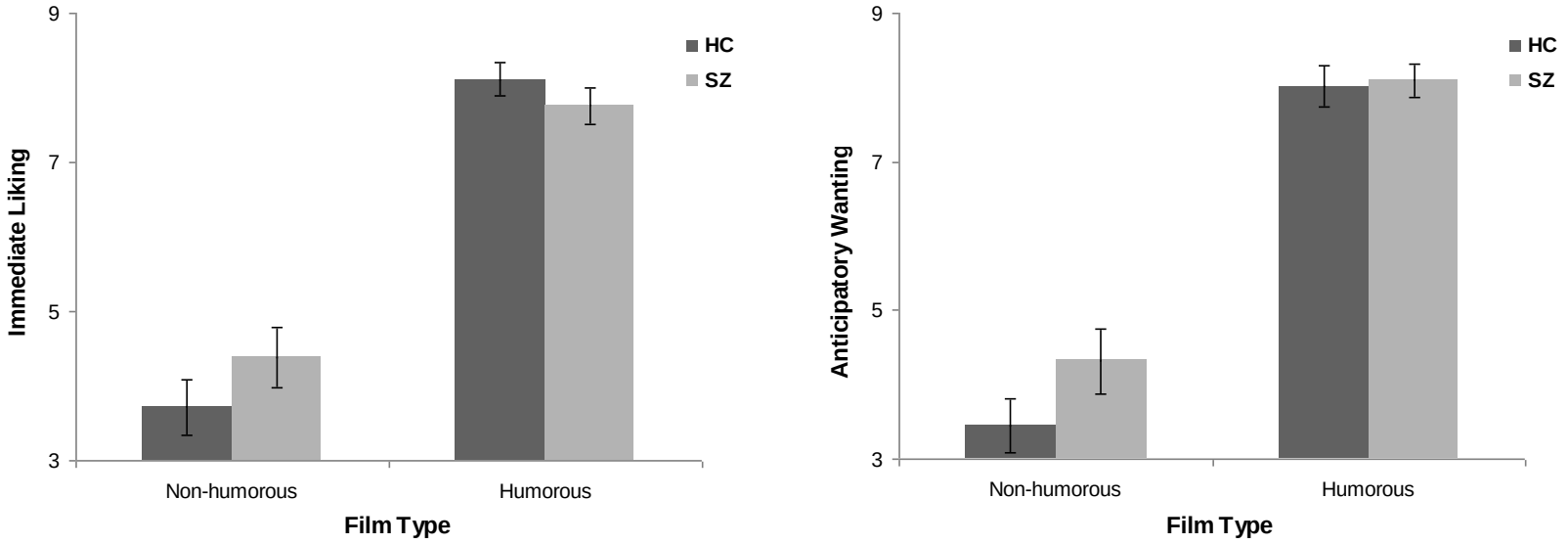

Figure 3A-B. Hedonic responses during the Effort-Reward Task as rated by schizophrenia (SZ) and control (HC) participants for humorous and non-humorous film clips based on immediate liking (3A) and anticipatory wanting (3B). Error bars depict standard error. *$P < .05$

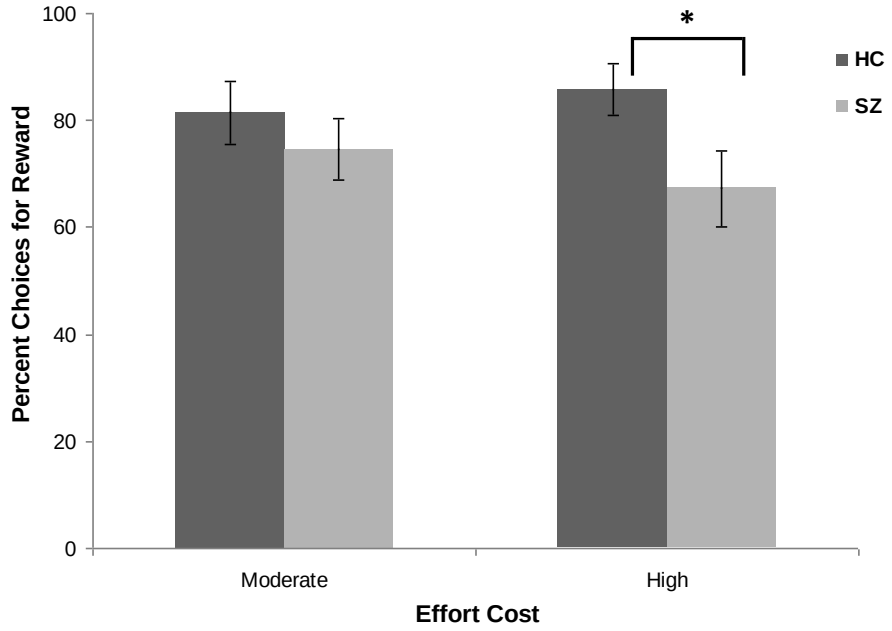

Figure 4. Exerted Effort during the Effort Reward Task for schizophrenia (SZ) and control (HC) participants. Exerted Effort was operationalized as the percentage of effort choices associated with higher levels of difficulty. Error bars depict standard error. *P < .05.

Table VIII

Binary Logistic Regression Predicting Effort from Group

Model/Predictor	$\hat{b}$	*SE* $\hat{b}$	$\hat{\beta}$	Wald χ^2	*P*	*OR*	Full Model
Moderate Choice 50% Group	-0.86	0.70	-0.07	1.5	.22	0.42	χ^2 (1, N = 51) = 1.56, *P* = .21
High Choice 50% Group	-1.74	0.74	-0.17	5.56	.02	0.18	χ^2 (1, N = 51) = 6.46, *P* = .01

Note. Moderate /High Choice 50% = likelihood of choosing more effortful task on greater than 50% of moderate/high cost trials. In each analysis, diagnostic group (SZ, HC) was dummy coded using HC as the reference group. $\hat{b}$ = unstandardized beta, $\hat{\beta}$ = semi-standardized beta weight, *OR* = odds ratio, χ^2= Chi Square.

D. Aim 3: Correspondence between Hedonic Experience and Exerted Effort

The correspondence between hedonic response and exerted effort were examined using two statistical approaches.

Correlational Analyses. The first approach utilized correlational analyses to examine the relationship between hedonic responses and exerted effort. Exerted effort was operationalized as the proportion of effort choices associated with higher levels of difficulty for moderate and high cost trials (i.e., RatioMod, RatioHigh). Given that several variables violated assumptions of normality, Spearman correlations were performed.

The relationship between hedonic responses and effort exerted appear in Table IX. No significant correlations emerged between hedonic responses during the Preference and Effort Reward tasks and exerted effort among both the HC (*P*'s >.15), and SZ participants (*P*'s >.41). Given that exerted effort variables were not normally distributed, an alternative statistical approach which allowed for prediction of dichotomous outcome variables with non-normal distributions was employed.

Binary Logistic Regression. The second approach utilized a series of logistic regressions as described in Aim 2 to predict the probability of participants electing to play the more difficult task on more than 50% of trials for each the moderate (Moderate Choice 50%,) and high (High Choice 50%) cost trials. In each analysis, diagnostic group (SZ, HC) was dummy coded using HC as the reference group. Separate analyses were conducted for the two effort cost conditions (moderate, high). Continuous predictors included 1) hedonic responses to the movie preview given the highest preference ranking in the Preference task and 2) hedonic responses to all humorous films in the Effort Reward task. Indices of immediate liking and anticipatory wanting were examined separately. All continuous predictor variables were centered and found to have a linear relationship with both of the dependent variables.

Hedonic Responses during Preference Task. Logistic models appear in Table X. The first model tested the main effects of group, immediate liking, and the group × immediate liking interaction on moderate cost trials. A test of the full model versus a model with intercept only was not statistically significant for moderate cost trials, χ^2 (3, N = 51) = 3.39, *P* = .34.

The second model tested the main effects of group, immediate liking, and the group × immediate liking interaction on high cost trials. A test of the full model trended towards statistical significance, χ^2 (3, N = 51) = 6.78, *P* = .08. A significant main effect of group was found (*P* = .03). As shown in Table X, the odds ratio for group indicates that SZ participants are 0.19 times less likely to choose the more effortful task. Inverted odds ratios for these dummy variables indicated that the odds of choosing the more effortful task were 5.19 times higher for HC participants than for SZ participants. Neither the immediate liking nor the group × immediate liking interaction were significant in predicting effort in this model.

The third model tested the main effects of group, anticipatory wanting, and the group × anticipatory wanting interaction on moderate cost trials. A test of the full model trended towards statistical significance, χ^2 (3, N = 51) = 7.05, *P* = .07. A significant main effect for anticipatory wanting *(P* = .04) indicated that when holding all other variables constant, a 1 unit increase on the nine-point anticipatory wanting scale was associated with the increasing odds of choosing the more effortful task by a multiplicative factor of 1.93. Group was not a significant predictor in this model (*P* = .14) but this was qualified by a trend level group × anticipatory wanting interaction (*P* =.07). Exploratory follow up analyses indicated that as anticipatory wanting increased, SZ participants were less likely to choose the more effortful task compared to HC participants. The change in odds of choosing the more effortful task versus not was 0.36 for the SZ and 2.76 for the HC participants. As seen in Figure 5, HC participants were more likely to choose the more effortful task for higher ratings of anticipatory wanting.

The fourth model tested the main effects of group, anticipatory wanting, and the group × anticipatory wanting interaction on high cost trials. A test of the full model trended towards statistical significance, χ^2 (3, N = 51) = 7.49, *P* = .06. A significant main effect of group was found (*P* = .03). The odds ratio for group indicates schizophrenia participants are .18 times less likely to choose the more effortful task. Inverted odds ratios indicated that the odds of choosing the more effortful task were 5.55 times higher for HC participants than for SZ participants. Neither the anticipatory wanting nor the group × anticipatory wanting interaction were significant in predicting effort in this model.

Hedonic Responses during Effort-Reward Task. Logistic models appear in Table XI. The first model tested the main effects of group, immediate liking, and the group × immediate liking interaction on moderate cost trials. A test of the full model versus a model with intercept only was not statistically significant for moderate cost trials, χ^2 (3, N = 51) = 1.63, *P* = .65. Neither the immediate liking nor the group × immediate liking interaction were significant in predicting effort in this model.

The second model tested the main effects of group, immediate liking, and the group × immediate liking interaction on high cost trials. A test of the full model was significant, χ^2 (3, N = 51) = 8.65, *P* = .03. A significant main effect of group was found (*P* = .02). As shown in Table XI, the odds ratio for group indicates that SZ participants are 0.15 times less likely to choose the more effortful task. Inverted odds ratios indicated that the odds of choosing the more effortful task were 6.67 times higher for HC participants than for SZ participants. Neither the immediate liking nor the group × immediate liking interaction were significant in predicting effort in this model.

The third model tested the main effects of group, anticipatory wanting, and the group × anticipatory wanting interaction on moderate cost trials. A test of the full model was not

significant, χ^2 (3, N = 51) = 3.86, *P* = .28. Neither the anticipatory wanting nor the group × anticipatory wanting interaction were significant in predicting effort in this model.

The fourth model tested the main effects of group, anticipatory wanting, and the group × anticipatory wanting interaction on high cost trials. A test of the full model trended towards statistical significance, *χ2 (3, N = 51) = 6.68, P =* .08. A significant main effect of group was found (*P* = .02). The odds ratio for group indicates schizophrenia participants are .17 times less likely to choose the more effortful task. Inverted odds ratios indicated that the odds of choosing the more effortful task were 5.85 times higher for HC participants than for SZ participants. Neither the anticipatory wanting nor the group × anticipatory wanting interaction were significant in predicting effort in this model.

Summary of Aim 3 Results. Taken together, group is a robust predictor for effort on high cost trials with controls choosing the more effortful condition more frequently than the SZ participants. Notably, this did not vary depending on hedonic responses during either the Preference or Effort Reward tasks. However, anticipatory wanting during the Preference task was predictive of higher effort choices on the moderate cost trials. This effect was qualified by a trend level group × anticipatory wanting interaction such that SZ participants were less likely to choose the more effortful task for increasingly higher levels of anticipatory wanting.

