ABSTRACT

Title of Thesis: THE VALUATION OF SOCIAL REINFORCEMENT IN SCHIZOPHRENIA

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Facial affect perception impairments impede social functioning in schizophrenia. What remains unknown is how individuals with schizophrenia assign value to pleasant facial expressions that typically motivate social affiliation. The current study adapted a matching pennies game (Shore & Heerey, 2011) to assess the subjective value of social feedback in terms of money. Individuals with schizophrenia and controls were instructed to choose the same side of a coin as six computerized partners, each of whom provided different rates of monetary feedback and types of social feedback. In a later test phase, participants chose which partner to play from amongst pairs of partners. Among participants who appropriately learned task contingencies, individuals with schizophrenia failed to use genuine smiles to motivate choices to the same extent as controls; however, money was equally valued. These findings suggest that there is a reduced sensitivity to social rewards in schizophrenia.

THE VALUATION OF SOCIAL REINFORCEMENT IN SCHIZOPHRENIA

by

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Chapter 1: Introduction

Social dysfunction has been recognized as a core feature of schizophrenia since the illness' conceptualization (Kraepelin, 1919), and remains a major diagnostic criterion of the disorder today (American Psychological Association, 2013). Social impairments are evident at all stages of the illness. Poor social relationships are exhibited as early as childhood and adolescence prior to illness onset (Tarbox & Pogue-Geile, 2008; Cannon et al., 1997; Davidson et al., 1999). Young people at risk for schizophrenia also have social difficulties as evidenced by limited peer engagement, immaturity, and unpopularity with peers (Hans, Auerbach, Asarnow, Styr, & Marcus, 2000; Dworkin et al., 1993). Similar evidence of social dysfunction exists among first-degree relatives of individuals with schizophrenia (Hans et al., 2000) and individuals experiencing their initial episode of psychosis (Ballon, Kaur, Marks, & Cadenhead, 2007).

Deficits in social functioning have devastating consequences for the individual, their families, and society at large. First, individuals with schizophrenia are less likely to achieve age appropriate milestones such as obtaining full time employment (Harvey et al., 2009) and managing self-supported independent living (Twamley, Doshi, Nayak, Palmer, Golshan, 2002). Interpersonally, individuals with schizophrenia tend to be socially isolated or withdrawn, and are less likely to establish meaningful, long-term, stable relationships (Vaughn & Leff, 1976). Social encounters for those with schizophrenia are often brief and superficial compared with healthy individuals (Vaughn & Leff, 1976). Overall, persons with schizophrenia have fewer friends and narrower social networks (Goldberg, Rollins, & Lehman, 2003; Pattinson, DeFrancisco, Wood, Frazier, & Crowder, 1975; Westermeyer & Pattinson, 1981), are less likely to be

involved in romantic relationships (Wiersma et al., 2000), and are six times more likely to remain unmarried compared to the general public (MacCabe, Koupil, & Leon, 2009).

A substantial amount of research has been conducted to reveal mechanisms that give rise to social impairments. Neurocognition (non-social) and social cognition are regarded as two distinct domains that uniquely contribute to social functioning deficits in schizophrenia (Mehta et al., 2013). Research has shown that traditional measures of neurocognition are only modestly related to social functioning, leaving as much as 60-80% of the variance unexplained (Couture, Penn, & Roberts, 2006; Penn, Corrigan, Bentall, Racenstein, & Newman, 1997; Green, 1996; Green, Kern, Braff, & Mintz, 2000). Social cognition is a specialized domain of cognition encompassing psychological processes that underlie social behavior. These processes allow individuals to perceive, interpret, and generate responses to social stimuli (Brothers, 1990; Fiske & Taylor, 1991). Research suggests that individuals with schizophrenia have social cognitive impairments and biases in the following domains: (1) emotion perception (i.e., the ability to perceive and use emotions); (2) attributional analysis (i.e., inferences about the causes of positive and negative events); (3) theory of mind (i.e., inferences about the intentions, dispositions, and beliefs in others); and (4) social perception (i.e., understanding social roles, societal rules, and social context) (Green et al., 2008; Penn, Sanna, & Roberts, 2008). Social cognition is a significant determinant of poor social functioning (Couture et al., 2006; Fett et al., 2011), and there is increasing support for social cognition as a key mediator between neurocognition and functional outcome (Brekke, Kay, Lee, & Green, 2005; Addington, Saeedi, & Addington, 2006; Sergi, Rassovsky, Nuechterlein, & Green, 2006).

Perhaps the most extensively studied area of social cognition in schizophrenia is facial affect perception, defined as the ability to decode, recognize, and identify emotional facial expressions (Lee et al., 2013). Traditional facial affect perception tasks use still images of posed faces, and measure the accuracy with which one can make automatic affective judgments (Ekman, 2003). The goal of traditional facial affect perception tasks is to either explicitly identify the emotion displayed by the face (i.e., identification), or to determine if two faces, presented side by side, are expressing similar or different emotions (i.e., discrimination). Individuals with schizophrenia generally perform poorly on facial affect perception tasks (for reviews see Kohler, Walker, Martin, Healey, & Moberg, 2010; Mandal, Pandey, & Prasad, 1998; Edwards, Jackson, & Pattison, 2002; Chan, Cheung, & Gong, 2010). Impairments in facial affect perception are significantly related to poorer community functioning (Brekke et al., 2005; Poole, Tobias, & Vinogradov, 2000), and are correlated with problems in interpersonal relationships (Poole et al., 2000; Addington et al., 2006).

While these findings have been informative, facial affect perception tasks have several limitations due to methodological constraints. One criticism is that facial affect perception paradigms look at static facial expressions in isolation and do not present a surrounding context (Feldman Barrett, Mesquita, & Gendron, 2011; Kring & Campellone, 2012). In the real world, facial expressions are interpreted from the context in which they are embedded (Feldman Barrett et al., 2011). Facial emotion interpretations are influenced by contextual information such as body postures or gestures, clothing and accessories (e.g., glasses, jewelry, facial hair, etc.), physical setting, and preceding emotional triggers (Matsumoto & Hwang, 2010). Interestingly, individuals with

schizophrenia perform comparably to controls in interpreting ambiguous facial expressions when a situational context was provided verbally (Lee et al., 2013) and through pictures (Chung & Barch, 2011).

Without a surrounding context, performance on facial affect perception tasks is based solely on one's ability to interpret structural features of the face. This is problematic because faces are complex visual stimuli. Successful interpretation of facial emotion requires holistic processing of configural information, (i.e., the spatial layout of facial features and their relations to one another), rather than featural information (i.e., individual facial features, independent from one another) (Carey & Diamond, 1977). Research suggests that individuals with schizophrenia exhibit disrupted configural processing and an over-reliance on featural processing (Joshua & Rossell, 2009), which is likely to hinder performance on facial affect perception tasks. Thus, poor performance on facial affect perception tasks may reflect a generalized deficit in in low-sensory processing of facial stimuli rather than a specific deficit in recognizing facial emotions (Chan et al., 2010).

Another critical limitation of facial affect perception tasks is that they assess negative emotional states, and do not assess nuanced positive emotional states (Ekman, 2003). Ekman and Frieman (1975) developed the most widely used facial stimuli set for affect perception tasks, which depicts universal emotions of anger, disgust, sadness, fear, happiness, and surprise. There is evidence to suggest that individuals with schizophrenia are most impaired at identifying negative affect states compared to positive affect states (Erwin et al., 1992; Heimberg, Gur, Erwin, Shtasel, & Gur, 1992; Mandal et al., 1998; Edwards et al., 2002; Kohler et al., 2003). However, happiness is the most easily

recognized facial expression both in the general population (Gosselin, Kirouac, & Doré, 1995) and among individuals with schizophrenia (Mandal et al., 1998). Expressions of happiness may be easier to identify because it is the only positive emotion in the stimulus set. Alternatively, happiness may be easier to detect because these expressions are less complex, involving at most two facial muscles (i.e., zygomatic major, orbicularis oculi). Other emotions such as anger, fear, sadness, or distress require up to four independent muscles (Hager & Ekman, 1982). In order to fully understand why individuals with schizophrenia have deficits in social affiliation, it is important to understand how individuals interpret nuanced positive expressions as well.