Table IX

Correlations between Hedonic Response and Exerted Effort

	HC				SZ			
Effort-Reward Cost	Preference Hedonic		Effort-Reward Hedonic		Preference Hedonic		Effort-Reward Hedonic	
Variable	Like	Want	Like	Want	Like	Want	Like	Want
Ratio Mod	0.07	0.22	0.03	0.19	-0.16	-0.13	-0.05	0.12
Ratio High	0.04	0.17	0.14	0.28	-0.13	-0.09	-0.18	0.06

Note. SZ = schizophrenia, HC = control participants. Preference Hedonic = response to the movie preview given the highest preference ranking; Effort Reward Cost = effort exerted to view hedonic stimuli; Like = immediate liking; Want =anticipatory wanting; Ratio Mod = proportion of moderate cost effort choices; Ratio High = proportion of high cost effort choices. Spearman significance level, *$p < .05$, **$p < .01$.

Table X

Binary Logistic Regression Predicting Effort from Group and Hedonic Responses during Preference Task

Model/Predictor	$\hat{b}$	*SE* $\hat{b}$	$\hat{\beta}$	Wald χ^2	*P*	*OR*	Full Model
Moderate Choice 50%							χ^2 (3, N = 51) = 3.39, P = .34
Group	-0.94	0.74	-0.08	1.61	0.20	0.39	
Liking	-0.11	0.71	-0.02	0.02	0.88	0.90	
Group x Liking	-0.39	0.86	-0.07	0.21	0.65	0.67	
High Choice 50%							χ^2 (3, N = 51) = 6.78, *P* = .08.
Group	-1.65	0.76	-0.15	4.74	0.03	0.19	
Liking	0.19	0.74	0.04	0.07	0.80	1.21	
Group x Liking	-0.56	0.83	-0.10	0.46	0.50	0.57	
Moderate Choice 50%							χ^2 (3, N = 51) = 7.05, P = .07
Group	-1.20	0.82	-0.10	2.15	0.14	0.30	
Wanting	0.66	0.32	0.15	4.20	0.04	1.93	
Group x Wanting	-1.01	0.56	-0.14	3.23	0.07	0.36	
High Choice 50%							χ^2 (3, N = 51) = 7.49, *P* = .06
Group	-1.71	0.79	-0.16	4.64	0.03	0.18	
Wanting	0.32	0.33	0.08	0.99	0.32	1.38	
Group x Wanting	-0.75	0.55	-0.11	1.89	0.17	0.47	

Note. Liking/Wanting= immediate liking/anticipatory wanting to participants' favorite films during the Preference Task. Moderate /High Choice 50% = likelihood of choosing more effortful task on greater than 50% of moderate/high cost trials. In each analysis, diagnostic group (SZ, HC) was dummy coded using HC as the reference group. $\hat{b}$ = unstandardized beta (change in outcome resulting from a 1unit change in predictor), $\hat{\beta}$ = semi-standardized beta weight, *OR* = odds ratio, χ^2= Chi Square.

Table XI

Binary Logistic Regression Predicting Effort from Group and Hedonic Responses during Effort Reward Task

Model/Predictor	$\hat{b}$	*SE* $\hat{b}$	$\hat{\beta}$	Wald χ^2	*P*	*OR*	Full Model
Moderate Choice 50%							χ^2 (3, N = 51) = 1.63, *P* = .65
Group	-0.89	0.72	-0.08	1.50	0.22	0.41	
Liking	-0.14	0.52	-0.03	0.07	0.80	0.87	
Group x Liking	0.17	0.64	0.00	0.07	0.80	1.18	
High Choice 50%							χ^2 (3, N = 51) = 8.65, *P* = .03
Group	-1.90	0.81	-0.18	5.49	0.02	0.15	
Liking	0.67	0.48	0.15	1.95	0.16	1.95	
Group x Liking	-0.85	0.60	-0.13	1.99	0.16	0.43	
Moderate Choice 50%							χ^2 (3, N = 51) = 3.86, *P* = .28
Group	-1.00	0.75	-0.09	1.77	0.18	0.37	
Wanting	0.42	0.32	0.09	1.77	0.18	1.52	
Group x Wanting	-0.10	0.52	-0.01	0.04	0.84	0.90	
High Choice 50%							χ^2 (3, N = 51) = 6.68, *P* = .08
Group	-1.77	0.75	-0.17	5.58	0.02	0.17	
Wanting	0.13	0.38	0.03	0.13	0.72	1.14	
Group x Wanting	-0.01	0.54	0.00	0.00	0.99	0.99	

Note. Liking/Wanting= immediate liking/anticipatory wanting to humorous films during the Effort Reward Task. Moderate /High Choice 50% = likelihood of choosing more effortful task on greater than 50% of moderate/high cost trials. $\hat{b}$ = unstandardized beta (change in outcome resulting from a 1unit change in predictor), $\hat{\beta}$ = semi-standardized beta weight, *OR* = odds ratio, χ^2= Chi Square. In each analysis, diagnostic group (SZ, HC) was dummy coded using HC as the reference group.

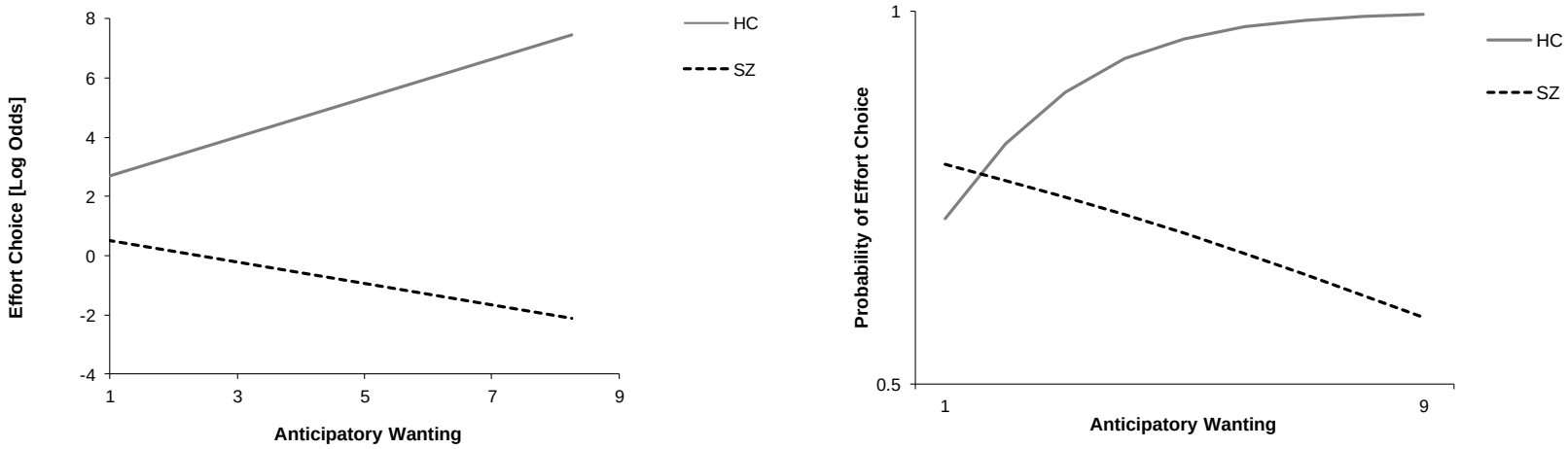

Figure 5A-B. Regression lines for the log odds (A) and probability (B) of choosing the more effortful task on moderate cost trials as predicted by anticipatory wanting and group status for schizophrenia (SZ) and control (HC) participants.

E. Aim 4: Relationships with Questionnaire and Clinical Data

Correlational analyses were used to examine the relationship between behavioral measures of hedonic response, exerted effort, and assessments of hedonic drives. These included self-report questionnaires assessing anticipatory (TEPS-ANT) and consummatory pleasure (TEPS-CON) trait anhedonia (Physical and Social Anhedonia Scales), and behavioral approach motivation (BIS/BAS) among SZ and HC participants. Hedonic responses included ratings of immediate liking and anticipatory wanting collected during the Preference and Effort Reward tasks. Exerted effort was operationalized as the proportion of effort choices associated with higher levels of difficulty for moderate and high cost trials (RatioMod, RatioHigh). We additionally examined the relationship between clinical measures of goal directed activity (i.e., Heinrich's Quality of Life Scale) and clinical symptoms among the schizophrenia participants. Given that several variables violated assumptions of normality, Spearman correlations were performed. To enable comparisons of select correlation coefficients, the Fisher's r to z transformation was used.

Relationships with hedonic questionnaires. The relationship between self-report questionnaires and hedonic responses during the Preference and Effort-Reward tasks appear in Tables XII-XIII. Two-tailed tests of significance indicated that higher levels of TEPS-ANT were positively correlated with hedonic responses to the movie preview given the highest ranking during the Preference task including, immediate liking, $r_S(27) = .53$, $P = .01$, among the HC but not the SZ, $r_S(22) = .28$, $P = .20$. However, the difference between these correlations was not statistically significant, $Z = .96$, $P = .34$. Positive correlations between TEPS-ANT and anticipatory wanting to movie preview given the highest ranking were also found among both HC, $r_S(27) = .41$, $P = .04$, and SZ participants, $r_S(22) = .43$, $P = .04$. Behavioral Inhibition (BIS) was negatively correlated with immediate liking to movie preview given the highest ranking

among the HC, $r_S(27) = -.40$, $P = .04$, but not the SZ, $r_S(22) = .05$, $P = .84$. However, the difference between these correlations was not statistically significant, $Z = -1.54$, $P = .12$.

Several correlations also emerged between the questionnaires and hedonic response to humorous movie clips during the Effort Reward task. Higher levels of TEPS-ANT were positively correlated with immediate liking among the HC, $r_S(27) = .70$, $P = .01$, and SZ participants at a trend level of significance, $r_S(22) = .40$, $P = .06$. The difference between these correlations was not statistically significant, $Z = 1.48$, $P = .14$. Positive correlations between TEPS-ANT and anticipatory wanting to the humorous clips were also seen among the HC, $r_S(27) = .60$, $P = .01$, but not the SZ, $r_S(22) = .23$, $P = .29$. Again, the difference between these correlations was not statistically significant, $Z = 1.52$, $P = .13$. Among the HC, higher levels of BAS-Reward were positively correlated with immediate liking, $r_S(27) = .59$, $P = .01$, and anticipatory wanting, $r_S(27) = .39$, $P = .05$. Significant associations with BAS-Reward were not observed among the SZ with regards to immediate liking, $r_S(22) = .13$, $P = .54$, or anticipatory wanting, $r_S(22) = -.11$, $P = .61$. The difference between these correlations trended towards significance for both immediate liking, $Z = 1.78$, $P = .08$, and anticipatory wanting, $Z = 1.72$, $P = .09$.

The relationship between self-report questionnaires and exerted effort appear in Tables XII-XIII. BAS-Reward was significantly negatively correlated with effort exerted to view hedonic stimuli for moderate cost trials among the SZ, $r_S(22) = -.46$, $P = .03$, but not the HC participants, $r_S(27) = -.06$, $P = .76$. BAS-Reward was also significantly negatively correlated with effort for high cost trials among the SZ, $r_S(22) = -.55$, $P = .01$, but not the HC participants, $r_S(27) = -.10$, $P = .62$. However, the difference between these correlations was not statistically significant for either moderate cost, $Z = 1.45$, $P = .15$, or high cost trials, $Z = 1.69$, $P = .09$.

Relationship with clinical symptoms and functional outcome. The relationship between clinical variables task variables appear in Table XIV. Two-tailed tests of significance indicated that among SZ participants, higher levels of PANSS General symptoms were

negatively correlated with *immediate liking* to humorous movie clips during Effort Reward task, $r_S(23) = -.43$, $P = .04$. Higher levels of depressive symptoms, $r_S(22) = -.49$, $P = .02$, and PANSS Positive symptoms, $r_S(22) = -.48$, $P = .04$, were negatively correlated with anticipatory wanting during the Effort Reward task. With the exception of a trend level correlation between instrumental role functioning, $r_S(22) = .38$, $P = .09$, and anticipatory wanting during the Effort Reward task, no significant correlations emerged between clinical variables and exerted effort and hedonic responses during the Preference Task.