Lastly, traditional facial affect perception tasks do not evaluate the motivational value of emotional facial expressions. In the real world, we acquire social information from our surroundings in order to inform our behavior. The information gleaned from social cues shape our behavior over time through learning processes. Facial expressions serve as one type of reinforcer that modulates the likelihood of a particular behavior (Shore & Heerey, 2011; Blair, 2003). For example, smiles are easily recognized cues of positive affect that signal to the perceiver that someone is safe to approach. The decision to initiate social contact is reinforced by the social reward of a smile. Indeed, facial displays of emotion serve a communicatory function, providing a quick and easy way to impart information to an observer (Blair, 2003). Emotions communicate important information such as the internal state of an individual, their intentions, or the valence of an object or situation in the environment. The ability to learn from social cues is a critical skill in order to adapt to one's social environment (Behrens et al., 2009).

One explanation of social dysfunction in schizophrenia that remains unexplored is that there is a deficiency in learning the positive, rewarding value of social cues that typically guide the motivation and desire to engage in social interactions. Among individuals with schizophrenia, ruptures in social affiliation are especially prominent for those with experiential negative symptoms. Specifically, individuals with schizophrenia exhibit varying degrees of social anhedonia (i.e., the diminished capacity to experience pleasure from social interactions), asociality (i.e., the degree to which an individual values or desires close social bonds, and the frequency of social interactions), and social avolition (i.e., a lack of motivation to initiate and persist in social activity, independent of the relationship quality). Thus, experiential negative symptoms may be related to more pronounced deficits in underlying social learning processes.

The current study presents a novel approach to understanding how individuals with schizophrenia value positive social feedback compared to healthy participants. We used a matching pennies game, adapted from Shore & Heerey (2011), which allows us to evaluate smiles in terms of a more common currency: money. The matching pennies game is a version of a coordination game adopted from the field of behavioral economics. In the game, participants attempt to choose the same side of a coin as a computerized partner. Unbeknownst to participants, partners provide different rates of monetary and types of social feedback. In a later test phase, participants choose which partner to play from amongst pairs of partners.

This probabilistic reinforcement-learning paradigm utilizes two different types of social reinforcers—polite smiles and genuine smiles. Polite smiles are generated from the zygomatic major muscle, which extends from the cheekbones down to the corner of the

lips. Fake smiles can be evoked even when the individual is not feeling enjoyment (Frank, Ekman, & Friesen, 1993; Frank & Ekman, 1993). A genuine, felt smile is also generated from the zygomatic major muscle, but simultaneously activates the orbicularis oculi, a muscle circling the eye. The orbicularis oculi is made up of two parts: an inner part that tightens the eyelids, and an outer part that circles the socket, pulls down the eyebrows, pulls up the skin below the eye, and raises the cheeks (Ekman, 2003). The outer part of the orbicularis oculi is what distinguishes genuine smiles from polite smiles, as it is very difficult to voluntarily contract without feelings of enjoyment (Ekman, Roper, & Hager, 1980). We have added to the original paradigm to also include partners that display neutral expressions while providing written win-loss feedback.

In the original study (Shore & Heerey, 2008), participants choose to play against partners who displayed genuine smile feedback over partners who displayed polite smile feedback. The authors concluded that genuine smiles enhance partner utility and carry intrinsic reinforcement value over polite smiles. The primary aim of the current study is to determine whether choice behavior in the matching pennies task is differentially modulated by monetary and types of social feedback (genuine smiles, polite smiles, or neutral expressions) among individuals with schizophrenia and healthy controls. Secondarily, we aim to determine if the expected value assigned to the social feedback varies as a function of negative symptoms and trait social anhedonia in the schizophrenia sample. Our hypotheses are as follows:

1) Individuals with schizophrenia will exhibit choice behavior during the matching pennies game that is consistent with an undervaluation of genuine social feedback relative to controls.

2) In terms of overt partner rankings, controls will rank primarily in terms of social feedback (i.e., genuinely smiling partners the highest, followed by politely smiling partners, then partners who display neutral facial feedback), and secondarily based on monetary feedback. Patients will rank order partners according to monetary feedback.

3) In the full sample, individual differences in trait social anhedonia will be negatively correlated with preferences to play against genuinely smiling partners.

4) Within the schizophrenia group, individual differences in negative symptoms and trait social anhedonia will also be negatively correlated with preferences to play against genuinely smiling partners.

Chapter 2: Method

Participants

The sample consisted of 46 individuals with schizophrenia or schizoaffective disorder and 34 healthy controls. Individuals with schizophrenia were recruited from outpatient clinics at the Maryland Psychiatric Research Center (MPRC) and local community mental health clinics. Participants were on a stable medication regimen of constant doses and types for at least four weeks prior to testing, and were deemed clinically stable by their mental health clinician prior to enrollment. Control participants were recruited through random digit dialing, word of mouth among recruited participants, and through online and newspaper advertisements. Controls were excluded for clinically significant DSM-IV Axis I diagnoses.

Participants were excluded from the study if any of the following exclusion criteria were meet: 1) DSM-IV criteria for alcohol dependence or drug dependence in the last six months; 2) DSM-IV criteria for alcohol abuse or drug abuse in the last month; 3) mental retardation; 4) history of significant head injury or trauma; 5) significant neurological disease (e.g. seizure disorders); 6) inability to provide informed consent; or 7) an inadequate command of the English language. Control participants were excluded if they meet DSM-IV criteria for current Axis I or Axis II diagnoses, as evaluated by the SCID-I and the Minnesota Multiphasic Personality Inventory (MMPI), respectively. Additionally, control participants were excluded if they had a family history of psychosis.

Measures

Symptom Measures.

Structured Clinical Interview for DSM-IV (SCID-I; First et al., 1997). The SCID-I is a semi-structured interview used in research settings as a diagnostic instrument to determine history and/or presence of Axis I disorders from the *Diagnostic and Statistical Manual of Mental Disorders* 4th ed. (*DSM-IV*). The SCID-I will be used to confirm diagnostic inclusion and exclusion criteria for both the schizophrenia and control groups.

Clinical Assessment Interview for Negative Symptoms (CAINS) (Kring et al., 2013). The CAINS is a new interview-based measure developed out of the NIMH-MATRICS consensus statement on negative symptoms (Kirkpatrick et al., 2006) to address limitations of former negative symptom assessments (see Appendix A). This 13-item measure reflects findings from converging structural analyses that provide evidence for a two-factor structure of negative symptoms: 1) Motivation and Pleasure (MAP; 9 items); and 2) Expression (EXP; 4 items) (Blanchard & Cohen, 2006; Horan, Kring, Gur, Reise, & Blanchard, 2011; Strauss et al., 2012). The CAINS has good internal consistency for the overall CAINS scale (α =0.76), as well as for the two factor scales of Expression (α = 0.88) and Motivation and Pleasure (α = 0.74). The CAINS also demonstrates good inter-rater reliability for both scales (EXP, average ICC = .77; MAP, average ICC = .93), and adequate test-retest reliability (average ICCs = .69 for both scales). Further, the CAINS demonstrates good convergent validity with other negative symptom scales (i.e., BPRS, SANS, FACES coded facial expressions, and self-report measures), and

good discriminate validity from other symptoms of schizophrenia (i.e., positive symptoms, depression, medication side effects, and cognition) (Kring et al., 2013). For analyses, we will also look at a derivation of the MAP scale called the SMAP (social motivation and pleasure score), which eliminates motivation and pleasure items that are not social in nature.

Brief Psychiatric Rating Scale (BPRS) (Overall & Gorman, 1962; Ventura et al., 1993). The BPRS is a clinician-rated interview assessing the severity of twenty psychiatric symptoms from the past week (see Appendix B). Symptoms are individually rated on a seven-point Likert scale, ranging from 1 (not present) to 7 (extremely severe). The scale is divided into four subscale scores based on a factor structure derived by Kopelowicz and collegues (2008): 1) Positive Symptoms; 2) Negative Symptoms; and 3) Disorganized Symptoms. The BPRS has well-established psychometric properties (Anderson, Larsen, Schultz, et al., 1989; Morlan & Tan, 1998; Overall & Gorham, 1962).

Calgary Depression Scale for Schizophrenia (CDSS) (Addington, Addington, Maticka-Tyndale, & Joyce, 1992). The CDSS is the recommended scale to estimate depression severity among individuals with schizophrenia (Collaborative Working Group on Clinical Trial Evaluations, 1998). This scale consists of 9-items that evaluate depressive symptoms over the past two weeks in semi-structured interview format (see Appendix C). Items are rated on a four-point Likert scale ranging from 0 (absent) to 3 (severe), and are aggregated to yield a total that is

discriminant from positive, negative, and extrapyramidal symptoms. The CDSS has excellent psychometric properties. In particular, the scale demonstrates good internal consistency, inter-rater reliability, sensitivity, and specificity (Addington, Addington, & Atkinson, 1996; Addington et al., 1994; Collins, Remington, Coulter, & Birkett, 1996; Lancon et al., 2001, Addington et al., 1992). The scale has good convergent validity and discriminant validity (Addington et al., 1992).

Revised Social Anhedonia Scale (Eckblad, Chapman, Chapman, & Mishlove, 1982). The RSAS will be administered to assess aspects of stable individual differences in the capacity to experience pleasure from social-interpersonal sources (see Appendix D). The RSAS has been one of the most widely used and established measures to assess social anhedonia in schizophrenia (Horan, Kring, & Blanchard, 2006). This self-report questionnaire is comprised of 40 true/false items that describe common social situations (e.g., "I prefer watching television to going out with other people," keyed true). Total scores range from 0 to 40 (the lower the score, the less severe the anhedonia). The RSAS has documented good internal consistency with alpha coefficients between 0.79 and 0.84 (Blanchard, Mueser, & Bellack, 1998; Mishlove & Chapman, 1985), and high test-retest reliability over both 90-day and one-year periods (Blanchard, Horan, & Brown, 2001; Blanchard et al., 1998). The Infrequency Scale (INFS) for the RSAS was also included to identify those individuals who may be responding randomly or dishonestly (Chapman & Chapman, 1983). The

INFS consists of 13 true/false items that are universally answered in one direction (e.g., "I believe that most light bulbs are powered by electricity," keyed true). In line with previous studies, subjects will be excluded if they endorse 3 or more items in the unexpected direction (Kwapil, 1998).

Assessment of Cognitive Functioning. Cognitive functioning was assessed for all participants using the MATRICS, the WASI-II, and the WTAR. This neurocognitive battery was included to determine whether individual differences in reward learning rates were related to overall intelligence and cognitive ability. If participants completed the neuropsychological battery within the past two years, the assessments were not re-administered. Individuals with schizophrenia were re-administered the assessments if there was a change in clinical status within the two year time frame. Study personnel administering the neurocognitive tasks included B.A. and M.A. level research assistants.

Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) (Green et al., 2004). The MATRICS battery was designed to assess treatment-related changes in cognition over time for individuals with schizophrenia. A panel of experts chose the MATRICS battery as part of the National Institute of Health (NIMH) Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) Project (Green, 2004). The MATRICS consists of 10 tests that assess cognitive functions in the following 7 domains: 1) *Speed of Processing*: Trail Making Test-Part A, Category Fluency-Animal Naming, and the Brief Assessment of Cognition in Schizophrenia (BACS) Symbol-Coding; 2) *Attention/Vigilance*: the Continuous Performance Test-Identical Pairs (CPT-IP); 3) *Working Memory*: Letter-Number

Span, Wechsler Memory Scale (WMS) 3rd edition-Spatial Span; 4) *Verbal Learning*: Hopkins Verbal Learning Test-Revised (HVLT-R); 5) *Visual Learning*: Brief Visuospatial Memory Test-Revised (BVMT-R); 6) *Reasoning and Problem Solving*: Neuropsychological Assessment Battery (NAB) Mazes; and 7) *Social Cognition*: Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT) managing emotions.

Wechsler Abbreviated Scale of Intelligence—Second Edition (WASI-II) (Wechsler, 2011). The WASI-II is an individually administered assessment of global intelligence for individuals between the ages of 6-90. This measure is abbreviated for a quick and accurate assessment of intelligence. The WASI-II is comprised of four subtests: Block Design, Vocabulary, Matrix Reasoning, and Similarities. Subtests yield composite scores that estimate intellectual functioning in the areas of Verbal Comprehension and Perceptual Reasoning (FSIQ-2 subtests). The WASI-II also estimates general intellectual ability from the four individual subtests (FSIQ-4). For the purposes of this study, analyses will be conduced using the FSIQ-4.

Wechsler Test of Adult Reading (WTAR). The WTAR is a 50-item standardized reading measure for adults aged 16-89 that provides an estimate of premorbid intellectual functioning and memory abilities. This measure requires the reading and pronunciation of words that have irregular grapheme-to-phoneme translation, but does not require text comprehension or knowledge or word meaning. This assessment minimizes the assessment of the examinee's current ability, and maximizes assessment of the examinee's previous word learning.

Reading recognition is relatively stable in the presence of cognitive declines (Crawford et al., 1992). This is especially advantageous in estimating intelligence among people with schizophrenia because it does not penalize those who are unemployed or were unable with continue school due to illness onset.

Social Laboratory Tasks.

Matching Pennies Game (Shore & Heerey, 2011). All tasks were programmed and presented using E-Prime (version 1.2; Psychology Software Tools). Participants played a "matching pennies" game, comprised of learning and test phases (see Figure 1), designed to assess the degree to which they value monetary and social feedback. In the learning phase, participants played a series of six computerized opponents, each identified by unique face image, in a neutral (non-expressive) pose. Participants' goal in the task is to select the same side of a coin (i.e., heads or tails) as the opponent. "Matches" were worth 5 cents and "non-matches" 0 cents (participants received their earnings as bonus money at the end of the task). Unbeknownst to participants, opponents provided feedback regardless of their behavior. Three opponents provided match feedback on 80% of trials and the other three on 60% of trials. Two opponents (one 80%, one 60%) provided this feedback by displaying genuine smiles, two opponents (one 80%, one 60%) provided polite smile feedback, and the remaining opponents retained neutral expressions and text feedback indicated match/non-match results (i.e., "You won!" or "You did not win"). Opponents that provided smile feedback displayed frowns on non-match trials. Participants played each opponent 25 times in random order across (150 trials). Because we were unable to counterbalance

reward probability, smile type, and opponent sex with six opponents, participants only saw opponents of one sex, counterbalanced by participant gender. Face images were roughly counterbalanced across social/monetary contingencies to ensure that image/outcome pairings did not affect the results.

Test phase trials (and feedback contingencies) were identical to learning phase trials except that participants chose which opponent they wished to play from amongst a pair of opponents. All possible opponent pairs were tested eight times each in random order (120 test trials). Choice behavior during the test phase served as the dependent variable in the task. Finally, as an explicit measure of participants' preferences for the opponents, they rank ordered each opponent from 1 (most frequently rewarded) to 6 (least frequently rewarded).

Smile Discrimination Task. To ensure that any group differences in preferences for social feedback were not due to differences in ability to distinguish genuine smiles, polite smiles, and neutral faces, participants completed a discrimination task. In one block of the task, participants viewed 80 static face images (40 male and 40 female), and indicated, via button press, whether the expression was "neutral" or a "smile" (20 polite smiles, 20 genuine smiles, and 40 neutral expressions). In a second block, they viewed 40 images of smiling faces (20 male and 20 female), and indicated whether the face displayed a polite smile (20 images) or a genuine smile (20 images).

Smile Stimuli. Smile stimuli in both tasks were obtained from the stimulus set used in Heerey (2014). Facial stimuli consisted of still images of 20 Caucasian actors (10 male, 10 female) displaying smiling, neutral, and frowning facial

expressions. Images were derived from short videos of naturally occurring facial expressions recorded with a high-definition digital camcorder. To capture genuine smiles, actors engaged in a smile induction procedure in which actors were asked to imagine or re-experience a situation when they felt happy, and to display their happiness as if they were sharing the experience with a good friend. To obtain polite smiles, actors were asked to mimic demonstrated examples of polite smiles. Each expression was displayed eight times per actor. From the short films, the first frame from the emotion's peak was chosen for the still image. Five photos from each actor were selected that most closely resembled the prototypical expression.

Procedure

The study was conducted as part of a larger NIMH funded grant directed by Dr. James Gold to understand the nature of reinforcement learning deficits in schizophrenia. The University of Maryland-Baltimore Institutional Review Board approved the protocol. Participants provided written informed consent prior to testing. Individuals with schizophrenia were administered the Evaluation to Sign Consent form (DeRenzo, Conley, & Love, 1998), a short questionnaire that evaluates participant comprehension of study requirements, risks, and rights (see Appendix I). A satisfactory score on the ESC is 10 points correct out of a total of 12 points. Participants who scored lower than 10 points on the ESC were excluded from the study. Inclusion and exclusion criteria were verified upon enrollment through a standard procedure. Consensus diagnosis for the schizophrenia group was established with a best-estimate approach based on medical records and confirmed with the SCID-I. Control participants completed the SCID-I, if not

previously completed in the past two years, to assess for clinically significant Axis I disorders. A medical history evaluation was conducted for all participants to screen for exclusionary medical disorders. After the consent process, a survey of demographic information was administered.