Summary of Aim 4 Results. In sum, positive associations between self-report indices of TEPS-ANT and hedonic response variables were found in both groups, although these associations were more robust among the HC participants. BAS-Reward was positively associated with hedonic variables in the Effort Reward task among HC participants. Interestingly, BAS-Reward was negatively associated with exerted effort but this relationship was unique to SZ participants. An unexpected pattern of associations emerged between hedonic responses and clinical symptoms among the SZ. General psychopathology, positive symptoms, and depressive symptoms were negatively correlated with hedonic responses while no significant effects were found for negative symptoms or psychosocial functioning. Additionally, clinical symptoms were unrelated to exerted effort in the SZ.

Table XII

Correlations between Self Report Questionnaires and Task Variables for Healthy Participants

Task	Preference Hedonic		Effort-Reward Hedonic		Effort-Reward Cost	
Variable	Like	Want	Like	Want	Ratio Mod	Ratio High
Social Anhedonia	0.21	0.10	0.27	0.17	0.18	0.17
Physical Anhedonia	0.07	0.32	0.22	0.25	0.23	0.22
Total Anhedonia	0.11	0.15	0.22	0.17	0.22	0.19
TEPS Anticipatory	0.59**	0.41*	0.70**	0.60**	-0.19	-0.08
TEPS Consumatory	-0.12	-0.12	-0.04	0.04	-0.08	-0.02
BAS Drive	0.21	0.05	0.28	0.22	-0.05	-0.10
BAS Reward Responsiveness	0.33	0.05	0.59**	0.39*	-0.06	-0.10
BAS Fun Seeking	-0.06	-0.29	0.19	0.01	-0.12	-0.15
BIS Total	-0.40*	-0.17	-0.23	-0.19	-0.13	-0.03

Note. Preference Hedonic = response to the movie preview given the highest preference ranking; Effort-Reward Hedonic = responses during effort-reward task; Effort Reward Cost = effort exerted to view hedonic stimuli; Like = immediate liking; Want =anticipatory wanting; Ratio Mod = proportion of moderate cost effort choices; Ratio High = proportion of high cost effort choices; Social/Physical Anhedonia = Chapman Scales; TEPS = Temporal Experience of Pleasure Scale, BIS = Behavioral Avoidance, BAS = Behavioral Approach. Spearman significance level, *$p < .05$, **$p < .01$.

Table XIII

Correlations between Self Report Questionnaires and Task Variables for Schizophrenia Participants

Task	Preference Hedonic		Effort-Reward Hedonic		Effort-Reward Cost	
Variable	Like	Want	Like	Want	Ratio Mod	Ratio High
Social Anhedonia	0.08	-0.06	0.04	0.02	-0.36	-0.31
Physical Anhedonia	0.15	0.11	-0.04	0.00	-0.24	-0.26
Total Anhedonia	0.02	0.34	-0.22	-0.10	-0.15	-0.13
TEPS Anticipatory	0.28	0.43*	0.40	0.23	0.14	-0.04
TEPS Consumatory	-0.04	-0.12	0.00	-0.10	0.03	-0.05
BAS Drive	0.14	0.00	0.09	0.02	-0.12	-0.24
BAS Reward Responsiveness	0.04	0.23	0.13	-0.11	-0.46*	-0.55**
BAS Fun Seeking	0.38	0.25	0.11	0.00	-0.07	-0.24
BIS Total	0.05	0.28	0.18	0.11	-0.33	-0.29

Note. Preference Hedonic = response to the movie preview given the highest preference ranking; Effort-Reward Hedonic = responses during effort-reward task; Effort Reward Cost = effort exerted to view hedonic stimuli; Like = immediate liking; Want =anticipatory wanting; Ratio Mod = proportion of moderate cost effort choices; Ratio High = proportion of high cost effort choices; Social/Physical Anhedonia = Chapman Scales; TEPS = Temporal Experience of Pleasure Scale, BIS = Behavioral Avoidance, BAS = Behavioral Approach. Spearman significance level, *$p < .05$, **$p < .01$.

Table XIV

Correlations between Clinical Measures and Task Variables for Schizophrenia Participants

	Preference Hedonic		Effort-Reward Hedonic		Effort-Reward Cost	
Variable	Like	Want	Like	Want	Ratio Mod	Ratio High
HDRS	-0.14	-0.09	-0.36	-0.49*	-0.28	-0.14
PANSS Positive	0.00	0.19	-0.36	-0.48*	-0.17	-0.12
PANSS Negative	0.08	0.26	-0.05	-0.05	-0.09	-0.10
PANSS General	0.03	0.14	-0.49*	-0.27	-0.05	0.08
PANSS Total	-0.03	0.22	-0.40	-0.35	-0.05	0.03
HQLS Instrumental Role	0.12	0.07	0.07	0.38	-0.05	-0.11
HQLS Interpersonal	0.21	0.21	-0.12	-0.03	-0.12	-0.05
HQLS Intrapsychic	-0.01	-0.11	0.13	0.24	0.04	-0.02
HQLS Total	0.08	0.07	-0.05	0.14	-0.07	-0.08

Note. SZ = schizophrenia participants. Preference Hedonic = response to the movie preview given the highest preference ranking; Effort-Reward Hedonic = responses during effort-reward task; Effort Reward Cost = effort exerted to view hedonic stimuli; Like = immediate liking; Want =anticipatory wanting; Mod = proportion of moderate cost effort choices; High = proportion of high cost effort choices. HDRS = Hamilton Depression Rating Scale; HQLS = Heinrich Quality of Life Scale; PANSS = Positive and Negative Syndrome Scale. Spearman significance level, $*p < .05$, $**p < .01$.

F. Aim 5: Relationship with Social Contextual Variables.

Given that a small subset of participants completed the PCS and IMI-SR (HC n =12; SZ n =13), analyses were exploratory in nature. Demographic characteristics for this sample are found in Table XV. Due to the significant difference in gender distribution among the two groups (HC: 83.8% female; SZ 38.5% female), subsequent analyses included gender as a covariate. Group differences in the PCS and IMI-SR variables were examined using analysis of covariance (ANCOVA). Controls endorsed higher levels of perceived self-competency for the Effort Reward task than SZ, $F(1, 25) = 7.58$, $P = .01$. However, gender was also significantly related to self-competency, $F(1, 25) = 5.04$, $P = .04$, with males endorsing higher levels of self-competency than females. Groups did not differ in their intrinsic interest, $F(1, 25) = 0.14$, $P = .71$, nor in their perceived choice, $F(1, 25) = 1.14$, $P = .29$. In contrast, groups differed in their perceived value of the Effort Reward task, $F(1, 25) = 4.58$, $P = .04$, with SZ reporting higher levels of value than HC participants.

Correlational analyses were used to examine the hypothesis that task value and perceived self-efficacy are associated with hedonic responses and exerted effort. Partial correlations, controlling for the effect of gender were conducted. Hedonic responses included ratings of immediate liking and anticipatory wanting collected during the Effort Reward task. Exerted effort was operationalized as the proportion of effort choices associated with higher levels of difficulty for moderate and high cost trials (RatioMod, RatioHigh). To enable comparisons of select correlation coefficients, the Fisher's r to z transformation was used.

The relationship between task value, perceived self-efficacy, hedonic responses, and exerted effort appear in Table XVI. Two-tailed tests of significance indicated that higher levels of task value were positively correlated with immediate liking among both the HC, $r = .72$, $P = .01$, and the SZ, $r = .78$, $P = .01$ (see Figure 6). The difference between these correlations was not statistically significant, $Z = -0.33$, $P = .74$. Task value was also positively correlated with

anticipatory wanting among the SZ, r = .69, P =.01, but not the HC, r = .19, P =.58. However, the difference between these correlations was not statistically significant, Z =.-1.45, P =.15. Higher levels of task interest were also positively correlated with immediate liking during the Effort Reward task among both the HC, r = .85, P =.01, and the SZ, r = .59, P =.04 (see Figure 7). The difference between these correlations was not statistically significant, Z =1.56, P =.12. Measures of task value and perceived self-efficacy were not associated with effort exerted in either group.

Summary of Aim 5 Results. Differences in perceived self-efficacy were predicted by group and gender. While HC endorsed higher levels of perceived self-competency for the Effort Reward task, this effect was strongly influenced by males endorsing higher levels of self-competency than females. In contrast, SZ reported higher perceived value than HC for the Effort Reward task. Contrary to predictions, measures of perceived self-efficacy and task value were unrelated to exerted effort. However, robust associations between task value/interest and hedonic responses were found among both HC and SZ participants.

Table XV

Demographic Characteristics for PCS/IMI Sample

	HC [M ± S.D.]	SZ [M ± S.D.]	Statistics
Age (years)	46.67 ± 14.34	46.77 ± 9.91	$F(1, 25) = 0.01$, $P = .92$
Female N (%)	10 (83.3%)	5 (38.5%)	χ^2 (1, N = 25) = 5.24, $P = .04$
Education (years)	15.33 ± 2.61	12.31 ± 2.81	$F(1, 25) = 9.87$, $P = .01$
Estimated IQ	97.50 ± 14.04	90.69 ± 8.39	$F(1, 25) = 2.69$, $P = .12$
Chapman Anhedonia			
Total	20.18 ± 10.37	24.17 ± 12.09	$F(1, 25) = 2.00$, $P = .17$
Social	10.73 ± 6.25	11.42 ± 4.14	$F(1, 25) = 0.92$, $P = .35$
Physical	9.45 ± 7.37	13.67 ± 9.02	$F(1, 25) = 1.99$, $P = .17$
TEPS			
Anticipatory	42.25 ± 10.64	44.38 ± 9.22	$F(1, 25) = 6.98$, $P = .41$
Consumatory	36.67 ± 12.13	35.31 ± 8.36	$F(1, 25) = 1.25$, $P = .28$
BIS/BAS			
Drive	12.42 ± 2.91	11.46 ± 3.55	$F(1, 25) = 1.86$, $P = .19$
Reward Responsiveness	18.17 ± 1.47	18.69 ± 1.70	$F(1, 25) = 0.04$, $P = .85$
Fun Seeking	12.08 ± 2.11	11.62 ± 3.23	$F(1, 25) = 2.23$, $P = .15$
BIS	18.75 ± 4.50	19.92 ± 3.10	$F(1, 25) = 0.77$, $P = .39$
PCS Total	26.42 ± 1.98	23.38 ± 5.55	$F(1, 25) = 7.58$, $P = .01$
IMI Interest	36.67 ± 9.87	40.31 ± 7.59	$F(1, 25) = 0.14$, $P = .71$
Choice	41.75 ± 7.14	40.62 ± 6.86	$F(1, 25) = 1.14$, $P = .29$
Value	31.67 ± 10.40	40.77 ± 8.35	$F(1, 25) = 4.58$, $P = .04$

Note. Estimated IQ = (WRAT-III Reading, Wechsler Test of Adult Reading- Second Edition, Wechsler Abbreviated Scale of Intelligence). TEPS = Temporal Experience of Pleasure Scale, BIS = Behavioral Avoidance, BAS = Behavioral Approach. PCS Total = Perceived Self Competency Scale composite; IMI = Intrinsic Motivational Inventory; SZ = schizophrenia (n =13), HC = control participants (n =12).