Testing was divided over two visits to prevent fatigue. Participants in the schizophrenia group completed symptom ratings (CAINS, BPRS, and CDSS). Participants in both groups completed the RSAS as an assessment of personality related to social drive and hedonic experience. Further, all participants completed a standard neuropsychological test battery (MATRICS & WASI-II) to determine general cognitive capacity and intellectual ability. In a subsequent visit, participants completed the matching pennies game and the smile discrimination task. The total testing battery took approximately 2 -2 ½ hours to complete. Participants were encouraged to take breaks as needed. Compensation for the study was $20 per hour plus a performance bonus. In the matching pennies task, participants earn five cents for every trial they win in the learning phase and in the test phase. A screen at the end of the task indicates the total performance bonus earned by the participant.

Data Analysis

Choice Behavior. We applied the logistic response function

$$P_{\text{Left Opponent}} = (\exp(\theta)/(1+ \exp(\theta))$$

to each participants' choice data to determine the utility of monetary and social feedback by determining how each contributed to a participant's likelihood of choosing the left opponent in a given pair (Figure 1B). θ was modeled as:

$$\theta = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

The Xs represent the differences between the left and right opponents' monetary values (X_1), genuine smiles (X_2), and polite smiles (X_3). X_1 was coded as the difference in the opponents' expected values (win amount x win probability). X_2 was coded as 1 if the left opponent smiled genuinely and the right opponent did not, -1 if the right opponent smiled genuinely and the left opponent did not, 0 if both opponents (or nether opponent) smiled genuinely. Polite smiles (X_3) were similarly coded. The βs represent unstandardized regression weights for money, genuine smiles, and polite smiles, and reflect the degree to which each variable contributed to choice behavior.

The logistic regression was conducted in MATLAB (the Mathworks, Inc.) using an iteratively re-weighted least squares algorithm to obtain the maximum likelihood estimate for each β. One-way ANOVAs on the unstandardized regression weights were conducted using the Statistical Program for Social Sciences version 20.0 (SPSS, Chicago, Ill) to examine group differences in reward type preferences based on choice behavior.

To more specifically examine preferences for genuine smiles, we calculated the average proportion of times genuinely smiling opponents were chosen over opponents of a different smile type (i.e., polite and neutral) in test pairs where monetary reward was equivalent. Proportions were calculated using Microsoft Excel spreadsheets. One-way ANOVAs were conducted in SPSS (Chicago, Ill) to evaluate group differences in the proportion of times genuinely smiling opponents were chosen when monetary reward was provided on 80% and 60% of trials.

Partner Ranking. In SPSS (Chicago, Ill), we ran a 2 (group: schizophrenia or control) x 2 (money type: 80% or 60% probability of reward) x 3 (smile type: genuine, polite, and neutral) repeated-measures ANOVA to examine overall mean differences in

partner rankings. Secondarily, we examined individual ranking schemes to determine whether social and/or monetary feedback guided partner rankings. There were five possible ranking schemes: 1) participants rank partners based on monetary value; 2) participants rank partners based on smile type; 3) participants rank partners based on both monetary value and smile type, but monetary value is most important; 4) participants rank partners based on both monetary value and smile type, but smile type is most important; 5) participants rank partners randomly and neither monetary value nor smile type were influential on partner rankings. The rankings schemes were coded as follows:

Ranking Scheme	**Genuine 80**	**Genuine 60**	**Polite 80**	**Polite 60**	**Neutral 80**	**Neutral 60**
1. money	2	5	2	5	2	5
2. smile	1.5	1.5	3.5	3.5	5.5	5.5
3. money then smile	1	4	2	5	3	6
4. smile then money	1	2	3	4	5	6

We correlated individual responses with each of the above ranking schemes. For each participant, we determined which ranking scheme was most representative by selecting the scheme with the highest correlation between the participant's response and the ranking schemes. The participant's ranking scheme was coded as random when the highest correlation did not reach statistical significance. We then counted the number of participants in each group that used each ranking scheme. Because we were primarily interested in whether smiles were differentially valued between groups, we collapsed categories into three total groups: 1) money is prioritized (ranking schemes 1 and 3), 2) smiles are prioritized (ranking schemes 2 and 4), and 3) rankings are random.

Discrimination Task. Smile discrimination task analysis was conducted in MATLAB (the Mathworks, Inc.) and used a signal detection theory (REF) model (Green

& Swets, 1966). In the task block in which participants discriminated smiles from neutral stimuli, we coded a correctly identified smile as a ‘hit’ and neutral faces identified as smiles as ‘false alarms’. In the task block in which they discriminated between smiles, we coded correctly identified genuine smiles as hits and polite smiles mistakenly called genuine as false alarms. An average d-prime and criterion score was calculated for each participant from the two parts of the smile discrimination task. In SPSS (Chicago, Ill), we utilized one-way ANOVAs to compare average scores between groups.

Chapter 3: Results

Analyses for the matching pennies game were conducted in two stages. First, we ran analyses in the full sample. Data from three participants (1 CN; 2 SZ) were excluded due to a failure to follow task instructions. These participants likely used strategies irrelevant to the game (e.g., choosing partners based on attractiveness, familiarity etc.), and were identified through a box-and-whisker outlier analysis on the unstandardized regression weights (i.e., β-genuine, β-polite, β-money). Extreme outliers beyond the outer fence of the data distribution did not fit our logistic regression model and were thus removed from our sample. Second, we conducted analyses in a reduced sample ($N = 57$) where we eliminated participants who demonstrated poor learning of monetary reward contingencies. To identify poor learners, we averaged the proportion of times participants chose partners associated with monetary rewards on 80% of trials over partners associated with monetary rewards on 60% of trials when smile types were constant. For example, if the participant appropriately learned monetary reward contingencies, the participant would choose the 80% genuinely smiling partner over the 60% genuinely smiling partner. Poor learners were defined as participants who chose partners associated with higher monetary reward contingencies when smile types were constant at chance level (.5) or below. It was critical to conduct analyses in a reduced sample where all participants demonstrated adequate levels of reward contingency learning in order to accurately interpret the utility of social feedback in monetary terms. The two samples are described below.

Part I: Full Sample

Demographic and clinical characteristics of the full sample are displayed in Table 1. The full sample consisted of forty-five individuals with schizophrenia and thirty-two healthy controls. Groups were similar in terms of gender, age, and race. The schizophrenia group had significantly fewer years of education and lower overall intelligence as estimated by the WTAR and the WASI-II (4-subtest score). Groups did not significantly differ in terms of parental education. Individuals with schizophrenia reported higher levels of social anhedonia.

Choice Behavior. First, we hypothesized that all participants would exhibit an intact ability to learn the monetary reward contingencies associated with each partner. As a group, individuals with schizophrenia appropriately chose the partner with the higher expected monetary value 59% of the time, which was significantly more often than chance, $t(44) = 3.84$, $p < .001$. The control group also appropriately chose the partner with the higher expected monetary reward 67% of the time and significantly more often than chance, $t(31) = 5.02$, $p < .001$. A one-way ANOVA examining learning rates between groups revealed that there was a trend difference suggesting that controls were better at learning monetary reward contingencies than individuals with schizophrenia, $F(1, 75) = 3.38$, $p < .10$ ($\eta^2 = .043$).

Second, we hypothesized that individuals with schizophrenia would exhibit choice behavior during the matching pennies game that reflected an undervaluation of social feedback compared with controls (see Figure 2A). Results indicated that controls ($M = .93$, $SD = 1.04$) valued monetary rewards more than individuals with schizophrenia ($M = .53$, $SD = .86$) at the trend level, $F(1, 75) = 3.40$, $p < .07$ ($\eta^2 = .043$). Controls ($M = .93$, $SD = 2.07$) also valued genuine smiles more than individuals with schizophrenia (M

= .25, *SD* = .92) at the trend level, $F(1, 75) = 3.76$, $p = .056$ ($\eta^2 = .048$). There were no group differences in the valuation of polite smiles, $F(1, 75) = .54$, $p = .47$ ($\eta^2 = .007$). One-sample *t*-tests comparing average unstandardized regressions weights to 0 revealed that both individuals with schizophrenia, $t(44) = 4.16$, $p < .001$, and controls, $t(31) = 5.08$, $p < .001$, used money to guide their decisions in the matching pennies game. In terms of social rewards, genuine smiles significantly influenced choice behavior in the control group, $t(31) = 2.53$, $p < .05$, but only influenced the choice behavior of individuals with schizophrenia at the trend level, $t(44) = 1.83$, $p < .10$. Polite smiles did not influence choice behavior for individuals with schizophrenia, $t(44) = .44$, $p = .66$, or controls, $t(31) = .96$, $p = .34$.