Table XVI

Partial Correlations between PCS/IMI and Task Variables

	HC				SZ			
Task	Effort-Reward Hedonic		Effort-Reward Cost		Effort-Reward Hedonic		Effort-Reward Cost	
Variable	Like	Want	Ratio Mod	Ratio High	Like	Want	Ratio Mod	Ratio High
PCS Total	-0.13	0.15	-0.01	-0.17	0.39	0.28	0.44	0.33
IMI								
Interest	0.85**	0.42	0.24	0.40	0.59*	0.48	0.30	0.04
Choice	-0.44	0.27	-0.22	-0.28	0.42	0.32	0.37	0.17
Value	0.72**	0.19	-0.01	0.40	0.78**	0.69*	0.22	-0.01

Note. Partial correlations controlling for gender. Preference Hedonic = response to the movie preview given the highest preference ranking; Effort-Reward Hedonic = responses during effort-reward task; Effort Reward Cost = effort exerted to view hedonic stimuli; Like = immediate liking; Want =anticipatory wanting; Ratio Mod = proportion of moderate cost effort choices; Ratio High = proportion of high cost effort choices; PCS Total = Perceived Self Competency Scale composite; IMI = Intrinsic Motivational Inventory; SZ = schizophrenia; HC = control participants. Significance level, *$p < .05$, **$p < .01$.

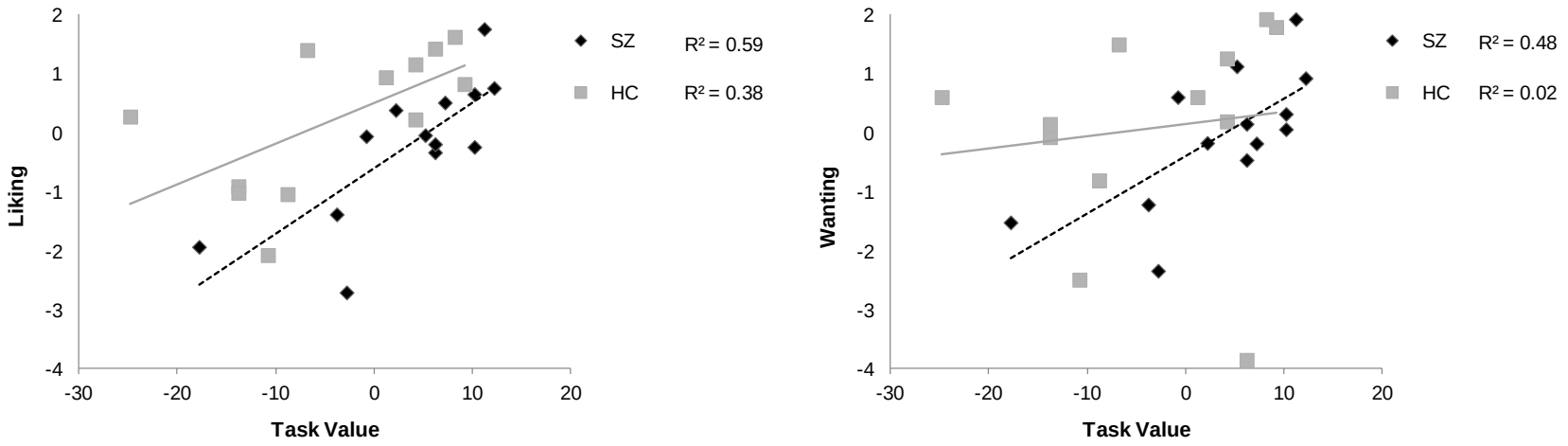

Figure 6A-B. Partial regression plots between measures of perceived task value and immediate liking (A) and anticipatory wanting (B) to humorous films during the Effort Reward task, controlling for gender, among schizophrenia (SZ) and control (HC) participants.

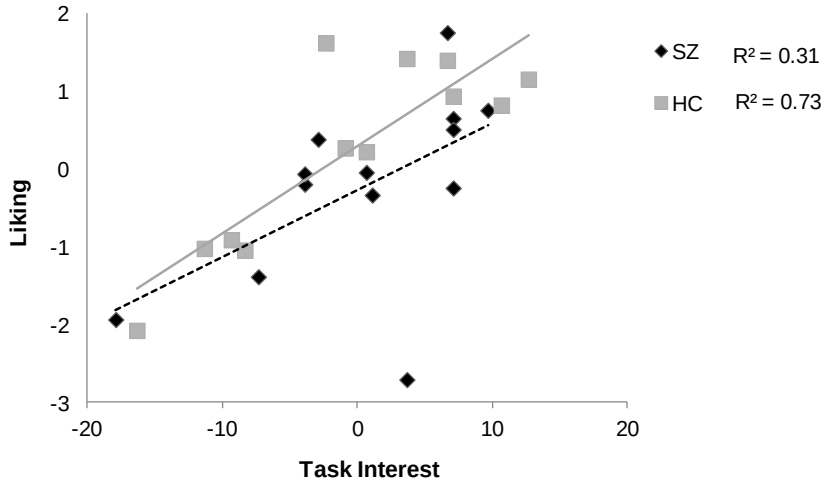

Figure 7. Partial regression plot between measures of perceived task interest and immediate liking to humorous films during the Effort Reward task, controlling for gender, among schizophrenia (SZ) and control (HC) participants.

IV. Discussion

A. Aim 1: Task Validation

A primary goal of this study was design a novel effort based decision making task to assess expended effort to obtain hedonic rewards. Several prior studies have found that SZ do not differ from controls in their hedonic experience yet do differ in their effort to obtain such rewards. As such, we used rewards individuals were likely to encounter in their daily lives. Building on paradigms using humorous cartoons as incentives (e.g., Sherdell et al., 2012; Waugh & Gotlib, 2008), we utilized humorous film clips from popular movies as rewards. Therefore we first examined task parameters to ensure participants were sufficiently motivated by the hedonic rewards.

In examining participants' responses to the movie previews shown in the Preference Task, group differences did not emerge. While participants found certain previews as more enjoyable than others, the lack of significant group differences indicates HC and SZ participants responded to the content of the previews in a similar fashion. A unique aspect of this study involved capitalizing on participants' preferences in determining hedonic rewards. Given the highly variable and idiosyncratic nature of humor preference, participants were allowed to self-select the source of their rewarding stimuli for the Effort Reward task. As such, we examined the frequency of the movie given the top preference ranking. Results indicated that participants' rankings varied significantly among the five previews shown, yet group membership did not predict the movie given the top rating. In general, all participants favored the more recent movie previews. It is possible these patterns emerged because participants were more likely to have encountered these movies in recent years, and thus were more familiar with their content.

To further ensure that participants were not ambivalent to the movie previews, we compared participants' hedonic responses to the preview given the highest ranking versus their responses to the remaining four movie previews. Results indicated participants discriminated

between highly the preferred movie preview and the other available previews. More specifically, participants reported greater intensity of hedonic response to the movie given their top preference. This suggests the reward stimuli were salient and conferred hedonic value prior to initiating the Effort Reward task. This also highlights the value of tailoring rewards to participants' idiosyncratic preferences in effort reward paradigms.

Last, we examined participants' responses to the two types of stimuli (i.e., humorous versus non-humorous movie clips) shown during the Effort Reward task. Results indicated that a small subset of participants reported greater enjoyment for presumed "non-humorous" rewards. Given that the more effortful conditions were always associated with the "humorous" film clips, these participants were excluded from analyses. This indicated the non-humorous films were at the very least more engaging to a small subset of the sample. It is possible these participants preferred films that were more informational in nature given that many of the non-humorous clips were portions of instructional films. However, the non-humorous films were purposely edited in manner so as dissuade repeated viewing. For instance, non-humorous clips were not presented in a sequential fashion nor did they come from a single source so as to build interest and engagement over the course of the task. Moreover, the vast majority of participants reported higher levels of enjoyment and wanting for the humorous versus non-humorous film clips. Again, this suggests that participants were sensitive to the experimental manipulation of hedonic rewards in the Effort Reward task. However, the possibility exists that non-humorous stimuli were in fact aversive as opposed to simply lacking reward value.

Taken together, results suggest participants were sufficiently incentivized by the hedonic rewards selected for this study. Although we used non-standardized stimuli, there was much evidence indicating participants enjoyed the nature of the stimuli. Moving forward, further task development could be aided by comprehensive validation of task stimuli to formally distinguish rewarding from non-rewarding stimuli. Building a database of norms and standardizing stimuli

for content and general engagement would also inform how such factors relate to hedonic response. Given the robust differences in hedonic response to highly preferred movies, future studies could also include the provision of a wider selection of movie options.

B. Aim 2: Group Differences in Hedonic Experience and Exerted Effort

Hedonic experience. Consistent with hypotheses, individuals with schizophrenia reported similar levels of hedonic experience as controls. As previously discussed, groups did not differ in their reported immediate liking to the movie previews in the Preference Task. Groups also similarly reported higher levels of immediate liking to their top ranked movie preview in comparison to the other available previews. Results agree with past work demonstrating normative emotional responses to emotionally laden stimuli (Heerey & Gold, 2007), positive film clips (Horan et al., 2006), and hedonic rewards in the context of both experimental (Fervaha et al., 2013; Waltz et al., 2009) and ecologically measured motivation (Gard, Sanchez, Cooper, Fisher, Garrett, & Vinogradov, 2015) among people with schizophrenia. Interestingly, we did not find group differences with regard to anticipatory wanting during the Preference or Effort-Reward tasks. This was somewhat surprising considering that deficits in hedonic function are proposed to relate to difficulties self-reporting non-current emotional states (Strauss & Gold, 2012) including difficulty recollecting past emotional experiences (Hall et al., 2007; Herbener et al., 2007; Lakis et al., 2011; although see Horan et al., 2006) and predicting anticipated pleasure for future goal oriented behavior (Gard et al., 2007). However not all studies find impairments in anticipation of pleasure among people with schizophrenia. Notably, in a recent ecological momentary assessment (ESM) study SZ reported *higher* levels of anticipated pleasure (i.e., “how much do you think you will enjoy this goal?”) than controls (Gard et al., 2014). The current study’s assessments of anticipatory wanting taps a related although distinct construct (i.e., “how much would you like to see more of this movie?”). Arguably, this question elicits a current emotional state regarding the continuation

of a very recent experience. Therefore it does not require individuals to predict a future emotional state, and it is anchored in a familiar and specific context. This is relevant considering that traditional measures of hedonic experience may elicit attitudes and value assigned to temporally distant and imprecise experiences (Leventhal, Chasson, Tapia, Miller, & Pettit, 2006; Strauss & Gold, 2012). As such, results add to recent work indicating that motivational drives for pleasure based goals are intact in people with schizophrenia.

In contrast to these findings, a single trend effect for group (*P* =.07) emerged with controls reporting higher levels of immediate liking than SZ during the Effort Reward task. Given group differences in exerted effort (discussed below) it is quite possible that participants' hedonic response to the rewarding clip were influenced by their feelings towards the effortful task. For example, if participants did not feel their effort was warranted or they became fatigued by the end of the effort trial, they may have been less inclined to endorse their "reward" as enjoyable. Indeed, people with schizophrenia tend to discount the value of rewards especially at higher levels of required effort (Barch et al., 2014; Ferhava et al., 2013). As such, exploratory analyses could examine the extent to which effort condition moderates these findings. It is notable however that groups reported similar levels of anticipatory wanting, suggesting incentive salience of the rewards were robust. Therefore subsequent studies could employ a time-dependent analysis to better understand the interactive effects of effort condition, task duration, and hedonic experience.

We also examined non-humorous stimuli to determine if groups differed in their hedonic responses to the stimuli associated with the less effortful tasks. As noted, a small number of participants reported greater hedonic responses to the non-humorous versus humorous films, and a majority of these individuals were in the schizophrenia group (SZ n =4; HC n =1). However, after these participants were excluded groups did not differ in their hedonic responses to the non-humorous stimuli.