To more specifically examine preferences for genuine smiles, we conducted a one-way ANOVA on the proportion of times participants picked the 80% genuinely smiling partner over another 80% partner with a different smile type (i.e., polite or neutral) (see Figure 2B). There were no significant group differences in the frequency with which the genuinely smiling partner was chosen, $F(1, 75) = 2.11$, $p = .15$ ($\eta^2 = .027$). Second, we conducted a one-way ANOVA on the proportion of times participants picked the 60% genuine partner over another 60% partner with a different smile type (i.e., polite or neutral). We found no significant group differences in the frequency with which the genuinely smiling partner was chosen, $F(1, 75) = 2.01$, $p = .16$ ($\eta^2 = .026$).

Partner Rankings. Our third hypothesis was that explicit rankings of partners would be consistent with choice behavior, and would reflect an undervaluation of genuine smiles in the schizophrenia sample. A repeated-measures ANOVA was conducted to examine overall mean differences of rankings according to smile type and

money type between each group (see Figure 2C). Analyses showed a main effect of smile type, $F(2, 74) = 7.55$, $p = .001$ ($\eta_p^2 = .169$), and a main effect of money type, $F(1, 75) = 44.45$, $p < .001$ ($\eta_p^2 = .372$), but there was not an interaction effect for money type x smile type, $F(1, 75) = 0.52$, $p = .52$ ($\eta_p^2 = 0.18$). These results suggest that across diagnostic groups, both forms of feedback influenced rankings independently. There was not a significant effect for smile type x group, $F(2, 74) = .43$, $p = .65$ ($\eta_p^2 = .011$), or money type x group, $F(1, 75) = .02$, $p = .88$ ($\eta_p^2 = .000$); however, there was a trend-level significant interaction effect for smile type x money type x group, $F(2, 74) = 2.40$, $p < .10$ ($\eta_p^2 = .061$). This relationship is described below.

Looking at the average rank order of partners by each group (see Figure 2C), individuals with schizophrenia ($M = 2.60$, $SD = 1.34$) and controls ($M = 2.47$, $SD = 1.50$) both ranked the 80% genuine partner as the most rewarding. For the second rank position, individuals with schizophrenia selected the 80% neutral partner ($M = 2.91$, $SD = 1.65$), whereas controls selected the 80% politely smiling partner ($M = 2.88$, $SD = 1.54$). This result suggests that controls ranked polite smiles as more intrinsically motivating than neutral expressions in the high monetary payoff condition, yet individuals with schizophrenia did not rank based on the more valuable social cue (i.e., polite smiles). For the third rank, individuals with schizophrenia selected the 80% politely smiling partner ($M = 3.38$, $SD = 1.54$), and controls selected the 60% genuinely smiling partner ($M = 3.41$, $SD = 1.46$). This result suggests that controls ranked genuine smiles from the 60% partner to be more rewarding than receiving extra money from the 80% neutral expression partner. The average rankings for the top three most rewarding partners within the schizophrenia group show a preference for monetary rewards first and foremost: 1)

80% genuine, 2) 80% neutral, and 3) 80% polite. In the fourth position, individuals with schizophrenia ranked the 60% genuine partner (M = 3.98, SD = 1.78), and controls ranked the 80% neutral expression partner (M = 3.47, SD = 1.88). Rank orders for the 60% politely smiling partner and 60% neutral expression partner were consistent between groups, 5th and 6th respectively.

Additionally, a chi-square test of goodness-of-fit was performed to determine whether ranking schemes were equally utilized among groups. In the control group, 40.6% of participants used a ranking scheme that prioritized money, 40.6% of participants used a ranking scheme that prioritized smiles, and 18.8% exhibited a ranking scheme that did not take money or smiles into account. In the schizophrenia group, 59.09% of participants used a ranking scheme that prioritized money, 29.55% of participants used a ranking scheme that prioritized smiles, and 11.36% of participants used a random ranking scheme without consideration for money or smiles. Results indicated that utilization of the different ranking schemes was not significantly different among groups, χ^2 (4, N = 77) = 4.07, p = .40.

Smile Discrimination Task. One-way ANOVA's were conduted to determine whether individuals with schizophrenia were able to differentiate between facial expressions (d') compared with controls, and whether or not their judgments of facial expressions were biased (C) compared with controls (see Figure 3). Groups did not differ in their overall discrimination ability of facial expressions, F(1, 75) = 1.74, p = .19; η^2 = .02, nor did they significantly differ in terms of categorization bias (C), F(1, 75) = .07, p = .80 ; η^2 = .00. Furthermore, the extent to which individuals with schizophrenia valued genuine smiles (β –genuine) was not correlated with measures of discrimination (d'),

$r(45) = .10$, $p = .53$, or categorization bias (C), $r(45) = -.06$, $p = .70$. The valuation of polite smiles (β-polite) was also not related to discrimination ability (d'), $r(45) = .16$, $p = .29$, or categorization bias, $r(45) = -.15$, $p = .32$. These results suggest that the valuation of social feedback was not related to facial affect perception ability.

Correlations with Symptoms. We examined the relationship between choice behavior during the matching pennies game and psychiatric symptoms such as social anhedonia, negative symptoms, depression, and positive symptoms. We also explored the relationship between facial affect perception ability and psychiatric symptoms. Results are detailed below:

Social Anhedonia. Pearson's correlations were conducted between estimates of reward type preference (i.e., β-money, β-genuine, and β-polite) and self-reported social anhedonia (RSAS total score). Eleven participants (schizophrenia, $n = 10$; controls, $n = 1$) were excluded from analyses due to infrequent responding. Collapsing across groups, social anhedonia was significantly correlated with preferences for politely smiling partners, $r = .27$, $p = .03$, but not with preferences for money, $r = -.14$, $p = .26$, or genuinely smiling partners, $r = .02$, $p = .87$. Within the schizophrenia sample, social anhedonia was also significantly correlated with preferences for politely smiling partners, $r = .40$, $p = .02$, but was not related to preferences for genuinely smiling partners, $r = .14$, $p = .42$, or money, $r = -.17$, $p = .34$.

To further explore the relationship between social anhedonia and the valuation of genuine smiles, we calculated bivariate correlations between social anhedonia (RSAS total score) and the proportion of times genuinely smiling

partners were chosen in test pairs where money was held constant. First, we ran analyses across both groups. When both partners in the test pair were associated with monetary rewards on 80% of trials, there was a trend to suggest that social anhedonia was associated with less of a preference for the genuinely smiling partner, $r(55) = -.25$, $p = .06$. There was not a significant correlation between social anhedonia and the proportion of times the 60% genuinely smiling partner was chosen over another 60% partner, $r(55) = -.07$, $p = .60$. In the schizophrenia sample, social anhedonia was not significantly correlated with choosing the 80% genuinely smiling partner, $r(29) = -.08$, $p = .67$, or the 60% genuinely smiling partner, $r(29) = -.04$, $p(29) = -.04$, $p = .84$, in pairs where money was held constant.

Additionally, we conducted bivariate correlations between social anhedonia (RSAS total score) and measures of facial affect perception ability. Collapsing across diagnostic groups, social anhedonia was not significantly correlated with average discrimination ability, $r(55) = -.07$, $p = .60$, or the average criterion score. In the schizophrenia sample, social anhedonia was also not correlated with average discrimination ability, $r(29) = -.23$, $p = .21$, or the average criterion score, $r(29) = .14$, $p = .44$.

Negative Symptoms. Pearson's correlations demonstrated that negative symptoms related to social motivation and pleasure (SMAP) trended on significance with preferences for polite smiles (β-polite) during the matching pennies game (see Table 2). There was not a significant relationship between negative symptoms and preferences for money (β-money) or genuine smiles (β-

genuine). We also calculated bivariate correlations between negative symptoms and the proportion of times genuinely smiling partners were selected in pairs where money as held constant (see Table 3). We found that motivation and pleasure deficits (MAP) and greater overall negative symptoms (CAINS total score) were associated with choosing the 60% genuinely smiling partner less often than another 60% partner in a pair. Negative symptoms were not significantly correlated with choosing the genuine partner in the other test pairs (i.e., 80% genuine vs. 80% partner.

In terms of facial affect perception ability, negative symtpoms were not significantly correlated with discrimination ability, $r(45) = .05$, $p = .73$ (SMAP), $r(45) = -.12$, $p = .43$ (MAP), $r(45) = -.09$, $p = .56$ (EXP), $r(45) = -.13$, $p = .41$ (CAINS total score). However, negative symptoms were signficantly correlated with the average criterion score, $r(45) = -.30$, $p = .04$ (SMAP), $r(45) = -.37$, $p = .01$, (MAP), and $r(45) = -.37$, $p = .01$ (CAINS total). There was a trend level difference between expressivity (EXP) and categorization bias, $r(45) = -.26$, $p = .08$. These results indicate that individuals with higher levels of negative symptoms were able to discriminate between different types of facial expressions, but have a bias to classify expressions as more genuine. In other words, they have a lower threshold criteria for what is considered a genuine smile, and were therefore more likely to judge an expression as genuine.

Psychiatric Symptoms. It is possible that other psychiatric symptoms may influence one's ability to experience pleasure from positive social stimuli. Thus, we conducted Pearson's correlations between psychiatric symptoms and reward

type preferences to ensure that other psychiatric symptoms did not influence choice behavior during the matching pennies game. There was not a significant relationship between depression (CDSS total score) and the valuation of money, $r(45) = .21$, $p = .17$, genuine smiles, $r(45) = -.08$, $p = .60$, or polite smiles, $r(45) = -.04$, $p = .80$. Positive symptoms (BPRS positive subscale) were similarly not related to the valuation of money, $r(45) = .10$, $p = .50$, genuine smiles, $r(45) = -.19$, $p = .21$, and polite smiles, $r(45) = -.06$, $p = .71$.

Correlations with Measures of Neurocognition. Bivariate correlations were calculated separately for schizophrenia and control groups to determine whether cognitive and intellectual ability was related to performance on the matching pennies game. Within the schizophrenia group, Pearson's correlations showed that lower learning rates (i.e., selecting the 80% partner over the 60% partner when smile type is constant) were related to lower overall intelligence as estimated by the WTAR, $r(43) = .47$, $p = .001$, and the WASI-II (4-subtest score) $r(43) = .48$, $p = .001$. Furthermore, lower learning rates were related to lower overall cognitive ability as measured by the MATRICS composite score, $r(43) = .49$, $p = .001$. The control group exhibited a similar pattern of results. Lower rates of learning were correlated with lower overall intelligence, $r(30) = .59$, $p < .001$ (WASI-II 4 subtest), $r(30) = .36$, $p < .05$ (WTAR), and lower cognitive ability, $r(30) = .56$, $p = .001$ (MATRICS composite score). Correlations were transformed into z-scores using Fisher's *r*-to-*z* transformation. Correlations between learning rates and the WASI-II, $Z = -0.64$, $p = .26$, the WTAR, $Z = 0.55$, $p = 29$, and the MATRICS composite score, $Z = -0.4$, $p = .34$, were not significantly different between groups.

We also looked at correlations between preferences for reward types and measures of neurocognition. In the schizophrenia group, preference for monetary rewards (β-money) was correlated with higher intelligence on the WASI-II (4-subtest score), r = .56, p < .001, and on the WTAR, r = .54, p < .001. Preference for monetary rewards was similarly related to greater overall cognitive ability on the MATRICS (composite score), r = .56, p < .001. In the control group, correlations were also significant between preference for monetary rewards (β-money) and intelligence on the WASI-II (4-subtest score), r = .58, p = .001, and on the WTAR, r = .35, p < .05. Overall cognitive ability on the MATRICS (composite score) was similarly related to the valuation of money, r = .48, p < .01. Fisher's r-to-z transformation test indicated that correlations were not significantly different between groups for the WASI-II, Z = -0.12, p = .90, WTAR, Z = 0.99, p = .32, and MATRICS composite score, Z = 0.45, p = .65.

In terms of social rewards, intelligence as measured by the WASI-II (4-subtest score) was correlated with preference for genuine smiles in the control sample, r = .44, p < .05. There was also a trend-level significant correlation in the control sample between preferences for genuine smiles and premorbid intelligence (WTAR), r = .34, p < .10, and overall cognitive ability (MATRICS composite score), r = .33, p < .10. In the schizophrenia sample, the valuation of genuine smiles was not correlated with any measure of neurocognition. Fisher's r-to-z transformation test indicated there were no significant group differences between preferences for genuine smiles and scores on the WASI-II, Z =-0.99, p = .32, the WTAR, Z = -0.93, p = .35, or the MATRICS (composite score), Z = -0.84, p = .40. Preferences for polite smiles (β-polite) were not significantly correlated with measures of neurocognition in either group.

In conclusion, these results suggest that cognitive and intellectual deficits hinder one's ability to learn monetary reward contingencies during the matching pennies game. Lower intelligence and overall cognitive ability were similarly related to an undervaluation of monetary rewards. Importantly, these relationships are not dependent on diagnostic group, in that effect sizes are not significantly different between groups. Results also indicated that there is a significant correlation between greater intellectual ability and more preference for genuine smiles in the control group. Although there was not a significant relationship in the schizophrenia group, the influence of intellectual ability on preference for genuine smiles was not significantly different between groups.

Part II: Reduced Sample

In order to reliably estimate social reward value, participants must learn the monetary outcomes associated with each partner. There were twenty participants (schizophrenia, $n = 14$; controls, $n = 6$) that demonstrated poor learning of monetary reward contingencies (i.e., choosing partners associated with higher monetary rewards in pairs where smile types were held constant at chance level or below). These individuals were excluded from subsequent analyses. The percentage of participants excluded from the schizophrenia group (31.1%) was not significantly different than the percentage of participants excluded from the control group (18.8%), $\chi^2 (1) = 1.49$, $p = .22$. Overall, excluded participants had lower intelligence as measured by the WASI-II (4 subtest score), $F(1, 75) = 6.25$, $p = .02$; $\eta^2 = .08$, and the WTAR, $F(1, 75) = 7.28$, $p = .01$; $\eta^2 = .09$, and trended towards having less years of education, $F (1, 75) = 3.95$, $p = .05$; $\eta^2 = .05$. Included and excluded participants were comparable in terms of age, gender, race, parental education, and social anhedonia.

Table 4 shows demographic and clinical characteristics of participants who were included and excluded within the schizophrenia sample. Poor learners with schizophrenia had lower premorbid intelligence, trended towards having less education, and trended towards being male. Poor learners did not differ from those who achieved adequate learning rates in terms of age or parental education. There was not a statistically significant difference between poor learners (M = 88.57, SD = 13.61) and adequate learners (M = 96.74, SD = 16.96) in overall intelligence as measured by the WASI-II (4-subtest score), $F(1, 43) = 2.51$, $p = .12$ ($\eta^2 = .06$). Furthermore, poor learners did not differ in clinical characteristics; although, adequate learners trended on having more self-reported depression.

Table 5 shows demographic characteristics of participants who were included and excluded in the control sample. Poor learners in the control group were comparable to those who achieved adequate learning levels in terms of age, race, and education. There was a trend level significant difference suggesting that poor learners were male, and had lower parental education. There was not a statistically significant difference between learning groups for premorbid intelligence as measured by the WTAR, $F(1, 30) = .79$, $p = .38$ ($\eta^2 = .026$). There was also not a statistically significant difference between learning groups for intelligence as estimated by the WASI-II (4-subtest score), $F(1, 30) = 2.35$, $p = .14$ ($\eta^2 = .073$).