Exerted effort. As predicted, group differences in exerted effort did not emerge when the effort-to- reward cost ratio was moderate. In contrast, SZ demonstrated reduced effort compared to controls when the effort-to-reward cost ratio was high. In understanding the pattern of these results, it is helpful to appreciate that effort based performance is multi-determined (Gold, Waltz, & Frank, 2015). The evaluation of potential rewards (i.e., assessment of the expected or potential value of the reward) is one such factor implicated in schizophrenia. For instance SZ are shown to discount rewards more steeply than controls and have difficulty representing the value of potential rewards. However, reductions in reward valuation are less apparent when SZ are explicitly asked (as shown in Ferhava et al., 2013 and Gard et al. 2014), as was the case in the current study. Given the lack of group differences in hedonic responses to the rewards, it is unlikely that results reflect deficits in reward valuation. Moreover, the magnitude of rewards was constant across levels of task difficulty. While this limits our ability to identify deficits in reward valuation, this is more akin to circumstances surrounding naturalistic rewards. It also suggests group effects relate to difficulties evaluating the cost of effort. Our results converge with several studies demonstrating a reduction in effort as task demands increase (Fervaha et al., 2013; Barch et al., 2014; Treadway et al., 2015). Such patterns are conceptualized as difficulties accurately computing effort-reward costs (Gold et al., 2013) and are thought to relate to dopaminergic (DA) excitability in the striatum. The anterior cingulate cortex (ACC) is also thought to play a critical role in cost-benefit analysis necessary for balancing rewards and effort (Kring & Barch, 2014). In light of spared neural response to hedonic stimuli among SZ, it is proposed that these systems do not effectively scale up for changes in effort demands (Gold et al., 2015). Translated to daily life, people with schizophrenia may be biased in judging the positive outcomes associated with difficult or effortful behavior. Consistent with this, SZ are found to be inaccurate in their valuation of effort, including overestimating the costs associated with completing certain goals (Gard et al., 2014).

Interestingly, patients in this study engaged in a disproportionate level of pleasurable, albeit passive, goals such as watching television in comparison to the long-term and more effortful goals reported by controls. In the current study, it is notable that levels of effort were made quite overt to participants. At the onset of each trial, participants were presented with effort task descriptors (i.e., “Easy”, “Medium”, “Hard), which may have unduly influenced effort decisions. While this does not negate difficulties estimating effort cost, this may have implications for clinical interventions aimed at addressing goal-directed behaviors.

Further limitations to these interpretations are worth noting. First, as previously discussed, reward value (i.e., duration of humorous films) did not vary for moderate versus high effort cost which may have adversely impacted effort decisions in schizophrenia group. Therefore it is possible participants quickly learned that their increased effort did not translate to a more rewarding outcome. Arguably, scaled rewards were not necessary due to the nature of the stimuli. As participants chose more effortful tasks, they viewed more successive clips from the same movie. Therefore it is possible that rewards had an additive effect such that participants were increasingly motivated to view humorous clips in order to see a particular story line or scene play out. Given that many experimental paradigms vary effort and reward value simultaneously (Gold et al., 2015), our design allows for clearer interpretation of deficits. Another probable limitation relates to confound between effort cost and the duration to reward receipt. Harder tasks required more effort but also more time, thereby delaying the time until the movie clip was shown. This is relevant as SZ devalue rewards that are more temporally distant in lieu of more immediate rewards, regardless of reward magnitude (Heerey et al., 2007; Gold, Waltz, Prentice, Morris, & Heerey, 2008). Few published studies have directly addressed this confound, with mixed results regarding group differences (i.e., Docx et al., 2015; Hartmann, et al., 2015). Therefore, future studies could examine this possibility by holding the time of effort task and time to reward receipt constant.

C. Aim 3: Correspondence between Hedonic Experience and Exerted Effort

Hypotheses regarding the correspondence between hedonic response and exerted effort were partially supported. The relationship between hedonic response and effort varied as a function of group and the effort-to- reward cost ratio. In general however, group was a more robust predictor of effort performance than hedonic response when the effort cost was high. Regardless of the hedonic response variable entered in the model, SZ participants exerted reduced effort compared to controls on high cost trials. As previously discussed, this pattern is likely due to differences in effort valuation and allocation.

Only one logistic regression model revealed a significant effect of hedonic response in predicting effort. That is, anticipatory wanting during the Preference task was predictive of effort when the effort-to- reward cost ratio was moderate. Higher ratings of anticipatory wanting to the highly preferred movie (i.e., the movie used for humorous clips) were predictive of effort choices on the moderate cost trials. However, a trend level, group × anticipatory wanting interaction qualified this effect. Controls were more likely to choose an effortful task for increasingly higher levels of anticipatory wanting whereas schizophrenia participants were less likely to exert effort. This is line with the hypothesized disconnect between hedonic experience and exerted effort seen in people with schizophrenia, although in the opposite manner than expected for the lower reward cost condition. Nonetheless, our results agree with several prior studies finding a weak correspondence between internal states and motivated behavior in schizophrenia (Gard et al., 2014; Treadway 2010). In comparison, controls generally respond to self-reports of hedonic experience in a way that aligns with their performance on measures of evoked emotion (Heerey & Gold, 2007), emotional memory (Herbener et al., 2007), and effort (Sherdell et al., 2012). Contrary to hypotheses, hedonic responses were uniquely predictive of exerted effort for moderate but not high cost trials among the HC. However, this is consistent with previous work

(Waugh & Gotlib, 2008) showing a trade-off between reward preference and required effort at higher levels of effort among controls.

It is also notable that anticipatory wanting during the Preference task was the only hedonic variable to reliably predict effort performance. It is possible this effect emerged due to the temporal delay between the Preference and Effort Reward tasks. In contrast to hedonic responses elicited during the Effort Reward task, ratings of anticipatory wanting during the Preference task were taken several minutes prior to participants being faced with effort-cost decisions. The introduction of the effortful task may have been perceived as a barrier to translating hedonic drives into goal-driven behavior. This is consistent with SZ specific deficits in adapting behavior to maximize rewards in the long term and in the face of changing demands (Gold et al., 2008). All together, amotivation in schizophrenia does not appear related to deficits in the immediate experience of pleasure (i.e., "liking"). Rather, reductions in approach related behavior in SZ stem from an incongruence between hedonic drives and behavior as well as impaired assessment of effort cost. The current results align with research documenting impairments in behavioral "wanting" in effort based decision making tasks, and extend the application of this phenomenon to rewards SZ are likely encounter in their daily lives.

D. Aim 4: Relationships with questionnaire and Clinical Data

The fourth aim involved examining the relationship between task variables, traditional self-report questionnaires used to assess hedonic drives and attitudes, and clinical variables.

Relationship with hedonic questionnaires. Results of correlational analyses revealed associations between hedonic responses and indices of anticipatory pleasure (TEPS-ANT) and BAS-Reward, yet these findings were more robust among HC than SZ. Specifically, TEPS-ANT was significantly associated with all four hedonic response variables among controls while only one significant association emerged for the schizophrenia participants. The TEPS-ANT subscale is thought to assess pleasure that people experience at the thought of a future event.

Sample items include: “Looking forward to a pleasurable experience is in itself pleasurable” and “When I hear about a new movie starring my favorite actor, I can't wait to see it”. A related but separate construct, *anticipated pleasure*, as described by Strauss, Wilbur, Warren, August, and Gold (2011) reflects the degree of pleasure people predict they will experience for future events (as cited in Loewenstein, Weber, Hsee, & Welch, 2001). Broadly however, both anticipatory pleasure (i.e., TEPS-ANT) and anticipated pleasure are acknowledged to reflect the “wanting” domain (Kring & Barch, 2014). Thus, the controls in this study demonstrated a high degree of consistency when answering questions sensitive to internal experiences of “wanting” and when rating their in-vivo hedonic experience. There was considerably less evidence of this among the schizophrenia participants.

We also found group specific patterns of associations among the BAS Reward Responsiveness subscale and Effort Reward task variables. Among controls, reward responsiveness was positively associated with hedonic responses during the Effort Reward task. Given that BAS reward responsiveness has been shown to correlate strongly with TEPS-ANT (Gard et al., 2007; Strauss et al., 2011), it is not surprising that this subscale was associated with hedonic responses in a similar, albeit more limited fashion as TEPS-ANT among the controls.

The failure to find more consistent relationships between trait anhedonia (Chapman Scales of Physical and Social Anhedonia) and task variables was unexpected as elevated trait anhedonia is associated with atypical neural response to positive stimuli in regions responsible for signaling reward (Harvey, Armony, Malla, & Lepage, 2010). It may be that the TEPS and BAS are more sensitive to reward and goal-directed behaviors in comparison to the Chapman scales which tap into attitudes and value assigned to pleasurable experiences (Leventhal et al., 2006).

Overall, the lack of associations between hedonic responses and questionnaire measures (TEPS-ANT, BAS Reward) among the schizophrenia participants is notable. Yet, this is not entirely surprising as self-report questionnaires tapping hedonic functioning are likely to elicit cognitive processes (e.g., memory for previous experiences of pleasure, affective forecasting) similar to those involved in recollective experience. Both of which are shown to be impacted in schizophrenia. Taken together, results aligns with theories suggesting that impaired "wanting" in schizophrenia relates to difficulties with immediate (Kring, Gard, & Gard, 2011; Gard et al., 2011; Ursu et al., 2011) and long-term maintenance (Herbener et al., 2007) of hedonic experience.

Unexpectedly, few associations emerged between self-report measures and exerted effort among all participants. One notable exception included negative correlations between BAS Reward and effort exerted for moderate and high cost trials among the schizophrenia participants. Again, this seems to be consistent with the observed disconnect between internal hedonic experiences and goal directed behavior in individuals with schizophrenia.

Relationship with clinical symptoms and functional outcome. We also examined the relationship between clinician rated measures of symptoms and goal directed activity with task variables among the schizophrenia participants. First, depressive symptoms were negatively correlated with anticipatory wanting to rewarding stimuli during the Effort-Reward task. While not central to our hypotheses, this finding fits with literature linking depressive symptoms, anticipatory anhedonia, and effort-reward performance in individuals with major depression (Sherdell et al., 2012; Treadway & Zald, 2013). Second, general and positive symptoms were negatively correlation with hedonic responses during the Effort-Reward task. Although unexpected, Barch, et al. (2014) also found relationships between disorganized and positive symptoms and exerted effort. Although speculative, our results align with the notion that dysregulated dopaminergic systems contribute to aberrant attribution of salience (Kapur, 2003)

which may also impact salience for relevant, reward related stimuli. Third, task variables were not associated with negative symptoms. As noted by Green and colleagues, clinician rated indices of negative symptoms are often problematic because the individual must recollect specific experiences related to hedonic, social, and goal directed activities and concomitant feelings (Green, Horan, Barch, & Gold, 2015). Moreover, the PANSS negative symptoms subscale is more heavily weighted towards reduced emotional expression (flat affect), ratings of experiential impairment (asociality), and barren thought content (alogia) which are largely informed by observation and performance rather than internal "drives". This may explain the lack of congruence between clinician rated negative symptoms and task performance in the current study. Although a number of studies show associations between negative symptoms and effort based decision making (e.g., Barch, et al., 2014, Treadway et al., 2015) this is not always the case (Docx et al., 2015; Ferhava et al., 2013; Heerey & Gold, 2007). Fourth, task variables were not associated with psychosocial functioning. Again, this literature is also quite mixed with some studies showing significant relationships (Barch et al., 2014; Hartmann et al., 2015) and others showing no relationship (Fervaha et al 2013). Collectively, it is possible that the nature of this task, including highly predictable contingencies and naturalistic rewards did not capture the deficits which contribute to social and motivational drives in daily life. Alternatively, this study may have been underpowered in detecting these associations.

E. Aim 5 Relationship with social contextual variables.

A final aim involved examining the relationship between hedonic response and exerted effort with social contextual variables. Given that a small subset of participants completed these measures, and that the gender distribution across diagnostic groups was heavily skewed, interpretations of results are tentative. First, perceived task value and interest were positively correlated with hedonic responses among both HC and SZ during the Effort Reward task. Although we were unable to determine if task value/ interest potentially moderated the

correspondence between hedonic response and effort, these findings underscore the importance of assessing attitudes towards effort reward paradigms. Given that approach behavior depends heavily on an individuals' particular state (e.g., being hungry in the midst of edible rewards) (Green et al., 2015), future studies of motivation may be informed by routinely assessing these attitudes.