Reduced Sample Characteristics. The reduced sample consisted of thirty-one individuals with schizophrenia and twenty-six controls. This sample shared the same demographic characteristics as the full sample. Diagnostic groups did not differ in terms of age, $F(1, 55) = .12$, $p = .73$; $\eta^2 = .00$, gender, χ^2 (1) = 1.70, $p = .20$, or race, χ^2 (1) =

1.49, $p = .48$. Individuals with schizophrenia had significantly fewer years of education, $F(1, 55) = 6.67$, $p = .01$; $\eta^2 = .11$, had lower intelligence (WASI-II), $F(1, 55) = 13.79$, $p < .01$; $\eta^2 = .20$, and lower premorbid intelligence (WTAR), $F(1, 55) = 6.48$, $p = .01$; $\eta^2 = .10$. Groups did not differ in terms of parental education, $F(1, 51) = .00$, $p = .96$; $\eta^2 = .00$. Individuals with schizophrenia had higher levels of social anhedonia, $F(1, 48) = 9.44$, $p = .00$; $\eta^2 = .16$.

Choice Behavior. When we eliminated the poor learners from our sample, individuals with schizophrenia and controls did not differ in terms of monetary reward learning, $F(1, 55) = 2.17$, $p = .15$. Individuals with schizophrenia chose partners associated with the higher monetary rewards in pairs where smile types were held constant 68% of the time, and significantly more often than chance, $t(30) = 9.69$, $p < .01$. Healthy controls chose partners associated with the higher monetary rewards in pairs where smile type was held constant 73% of the time, and significantly more often than chance, $t(25) = 7.58$, $p < .01$.

As seen in Figure 4A, one-way ANOVAs revealed that controls ($M = 1.33$, $SD = 1.95$) valued genuine smiles more than individuals with schizophrenia ($M = .30$, $SD = .96$), $F(1, 55) = 6.83$, $p = .01$ ($\eta^2 = .110$). There was not a significant difference between groups in terms of the valuation of money, $F(1, 55) = 1.20$, $p = .28$ ($\eta^2 = .021$), or polite smiles, $F(1, 55) = 1.40$, $p = .24$ ($\eta^2 = .025$). One sample t-tests comparing average β-money to 0 indicated that both individuals with schizophrenia, $t(30) = 7.45$, $p < .001$, and controls, $t(25) = 5.90$, $p < .001$, used money to guide their choice behavior. In terms of social feedback, genuine smiles significantly influenced control's choices, $t(25) = 3.50$, $p < .001$, but only influenced the choices of individuals with schizophrenia at the trend

level, $t(30) = 1.74$, $p < .10$. Polite smiles did not influence choice behavior for individuals with schizophrenia, $t(31) = .61$, $p = .55$. There was a trend level significant difference suggesting that controls used polite smiles to inform choice behavior, $t(31) = .1.74$, $p = .09$.

To further explore the nature of the undervaluation of genuine smile feedback among individuals with schizophrenia, we compared the proportion of times genuine partners were chosen in a given test pair between groups (see Figure 4B). We found that individuals with schizophrenia ($M = .48$, $SD = .25$) picked the 80% genuine partner over another 80% partner with a different smile type (i.e., polite or neutral) significantly less than controls ($M = .68$, $SD = .26$), $F(1, 55) = 8.31$, $p < .01$ ($\eta^2 = .131$). Second, there was not a significant difference between groups in the amount of times participants chose the 60% genuinely smiling partner over another 60% partner with a different smile type (i.e., polite or neutral), $F(1, 55) = 0.60$, $p = .44$ ($\eta^2 = .011$). These results suggest that individuals with schizophrenia attribute less value to partners with genuinely smiling expressions when monetary payoff between both partners in the pair is high (i.e., 80%) compared to controls.

This experimental design allowed us to estimate the utility of social rewards in monetary terms. For controls, the regression weight for genuine smiles ($M = 1.33$) was 1.15 times greater than the regression weight for money ($M = 1.16$). Put another way, the difference between genuine smiles and neutral expressions was 1.15 times more important in determining partner choices than a 20% difference in the probability of winning a nickel. We estimate that controls would have picked a genuinely smiling partner associated with a 57% probability of monetary reward (80% - 23% = .80 - (.20

monetary reward probability difference x 1.15)) equally as often as a neutral expression partner associated with an 80% probability of monetary reward. In other words, controls were willing to give up 1.15 cents (23% x 5 cents) to receive a genuine smile. For individuals with schizophrenia, the regression weight for money (M = .91) was 3.03 times greater than the regression weight for genuine smiles (M = .30), suggesting that the 20% difference in the probability of winning a nickel was 3.03 times more important in choosing an partner than the difference between genuine smiles and neutral expressions. We estimate that individuals with schizophrenia would have picked a genuinely smiling partner associated with a 73% probability of monetary reward (80% - 7% = 80 - (.20 monetary reward probability difference x .33)) equally as often as a neutral partner associated with an 80% probability of monetary reward. Genuine smiles had a utility of .35 cents (7% x 5 cents) for individuals with schizophrenia, suggesting that these individuals were only willing to give up .35 cents to see a genuine smile. The utility of genuine smiles for controls was 3.29 times greater than the utility of genuine smiles for individuals with schizophrenia.

Partner Rankings. Figure 4C shows the average rank assigned to each partner by group. A repeated-measures ANOVA showed a main effect of smile type, $F(2, 54) = 5.58$, $p < .01$ ($\eta_p^2 = .171$), and money, $F(1, 55) = 62.91$, $p < .001$ ($\eta_p^2 = .534$), suggesting that participants used monetary and smile feedback to base their rankings. Interestingly, there was not a statistically significant effect for smile type x group, $F(2, 54) = 2.09$. $p = .13$ ($\eta_p^2 = .072$), despite the undervaluation of genuine smile feedback in the schizophrenia group as evidenced by their choice behavior. The effects for money type x group, $F(1, 55) = .60$, $p = .44$ ($\eta_p^2 = .011$) was also not significant. There was a trend

level smile type x money type x group interaction, $F(2, 54) = 2.46$, $p < .10$ ($\eta_p^2 = .083$). These results indicate that the average ranks assigned to partners were comparable among individuals with schizophrenia and controls.

Looking at the rank order of each partner by group (see Figure 4C), controls ranked partners in the following order: 1) 80% genuine, 2) 80% polite, 3) 60% genuine, 4) 80% neutral, 5) 60% polite, and 6) 60% neutral. Individuals with schizophrenia differed from controls in that they ranked the 80% neutral expression partner as the most rewarding, followed by the 80% genuine smiling partner in the second position. Controls gave the third most rewarding position to the 60% genuine smiling partner, but individuals with schizophrenia preferred money (i.e., the 80% neutral expression partner) to the receipt of a genuine smile. Individuals with schizophrenia ranked the 60% genuinely smiling partner in the 4th position. Both groups ranked the 60% neutral partner as least rewarding. Although not statistically significant according to the repeated-measures ANOVA, the data from overt partner rankings seem to qualitatively suggest that genuine smiles were not as rewarding to individuals with schizophrenia as controls.

To further examine ranking patterns, a chi-square test of goodness-of-fit was performed to determine whether ranking schemes were equally utilized among groups. When ranking schemes were collapsed to reflect whether money was prioritized, whether smiles were prioritized, or whether rankings were random, there was significant difference between groups, χ^2 (2, $N = 56$) = 6.10, $p < .05$. In the schizophrenia sample, 73.30% of participants prioritized money while ranking partners, 13.30% of participants prioritized smiles, and 13.30% exhibited a random ranking scheme where neither money nor smiles were prioritized. In the control sample, 46.2% of participants prioritized

money while ranking partners, 42.3% of participants prioritized smiles while ranking partners, and 11.5% of participants had a random ranking pattern that did not take money or smiles into account. Taken together, these results suggest that individuals with schizophrenia were more likely to utilize a ranking scheme that prioritized money while rank ordering partners compared with controls, and were less likely than controls to prioritize social feedback while rank ordering partners.

Smile Discrimination Task. As demonstrated in the full sample, individuals with schizophrenia and controls did not differ in terms of overall discrimination ability of facial expressions, $F(1, 55) = .10$, $p = .76$, or in terms of overall categorization bias, $F(1, 55) = .13$, $p = .72$ (see Figure 5). The extent to which individuals with schizophrenia valued genuine smiles was not correlated with measures of discrimination, $r = .06$, $p = .77$, or categorization bias, $r = -.02$, $p = .91$, suggesting that the undervaluation of genuine smiles was not related to a facial affect perception abnormality.