Contrary to predictions, perceived self-efficacy and task value were unrelated to exerted effort yet group differences in these variables emerged. Controls endorsed higher levels of self-efficacy than SZ but this effect was confounded by males reporting higher self-efficacy than females. With regard to perceived task value, SZ endorsed the Effort Reward task as being more valuable than HC. This is somewhat consistent with ecological studies showing that SZ set more pleasure based goals (e.g., watching TV) and less long-term and effortful goals than HC (Gard et al., 2014). Perhaps schizophrenia participants found the task to be more valuable because it was akin to rewards they value in their daily life. Despite sample size limitations, group differences suggest that perceptions of task value and self-efficacy are useful constructs to explore in effort-reward paradigms.

F. Future Directions & Limitations

Taken together, results converge with literature showing that motivational impairments in SZ relate to difficulties modulating behavior to obtain reward, particularly when effort demands increase. Results are also highly consistent with a large body of work showing incongruence between hedonic drives and motivated behavior in schizophrenia. Some additional limitations are worth noting. A major challenge to this study and to effort-reward based tasks more generally (Green et al. 2015), involve the psychometrics of the paradigm. To ensure low cognitive demand, the Effort-Reward Task utilized definite (i.e., non-probabilistic) rewards to determine if differences in exerted effort were present when rewards were predictable. An unintended consequence of this design was the limited variability of participants' responses and

thus reduced sensitivity to detect thresholds for exerted effort. Existing paradigms (e.g., Treadway et al., 2009) allow for greater variability in effortful responding through the use of continuous outcome variables, probabilistic rewards, and individualized thresholds of effort (e.g., Hartmann et al., 2015; Sherdell et al., 2012). Thus, the task design made it difficult to detect nuances in exerted effort. Indeed, the use of multi-level linear models (e.g., Waugh & Gotlib, 2008; Treadway et al., 2009) could be a more sensitive and flexible data analytic strategy. For instance such methods could account for correlations among repeated measures and model trial-by-trial time dependent variables.

Notable strengths of this study include the use naturalistic rewards tailored to participants' personal preferences. It is likely that research examining personally relevant and ecologically valid rewards may have the greatest capacity to inform clinical intervention strategies. For instance, the use of predictable rewards and associated effort may be a helpful first step in increasing participation in goal directed activity. Another strength of this study lies in the simultaneous collection of traditional hedonic experience measures. Task variables were robustly associated with these measures, and thus supportive of construct validity. Last, although attempts to integrate social-contextual and neurobiological literatures were limited by sample size, preliminary results argue for routine assessment of task value and self-efficacy when evaluating motivational drives and behavior.

In summary, we found evidence of intact hedonic experience and a reduction in approach related behavior among individuals with schizophrenia. Such deficits related to incongruence between hedonic drives and behavior as well as impaired assessment of effort cost. Collectively, current results are consistent with impairments in behavioral "wanting" during effort based decision making tasks, and extend the application of this phenomenon to rewards people with schizophrenia are likely encounter in their daily lives.

Cited Literature

Ajzen, I. (2001). Nature And Operation Of Attitudes. *Annual Review of Psychology*, 52(1), 27-58.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review.* 84(2). 191-215.

Bandura, A. (1991). Self-efficacy Mechanism in Physiological Activation and Health-Promoting Behavior. In J. Madden (Ed.), Neurobiology of Learning, Emotion, and Affect. New York : Raven, pp. 229-269.

Barch, D. M., & Dowd, E. C. (2010). Goal Representations and Motivational Drive in Schizophrenia : The Role of Prefrontal – Striatal Interactions. *Schizophrenia Bulletin*, *36*(5), 919–934.

Barch, D.M., Treadway, M., & Schoen, N. (2014). Effort, anhedonia, and function in schizophrenia: Reduced effort allocation predicts amotivation and functional impairment. *Journal of Abnormal Psychology*, 123(2), 387-397.

Barch, D. M., Yodkovik, N., Sypher-Locke, H., & Hanewinkel, M. (2008). Intrinsic motivation in schizophrenia: relationships to cognitive function, depression, anxiety, and personality. *Journal of Abnormal Psychology*, *117*(4), 776–87.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*(3), 497–529.

Beck A.T., Rector N.A., Stolar N., Grant P. (2009*). Schizophrenia: cognitive theory, research, and therapy*. New York: The Guildford Press.

Bell, M., Fiszdon, J., Richardson, R., Lysaker, P., & Bryson, G. (2007). Are self-reports valid for schizophrenia patients with poor insight? Relationship of unawareness of illness to psychological self-report instruments. *Psychiatry Research, 151,* 37–46.

Berridge, K. C. (2004). Motivation concepts in behavioral neuroscience. *Physiology and Behavior*, 81(2), 179-209.

Berridge, K.C., Kringelbach, M.L., (2008). Affective neuroscience of pleasure: reward in humans and animals. *Psychopharmacology*. 199 (3), 457–480.

Berridge, K. C., & Robinson, T. E. (2003). Parsing reward. *Trends in Neurosciences*, *26*(9), 507–513.

Birnbaum, R., Glickman, J., Sarkissian, A.M. (Producers) & Ratner,B. 1998. *Rush Hour* [Motion picture]. United States: New Line Cinema.

Calev, A., & Edelist, S. (1993). Affect and memory in schizophrenia: Negative emotion words are forgotten less rapidly than other words by long-hospitalized schizophrenics. *Psychopathology*, 26, 229–235.

Cardenas, V., Abel, S., Bowie, C. R., Tiznado, D., Depp, C. A., Patterson, …Mausbach, B.T. (2013). When functional capacity and real-world functioning converge: the role of self-efficacy. *Schizophrenia Bulletin*, 39(4), 908–16.

Carpenter, W.T., Heinrichs, D.W., & Wagman, A.M.I. (1988). Deficit and nondeficit forms of schizophrenia: The Concept. *American Journal of Psychiatry*. 145(5), 578-583.

Carver, C. S., & Scheier, M. F. (2002). Control Processes and Self-Organization as Complementary Principles Underlying Behavior. *Personality and Social Psychology Review*, *6*(4), 304–315.

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology*, *67*(2), 319–333.

Chapman, L. J., Chapman, J. P., & Raulin, M. L. (1976). Scales for physical and social anhedonia. *Journal of Abnormal Psychology*, 85(4), 374-82.

Choi, J., Fiszdon, J. M., & Medalia, A. (2010). Expectancy-value theory in persistence of learning effects in schizophrenia: role of task value and perceived competency. *Schizophrenia Bulletin*, *36*(5), 957–65.

Choi, J.,& Medalia, A., 2010. Intrinsic motivation and learning in a schizophrenia spectrum sample. *Schizophrenia Research*. 118, 12–19.

Choi J, Mogami T, Medalia A. (2009) Intrinsic Motivation Inventory (IMI): an adapted scale for schizophrenia research. *Schizophrenia Bulletin*, 36 (5), 966-976.

Cohen, A. S., & Minor, K. S. (2010). Emotional experience in patients with schizophrenia revisited: meta-analysis of laboratory studies. *Schizophrenia Bulletin*, *36*(1), 143–50.

Couture, S. M., Blanchard, J. J., & Bennett, M. E. (2011). Negative expectancy appraisals and defeatist performance beliefs and negative symptoms of schizophrenia. *Psychiatry Research*, 189 (1), 43–48.

Davison, J.(Producer) & Abrahams, J., Zucker, D., Zucker, J. (Directors). 1980. Airplane! [Motion picture]. United States: Paramount Pictures.

D'Argembeau, A., Raffard, S., & Van der Linden, M. (2008). Remembering the past and imagining the future in schizophrenia. *Journal of Abnormal Psychology*, 117(1), 247-51.

Docx, L., de la Asuncion, J., Sabbe, B., Hoste, L., Baeten, R., Warnaerts, N., Morrens, M. (2015). Effort discounting and its association with negative symptoms in schizophrenia. *Cognitive Neuropsychiatry*, 20, 172-185.

Fervaha, G., Graff-Guerrero, A., Zakzanis, K.K., Foussias, G., Agid, O., Remington, G. (2013). Incentive motivation deficits in schizophrenia reflect effort computation impairments during cost-benefit decision making. Journal of Psychiatric Research, 47, 1590-1596.

First, M. D., Spitzer, R. L., Gibbon, M., & Williams, J. B. (2002). *Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Patient Edition. (SCID-I/P)*. New York: Biometrics Research, New York State Psychiatric Institute.

Foussias, G., Mann, S., Zakzanis, K. K., van Reekum, R., & Remington, G. (2009). Motivational deficits as the central link to functioning in schizophrenia: a pilot study. *Schizophrenia Research*, 115(2-3), 333–7.

Foussias, G., & Remington, G. (2010). Negative symptoms in schizophrenia: avolition and Occam's razor. *Schizophrenia Bulletin*, 36(2), 359–69.

Gable, S. L., & Gosnell, C. L. (2013). Approach and Avoidance Behavior in Interpersonal Relationships. *Emotion Review*, 5(3), 269–274.

Galderisi, S., Bucci, P., Mucci, A., Kirkpatrick, B., Pini, S., Rossi, A., … Maj, M. (2013). Categorical and dimensional approaches to negative symptoms of schizophrenia: focus on long-term stability and functional outcome. *Schizophrenia Research*, 147(1), 157–62.

Gard, D.E., Cooper, K., Fisher, M., Genevsky, A., Mikels, J.A., & Vinogradov, S. (2011). Evidence for a emotional maintenance deficit in schizophrenia. Psychiatry Research, 187, 24-29.

Gard, D. E., Fisher, M., Garrett, C., Genevsky, A., & Vinogradov, S. (2009). Motivation and its relationship to neurocognition, social cognition, and functional outcome in schizophrenia. *Schizophrenia Research*, 115(1), 74–81.

Gard, D. E., Kring, A. M., Gard, M. G., Horan, W. P., & Green, M. F. (2007). Anhedonia in schizophrenia: Distinctions between anticipatory and consummatory pleasure. *Schizophrenia Research*, 93(1-3), 253-60.

Gard, D.E., Sanchez, A.H., Cooper, K., Fisher, M., Garrett, C., Vinogradov, S. (2014). Do people with schizophrenia have difficulty anticipating pleasure, engaging in effortful behavior, or both? *Journal of Abnormal Psychology*. 123(4), 771-782.

Gold, J. M., Strauss, G. P., Waltz, J. A., Robinson, B. M., Brown, J. K., & Frank, M. J. (2013). Negative symptoms of schizophrenia are associated with abnormal effort-cost computations. *Biological psychiatry*, *74*(2), 130–6.

Gold, J. M., Waltz, J. A., & Frank, M. J. (2015). Effort cost computation in schizophrenia: A commentary on the recent literature. *Biological Psychiatry.* doi:10.1016/j.biopsych.2015.05.005

Gold, J. M., Waltz, J. A., Prentice, J., Morris, S. E., & Heerey, E. A. (2008). Reward processing in schizophrenia: A deficit in the representation of value. *Schizophrenia Bulletin*, 34(5), 835-847.

Grant, P. M., & Beck, A. T. (2010). Asocial beliefs as predictors of asocial behavior in schizophrenia. *Psychiatry Research*, 177(1-2), 65–70.

Gray, J. A. (1990). Brain systems that mediate both emotion and cognition. *Cognition and Emotion*, 4, 269–288.

Grazer, B., Simmons, R. (Producers) & Shadyac, T., (Director). 1996. *The Nutty Professor* [Motion picture]. United States: Universal Pictures.

Hall, J., Harris, J. M., McKirdy, J. W., Johnstone, E. C., Lawrie, S. M., (2007). Emotional memory in schizophrenia. *Neuropsychologia* 45, 1152-1159.

Hamilton, M. (1960). A rating scale for depression. *Journal of Neurology, Neurosurgery, and Psychiatry*. 23, 56- 62. doi: 10.1136/jnnp.23.1.56.

Hartman, M.N., Hager, O.M., Reimann, A.V., Chumbley, J.R., Kirschner, M., Seifritz, E.,…Stefan, K. (2015). Apathy but not diminished expression in schizophrenia is associated with discounting of monetary rewards by physical effort. *Schizophrenia Bulletin*, 41(2), 503-512.

Harvey, P.-O., Armony, J., Malla, A., Lepage, M. (2010). Functional neural substrates of self-reported physical anhedonia in non-clinical individuals and in patients with schizophrenia. *Journal of Psychiatric Research,* 44, 707-716.

Heerey, E., Bell-Warren, K., & Gold, J. (2008). Decision-making impairments in the context of intact reward sensitivity in schizophrenia. *Biological Psychiatry*, 64(1), 62–69.

Heerey, E. A., & Gold, J. M. (2007). Patients with schizophrenia demonstrate dissociation between affective experience and motivated behavior. *Journal of Abnormal Psychology*, 116(2), 268-78.

Heerey, E. A., Matveeva, T.M., & Gold, J. M. (2011). Imaging the future: Degraded representations of future rewards and events in schizophrenia. *Journal of Abnormal Psychology*, 120 (2), 483-489.

Heerey, E. A, Robinson, B. M., McMahon, R. P., & Gold, J. M. (2007). Delay discounting in schizophrenia. *Cognitive Neuropsychiatry*, *12*(3), 213–21.

Heinrichs, D. W., Hanlon, T. E., & Carpenter, W. T. (1984). The Quality of Life Scale: an instrument for rating the schizophrenic deficit syndrome. *Schizophrenia Bulletin*, 10(3), 388-98.

Herbener, E. S., & Harrow, M. (2004). Are negative symptoms associated with functioning deficits in both schizophrenia and nonschizophrenia patients? A 10-year longitudinal analysis. Schizophrenia Bulletin, 30(4), 813-25.

Herbener, E. S., Rosen, C., Khine, T., & Sweeney, J. A. (2007). Failure of positive but not negative emotional valence to enhance memory in schizophrenia. *Journal of Abnormal Psychology*, *116*(1), 43-55.

Herbener, E. S., Song, W., Khine, T. T., & Sweeney, J. A. (2008). What aspects of emotional functioning are impaired in schizophrenia? *Schizophrenia Research*, 98(1-3), 239-46.

Higgins, E. T. (1987). Self-discrepancy: a theory relating self and affect. *Psychological Review*, *94*(3), 319–40.

Horan, W. P., Green, M. F., Kring, A. M., & Nuechterlein, K. H. (2006). Does anhedonia in schizophrenia reflect faulty memory for subjectively experienced emotions? *Journal of Abnormal Psychology*, *115*(3), 496-508.

Horan, W. P., Rassovsky, Y., Kern, R. S., Lee, J., Wynn, J. K., & Green, M. F. (2010). Further support for the role of dysfunctional attitudes in models of real-world functioning in schizophrenia. *Journal of Psychiatric Research*, 44(8), 499–505.

Kapur, S. (2003). Psychosis as a state of aberrant salience: A framework linking biology, phenomenology, and pharmacology in schizophrenia. *American Journal of Psychiatry*, 160, 13-23.

Kay, S. R., Fiszbein, A., & Opler, L. (1987). The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophrenia Bulletin*, *13*, 261-276.

Kiang, M., Christensen, B.K., Remington, G., Kapur, S., 2003. Apathy in schizophrenia: clinical correlates and association with functional outcome. *Schizophrenia Research*. 63 (1–2), 79–88.

King, J. E. (2007, February). Standardized coefficients in logistic regression. Paper presented at the annual meeting of the Southwest Educational Research Association, San Antonio, TX. Retrieved from http://www.ccitonline.org/jking/homepage/.

Koch, K., Schachtzabel, C., Wagner, G., Schikora, J., Schultz, C., Reichenbach, J. R., …Schlosser, R. M. (2010). Altered activation in association with reward-related trial-and-error learning in patients with schizophrenia. *Neuroimage*, 50(1), 223-232.

Koh, S. D., Grinker, R. R., Marusarz, T. Z., & Forman, P. L. (1981). Affective memory and schizophrenic anhedonia. *Schizophrenia Bulletin*, *7*(2), 292-307.

Kraepelin E. *Dementia Praecox and Paraphrenia*. Edinburgh, UK: Livingstone; 1919.

Kring, A. M., Barch, D.M. (2014). The motivation and pleasure dimension of negative symptoms: Neural substrates and behavioral outputs. *European Neuropsychopharmacology*, 24, 725-736.

Kring, A. M., Barrett, L. F., & Gard, D. E. (2003). On the broad applicability of the affective circumplex: Representations of affective knowledge among schizophrenia patients. *Psychological Science*, *14*(3), 207-14.

Kring, A. M., Gard, M. G., Gard, D. E. (2011). Emotion deficits in schizophrenia: Timing matters. *Journal of Abnormal Psychology* 120, 79–87.

Lakis, N., Jiménez, J. A, Mancini-Marïe, A., Stip, E., Lavoie, M. E., Mendrek, A. (2011). Neural correlates of emotional recognition memory in schizophrenia: Effects of valence and arousal. *Psychiatry Research* 194, 245–56.

Lang, P. J., & Bradley, M. M. (2013). Appetitive and Defensive Motivation: Goal-Directed or Goal-Determined? *Emotion Review*, *5*(3), 230–234.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). International affective picture system IAPS): Digitized photographs, instruction manual and affective ratings (Tech. Rep. No. A-6). Gainesville: University of Florida, Center for the Study of Emotion and Attention.

Leventhal, A. M., Chasson, G. S., Tapia, E., Miller, E. K., Pettit, J. W. (2006). Measuring hedonic capacity in depression: A psychometric analysis of three anhedonia scales. *Journal of Clinical Psychology* 62, 1545-1558.

Loewenstein, G.F., Weber, E.U., Hsee, C.K., Welch, N. (2001). Risk as feelings. *Psychological Bulletin,* 127, 267–286.

Mausbach, B. T., Moore, R. C., Davine, T., Cardenas, V., Bowie, C. R., Ho, J., … Patterson, T.L. (2013). The use of the theory of planned behavior to predict engagement in functional behaviors in schizophrenia. *Psychiatry Research*, *205*(1-2), 36–42.

McCormick, B. P., Snethen, G., & Lysaker, P. H. (2012). Emotional episodes in the everyday lives of people with schizophrenia: the role of intrinsic motivation and negative symptoms. *Schizophrenia Research*, *142*(1-3), 46–51.

Medalia, A., & Brekke, J. (2010). In Search of a Theoretical Structure for Understanding Motivation in Schizophrenia. *Schizophrenia Bulletin*, *36*(5), 912–918.

Meehl P.E. (1962). Schizotaxia, schizotypy, schizophrenia. *American Psychologist.* 1962;17:827–838

Meehl, P. E. (1990). Toward an integrated theory of schizotaxia, schizotypy, and schizophrenia. *Journal of Personality Disorders, 4,* 1-99.

Messinger, J. W., Trémeau, F., Antonius, D., Mendelsohn, E., Prudent, V., Stanford, A. D., & Malaspina, D. (2011). Avolition and expressive deficits capture negative symptom phenomenology: implications for DSM-5 and schizophrenia research. *Clinical Psychology Review*, *31*(1), 161–8.

Picker, D.V.; McEuen, W., E. (Producers), & Reiner, C. (Director). 1979. The Jerk [Motion Picture]. United States: Aspen Film Society, Universal Studios.

Rado S. Psychoanalysis of Behavior: The Collected Papers of Sandor Rado. Vol 2. New York: Grune and Stratton; 1962.

Ryan R.M., Deci E.L. Self-determination theory and the facilitation of intrinsic motivation, social development, and wellbeing. *American Psychologist*, 2000;55:68–78.

Sayers, S. L., Curran, P. J., & Mueser, K. T. (1996). Factor structure and construct validity of the Scale for the Assessment of Negative Symptoms. *Psychological Assessment*, *8*(3), 269–280.

Schmidt, K., Nolte-Zenker, B., Patzer, J., Bauer, M., Schmidt, L.G., Heinz, A., 2001. Psychopathological correlates of reduced dopamine receptor sensitivity in depression, schizophrenia, and opiate and alcohol dependence. *Pharmacopsychiatry,* 34 (2), 66–72.

Sherdell, L., Waugh, C. E., & Gotlib, I. H. (2012). Anticipatory pleasure predicts motivation for reward in major depression. *Journal of Abnormal Psychology*, *121*(1), 51–60.

Silverstein, S. M. (2010). Bridging the gap between extrinsic and intrinsic motivation in the cognitive remediation of schizophrenia. *Schizophrenia Bulletin*, *36*(5), 949–56.

Simpson, E. H., Waltz, J. A, Kellendonk, C., & Balsam, P. D. (2012). Schizophrenia in translation: dissecting motivation in schizophrenia and rodents. *Schizophrenia Bulletin*, *38*(6), 1111–1117.

Strauss, G. P., Allen, D. N., Miski, P., Buchanan, R. W., Kirkpatrick, B., & Carpenter, W. T. (2012). Differential patterns of premorbid social and academic deterioration in deficit and nondeficit schizophrenia. *Schizophrenia Research*, 135(1-3), 134–8.

Strauss, G.P., Gold, J.M. (2012). A new perspective on anhedonia in schizophrenia. *American Journal of Psychiatry*, 169, 364-373.

Strauss, G. P., Horan, W. P., Kirkpatrick, B., Fischer, B. A, Keller, W. R., Miski, P., … Carpenter, W.T. (2013). Deconstructing negative symptoms of schizophrenia: avolition-apathy and diminished expression clusters predict clinical presentation and functional outcome. *Journal of Psychiatric Research*, *47*(6), 783–90.

Strauss, G. P., Wilbur, R.C., Warren, K.R., August, S.M., & Gold, J.M. (2011). Anticipatory vs. consummatory pleasure: What is the nature of hedonic deficits in schizophrenia? *Psychiatry Research*, 187, 36-41.

Treadway, M. T., Buckholtz, J. W., Cowan, R. L., Woodward, N. D., Li, R., Ansari, M. S., Baldwin, R. M., et al. (2012). Dopaminergic mechanisms of individual differences in human effort-based decision-making. *The Journal of Neuroscience,* 32(18), 6170–6.

Treadway, M. T., Buckholtz, J. W., Schwartzman, A.N., Lambert, W.E., & Zald, D.H. (2009). Worth the 'EEfRT'? The Effort Expenditure for Rewards Task as an objective measure of motivation and anhedonia. *PLos One,* 4 (8),e6598, doi: 10.1371/journal.pone.0006598.

Treadway, M. T., Peterman, J.S., Zald, D.H., Park, S. (2015). Impaired effort allocation in patients with schizophrenia. *Schizophrenia Research*, 161, 382-38.

Treadway, M. T., Zald, D.H. (2013). Parsing anhedonia: Translational models of reward processing deficits in psychopathology. *Current Directions in Psychological Science*, 22(3), 244-249.

Trémeau, F., Antonius, D., Cacioppo, J. T., Ziwich, R., Butler, P., Malaspina, D., & Javitt, D. C. (2010). Anticipated, on-line and remembered positive experience in schizophrenia. *Schizophrenia Research*, *122*(1-3), 199–205.

Trémeau, F., Goldman, J., Antonius, D., & Javitt, D. C. (2013). Inpatients with schizophrenia report impaired situational motivation but intact global and social motivation. *Psychiatry Research*, 1–7.

Ursu, S., Kring, A.M., Gard, M.G., Minzenberg, M.J., Yoon, J.H., Ragland, J.D., Solomon, M, Carter, C.S. (2011). Prefrontal cortical deficits and impaired cognition-emotion interactions in schizophrenia. *American Journal of Psychiatry* 168, 276-285.

Waltz, J. A, Frank, M. J., Wiecki, T. V., & Gold, J. M. (2011). Altered probabilistic learning and response biases in schizophrenia: behavioral evidence and neurocomputational modeling. *Neuropsychology*, 25(1), 86-97.

Waltz, J. A., & Gold, J. M. (2007). Probabilistic reversal learning impairments in schizophrenia: further evidence of orbitofrontal dysfunction. *Schizophrenia Research*, 93(1-3), 296-303.

Waltz, J. A., Schweitzer, J. B., Gold, J. M., Kurup, P. K., Ross, T. J., Salmeron, B. J., …Stein, E. A. (2009). Patients with schizophrenia have a reduced neural response to both unpredictable and predictable primary reinforcers. *Neuropsychopharmacology,* 34(6), 1567-77.

Waugh, C. E., & Gotlib, Æ. I. H. (2008). Motivation for reward as a function of required effort : Dissociating the " liking " from the " wanting " system in humans, 323–330.

Wessler, C.B., Krevoy, B., Stabler, S. (Producers) & Farrelly, P., Farrelly, B. (Directors). 1994. *Dumb and Dumber* [Motion picture]. United States: New Line Cinema.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-Value Theory of Achievement Motivation. *Contemporary Educational Psychology*, *25*(1), 68–81.

Wuensch, K. L. (2014). *Binary Logistic Regression with SPSS* [PDF]. Retrieved from http://core.ecu.edu/psyc/wuenschk/mv/multreg/logistic-spss.pdf

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice
Continuing Review

May 26, 2015

Ellen S. Herbener, PhD
Psychology
1007 W Harrison St
M/C 285
Chicago, IL 60607
Phone: (312) 413-2638 / Fax: (312) 413-4122

RE: **Protocol # 2009-1095**
"Emotion, Reward, Social Cognition and Social Interaction"

Dear Dr. Herbener:

Your Continuing Review application was reviewed and approved by the Expedited review process on May 14, 2015. You may now continue your research.

Please note the following information about your approved research protocol:

Please note that IRB approval at Rosalind Franklin University has been expired since 4 April 2015. Kindly remember to submit an updated copy of their IRB approval at your earliest convenience. A copy of the approval must be accompanied by an Amendment form when submitted to the UIC IRB.

Please note that investigator training for Emily Olsen expired on 19 March 2015 and she is not currently eligible to be involved in research conducted at UIC unless or until her training is updated.

Protocol Approval Period:	May 20, 2015 - May 19, 2016
Approved Subject Enrollment #:	200 (61 subjects enrolled)
Additional Determinations for Research Involving Minors: These determinations have not been made for this study since it has not been approved for enrollment of minors.	
Performance Sites:	UIC, Rosalind Franklin University, Threshold's Inc
Sponsor:	RTOG
PAF#:	Not applicable
Grant/Contract No:	Not applicable
Grant/Contract Title:	Not applicable

Research Protocol:

a) Social Protocol: Emotion, Reward, Social Cognition and Social Interaction; Version 4; 05/17/2012

Recruitment Materials:

a) Informational Talk Script; Version 1; 03/26/2010
b) Telephone Screening Script; Version 2; 08/05/2010
c) Web Ad; Version 3; 03/20/2013
d) Web Ad_C; Version 1; 03/20/2013
e) Web Ad A: Version 3; 03/20/2013

Informed Consents:

a) Debriefing Form; Version 1; 02/10/2010
b) Social Cognition and Interaction; Version 6; 03/20/2013
c) Social Cognition and Interaction-Friend, Version 1, 6/27/2011

HIPAA Authorization:

a) Emotion, Reward, and Social Interaction; Version 3; 04/01/2013

Please continue to use the authorization document approved by the IRB on 4/4/2013

Your research continues to meet the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific categories:

(4) Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving X-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.) Examples: (a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject's privacy; (b) weighing or testing sensory acuity; (c) magnetic resonance imaging; (d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography; (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual,
(6) Collection of data from voice, video, digital, or image recordings made for research purposes.,
(7) Research on individual or group characteristics or behavior (including but not limited to research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
05/13/2015	Continuing Review	Expedited	05/14/2015	Approved

Please remember to:

→ Use your **research protocol number** (2009-1095) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the OPRS website under:
"UIC Investigator Responsibilities, Protection of Human Research Subjects"
(http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0924.pdf)

Please note that the UIC IRB has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 996-2014. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Sandra K Costello

Sandra Costello
Assistant Director, IRB # 2
Office for the Protection of Research Subjects

Enclosures:

1. **Informed Consent Documents:**
   a) Debriefing Form; Version 1; 02/10/2010
   b) Social Cognition and Interaction; Version 6; 03/20/2013
   c) Social Cognition and Interaction-Friend, Version 1, 6/27/2011
2. **Recruiting Materials:**
   a) Informational Talk Script; Version 1; 03/26/2010
   b) Telephone Screening Script; Version 2; 08/05/2010
   c) Web Ad; Version 3; 03/20/2013
   d) Web Ad_C; Version 1; 03/20/2013
   e) Web Ad A: Version 3; 03/20/2013

cc: Michael E. Ragozzino, Psychology, M/C 285

VITA

NAME:	Emily Kristina Olsen
EDUCATION:	B.S., Psychology, University of California, Davis, 2005
	M.A., Psychology, University of Illinois, Chicago, 2012
RESEARCH POSITIONS:	Graduate Student Researcher, University of Illinois, Chicago, Department of Psychiatry, Neuropsychiatric Institute. PI: Ellen Herbener, Ph.D., Rajiv Sharma, MD (2009 - 2014).
	Research Clinician, Pediatric Neuropsychology Program, Department of Psychiatry and Behavioral Neuroscience, University of Chicago. PI: Scott Hunter, Ph.D. (2013-2014).
	Research Clinician, Hyperactivity, Attention, and Learning Problems (HALP) Clinic, Institute for Juvenile Research, University of Illinois at Chicago Medical Center. PI: Mark Stein, Ph.D. (2012-2013)
	Research Clinician, Pediatric Mood Disorders Program, Institute for Juvenile Research, University of Illinois, Chicago. PI: Amy West, Ph.D. (2011-2012).
	Study Coordinator, UC Davis, Department of Psychiatry and Behavioral Sciences, Imaging Research Center. PI: Cameron Carter, MD. (2005 - 2009).
CLINICAL TRAINING:	Pediatric Psychology Intern, Children's Hospital of Michigan, Department of Psychiatry and Psychology (2014-2015).
	Pediatric Neuropsychology Extern, Department of Psychiatry and Behavioral Neuroscience, University of Chicago (2013-2014).
	Psychotherapy & Assessment Extern, Hyperactivity, Attention, & Learning Problems (HALP), Institute for Juvenile Research, University of Illinois, Chicago Medical Center (2012-2013).
	Psychotherapy & Assessment Extern, The Craniofacial Center, Division of Plastic/Reconstructive Surgery, University of Illinois, Chicago Medical Center (2012-2013).
	Psychotherapy Extern, UIC Prep High School, LSV Campus of Noble Street Charter School, Chicago, IL (2012-2013).
	Psychotherapy & Assessment Extern, Office of Applied Psychological Services (OAPS), University of Illinois, Chicago (2010 – 2014).

TEACHING: Teaching Assistant, University of Illinois, Chicago, Department of Psychology (2009 – 2012).

PROFESSIONAL MEMBERSHIPS:
American Academy of Clinical Neuropsychology
American Psychological Association
Association for Psychological Science
PSI CHI, National Psychology Honor Society
Society of Clinical Child and Adolescent Psychology
Society for a Science of Clinical Psychology

ABSTRACTS:

Stein, M. A., Olsen, E. (May 2014). Measuring and Predicting Side Effects of Methylphenidate and Atomoxetine. Symposium presented at the Pediatric Academic Societies, Vancouver, BC, Canada.

Stein, M. A., Olsen, E., Newcorn, J. H., Cook, Edwin Jr., Waldman, I., Bishop, J., Newcorn, J.H. (June 2014). Variation in the Dopamine Transporter Gene and Methylphenidate and Atomoxetine Side Effect Factors. Poster presented at the Pharmacogenetics in Psychiatry, Hollywood, FL.

Olsen, E., Bodapati, A., Newcorn, J. H., Stein, M. A. (October 2013). The Atomoxetine-Stimulant Side Effects Rating Scale (ASSERS): Factor structure and associated clinical characteristics for OROS Methylphenidate and Atomoxetine. Poster presented at the American Academy of Child and Adolescent Psychiatry, Orlando, FL.

Stein, M. A., Olsen, E., Bodapati, A., Newcorn, J. H. (October 2013). Side effects of ADHD medications during 2 crossover studies. Symposium presented at the American Academy of Child and Adolescent Psychiatry, Orlando, FL.

Olsen, E., Bodapati, A., Bjorkquist, O., Herbener, E. S. (September 2013). Predictors of immediate and delayed motivational drive in schizophrenia. Poster presented at the Society for Research in Psychopathology, Oakland, CA.

Gin, H., Chase, K.A., Hu, E., Feiner, E. Olsen, E., Herbener, E., Sharma, R.P. (September 2013). Correlates between serum levels and lymphocyte mRNA levels in patients with schizophrenia. Poster presented at the University of Illinois at Chicago, Department of Psychiatry, Research Extravaganza, Chicago, IL.

Olsen, E., Herbener, E., Sharma, Rajiv. (May, 2013). Predictors of motivational drive in schizophrenia. Poster presented at the University of Illinois at Chicago, Research Forum, Chicago, IL.

Olsen, E., Bjorkquist, O., Bodapati, A., Herbener, E. (October, 2012). Neural activity associated with post emotional processing in

schizophrenia. Poster presented at the Society for Research in Psychopathology, Ann Arbor, MI.

Bjorkquist, O., Olsen, E., Bodapati, A., Herbener, E. (October, 2012). Aberrant salience may contribute to impaired social perception in schizophrenia. Poster presented at the Society for Research in Psychopathology, Ann Arbor, MI.

Herbener, E , Bjorkquist, O., Olsen, E., Bodapati, A. (October, 2012). The interaction of social context and emotional expression on social interpretation in schizophrenia. Symposium presented at the Society for Research in Psychopathology, Ann Arbor, MI.

Goldwin, M., Conybeare, D., Olsen, E., Jorgensen, I., Sibrava, N., Behar, E. (November, 2011). Concreteness of idiographic periods of trauma–related and depressive rumination. Poster presented at the 45th Annual Meeting of Association for Behavioral and Cognitive Therapies, Toronto, Ontario, Canada.

Herbener, E , Bjorkquist, O., Olsen, E., Bodapati, A. (October, 2011). Impact of delay duration on brain activity during recognition in individuals with schizophrenia. Poster presented at the Society for Research in Psychopathology, Boston, MA.

Olsen, E., Bjorkquist, O., Bodapatti, A., Shankman, S., Herbener, E. (October, 2011). *Clinical Correlates of Emotional Memory in Schizophrenia and Major Depression*. Poster Presented at the Society for Research in Psychopathology, Boston, MA.

Herbener, E., Bjorkquist, O., Olsen, E., Bodapatti, A., Nelson, B. (April, 2011). *Medial Temporal and Frontal Activity during Encoding of Positive, Negative, and Neutral Images and Memory Accuracy in Schizophrenia and Healthy Subjects*. Poster presented at the International Congress on Schizophrenia, Colorado Springs, CO.

Olsen, E., Solomon, M., Minzenberg, M., Ragland, J.D., Ursu, S., Yoon, J., Niendam, T., Carter, C.S. (May 2009). *Shared Social Deficits in Autism Spectrum Disorders, First Episode Schizophrenia and Ultra High Risk for Psychosis Patients*. Poster presented at the International Meeting for Autism Research, Chicago, IL.

Olsen, E., Solomon, M., Minzenberg, M., Ragland, J.D., Ursu, S., Yoon, J., Niendam, T., Carter, C.S. (March 2009). *Autism Spectrum Disorder Symptoms in First Episode and Ultra High Risk Patients*. Poster presented at the International Congress on Schizophrenia, San Diego, CA.

PULBICATIONS:

Solomon, M., Hessl, D., Chiu, S., Olsen, E., Hendren, R.L. (2009). Towards a Neurodevelopmental Model of Clinical Case Formulation. Psychiatry Clinics of North America, 32 (1): 199-211.

Solomon, M., Olsen, E., Niendam, T., Ragland, J. D., Yoon, J., Minzenberg, M., et al. (2011). From lumping to splitting and back again: Atypical social and language development in individuals with clinical-high-risk for psychosis, first episode schizophrenia, and autism spectrum disorders. *Schizophrenia Research*. 131 (1-3): 146-151.