Correlations with Symptoms. We examined correlations between choice behavior and psychiatric symptoms, as well as correlations between facial affect perception ability and psychiatric symptoms. Results are detailed below:

Social Anhedonia. When collapsing across diagnostic groups, there was a trend-level significant correlation between social anhedonia (RSAS total score) and the valuation of polite smiles, $r(48) = .26$, $p = .07$; however, social anhedonia was not related to the valuation of money, $r(48) = -.01$, $p = .94$, or genuine smiles, $r(48) = -.02$, $p = .90$. In the schizophrenia sample, there was a trend-level significant correlation between social anhedonia and the valuation of polite smiles, $r(23) = .36$, $p = .07$, but there was not a significant correlation with the

valuation of money, $r(23) = -.16$, $p = .46$, or genuine smiles, $r(23) = .04$, $p = .86$. These results show a small effect suggesting that individuals with social anhedonia prefer politely smiling partners. This might be better understood as a failure to value the more desirable social reward (i.e., a genuine smile) over a less desirable social reward (i.e., a polite smile), in that polite smiles are appear to be more intrinsically motivating for individuals with social anhedonia.

We took a closer look at the proportion of times participants chose genuinely smiling partners in pairs where monetary reward value was held constant (i.e., 80% genuine vs. 80% partner, 60% genuine vs. 60% partner). There was a trend-level significant correlation while collapsing across diagnostic groups suggesting that individuals with social anhedonia were less likely to choose the 80% genuinely smiling partner over another 80% partner, $r(48) = -.24$, $p < .10$. Social anhedonia was not significantly correlated with less preference for the 60% genuinely smiling partners while in a pair aganist another 60% partner, $r(48) = -.09$, $p = .56$. In the schizophrenia group, social anhedonia was not significantly correlated with less preference for the 80% genuinely smiling partner, $r(23) = -.08$, $p = .70$, or the 60% genuinely smiling partner, $r(23) = -.20$, $p = .35$, in pairs where monetary reward was held constant.

Bivariate correlations between social anhedonia and measures of facial affect perception were not significant. This finding suggests that social anhedonia is not related to impaired discrimination ability, $r(48) = .01$, $p = .97$, or categorization bias, $r(48) = -.10$, $p = .49$.

Negative Symptoms. We examined the preferences for monetary and social feedback in relation to negative symptoms. Negative symptoms were not significantly related to the valuation of money, genuine smiles, or polite smiles (see Table 6). However, there was a small effect suggesting that social anhedonia (SMAP), $r(29) = -.26$, $p = .16$, and motivation and pleasure deficits (MAP), $r(29) = -.25$, $p = .18$, were related to an undervaluation of genuine smiles. It is also worth noting that there was a small effect suggesting that social anhedonia, as measured by the CAINS (SMAP), was correlated with preferences for politely smiling partners, $r(29) = .17$, $p = .36$; although, this relationship was not statistically significant.

Looking at the proportion of times genuinely smiling partners were selected in pairs where money was constant (see Table 7), we found a large effect suggesting that negative symptoms were correlated with less preference for the 60% genuinely smiling partner when paired with another 60% partner of a different smile type (i.e., neutral or polite). The strongest correlation was with social motivation and pleasure (SMAP), $r(29) = -.62$, $p < .001$. There was not a significant correlation between negative symptoms and less preference for the 80% genuinely smiling partner when paired with another 80% partner of a different smile type (i.e., neutral or polite). In sum, it appears that individuals with negative symptoms were less concerned with their partner choice in the low monetary reward condition (60%), but did not show a devaluation of genuine smiling partners when monetary payoff was high (80%). These results suggest that genuine smiles are not as intrinsically motivating for these individuals, and

are thus not influencing participants to chose genuinely smiling partners when little monetary payoff is involved.

On the smile discrimination task, we replicated results from the full sample. Negative symptoms were not significantly correlated with discrimination ability, r = .05, p = .79 (SMAP), r = , p = (MAP), r = -.18, p = .34 (EXP), r = -.18, p = .33 (CAINS total score). However, negative symptoms were significantly correlated with average criterion scores, r = -.41, p = .02 (CAINS total score). These results indicate that individuals with elevated levels of negative symptoms were more biased to judge faces as expressing genuine smiles. Interestingly, expressive negative symptoms were related to participant's average criterion score in this sample, r = -.42, p = .02, suggesting that individuals with less expressivity were more likely to classify partners as showing genuine facial expressions.

Psychiatric Symptoms. In the schizophrenia sample, depression (CDSS total score) was not significantly correlated with the valuation of money, r = .04, p = .84, genuine smiles, r = -.11, p = .54, or polite smiles, r = -.07, p = .71. Positive symptoms (BPRS positive subscale) were also not related to the valuation of money, r = -.05, p = .81, genuine smiles, r = -.18, p = .33, and polite smiles, r = -.14, p = .46.

Correlations with Measures of Neurocognition. As in the full sample, bivariate correlations were calculated to determine whether cognitive and intellectual ability was related to performance on the matching pennies game. Rates of monetary learning were significantly correlated with overall intelligence as estimated by the WASI-II (4-subtest

score), $r(55) = .54$, $p < .001$, and the WTAR, $r(55) = .41$, $p = .001$. Moreover, learning rates were significantly correlated with overall cognitive ability on the MATRICS battery, $r(55) = .53$, $p < .001$. As in the full sample, cognitive and intellectual ability was related to one's ability to learn monetary reward contingencies.

We also conducted Pearson's correlations to explore whether the valuation of reward types was related to measures of cognition and intelligence within the schizophrenia group. The extent to which participants valued monetary rewards was correlated with measures of intelligences based on the WASI-II, $r(29)= .55$, $p = .001$, and the WTAR, $r(29) = .48$, $p <.01$. The valuation of monetary rewards was also correlated with overall cognitive ability from the MATRICS battery, $r(29) = .63$, $p < .001$. In terms of social rewards, the valuation of genuine smiles trended on significance with overall intelligence according to the WASI-II (4 subtest score), $r(29) = .36$, $p = .05$, but this relationship was not correlated with premorbid intelligence, $r(29) = .19$, $p = .31$. On the MATRICS, the value of genuine smiles was correlated with overall ability, $r(29) = .38$, $p < .05$. The valuation of polite smiles was also related to overall intelligence, $r = .38$, $p = .04$. In conclusion, these results suggest that the valuation of monetary rewards in the schizophrenia sample was greater for individuals with higher overall cognitive and intellectual ability. Further, individuals with higher overall intelligence were more likely to choose partners associated with genuine and polite smiles.

The MATRICS includes a measure of social cognition (MSCEIT) that measures the capacity to perceive emotions, use emotion to facilitate thought, understand emotional information, and manage emotions (Kee et al., 2009; Eack et al., 2010). While collapsing across both diagnostic groups, the MSCEIT total score trended on significance with the

value of genuine smiles, $r = .24$, $p < .10$, and the value of polite smiles, $r = .22$, $p < .10$. In the schizophrenia sample, there was not a statistically significant difference between social cognitive ability and the value of genuine smiles, $r = .21$, $p = .25$, or the value of polite smiles, $r = .24$, $p = .19$. Overall, there is a small effect size relationship (r's = .20-.22) to support that emotional intelligence was related to how much one places value on social feedback in the matching pennies game.

Ancillary Analyses: Gender and Race Effects

Because our task only has Caucasian facial stimuli, we explored the role of participant race on reward type preferences between groups in the reduced sample. We also examined the role of gender, given that there is some evidence to suggest that females are better at facial affect perception tasks (Chan et al., 2010). All analyses were conducted in the reduced sample. First, we ran one-way ANOVAs to determine whether there are differences in facial affect perception ability between Caucasian participants and non-Caucasian participants. There were no significant race group differences between discrimination ability, $F(55) = 0.17$, $p = .69$, and categorization bias, $F(55) = 0.86$, $p = .36$. Second, we ran bivariate correlations within the non-Caucasian group to determine whether measures of facial affect perception ability were related to their preferences assigned to genuine smiles. There were nonsignificant correlations between preferences for genuine smiles and discrimination ability, $r(21) = -.29$, $p = .17$, and categorization bias, $r(21) = -.05$, $p = .81$.

Next, We conducted three separate 2 (gender: male or female) x 2 (group status: controls or schizophrenia) x 2 (race: Caucasian or non-Caucasian) univariate ANOVAs for each reward type preference. First, we examined preferences for genuine smiles (β-

genuine). The three-way ANOVA yielded a significant group effect, $F(1, 49) = 4.34$, $p < .05$; $\eta_p^2 = .058$, such that individuals with schizophrenia did not value genuine smiles as much as controls. There was not a significant main effect for race, $F(1, 49) = 0.39$, $p = .53$; $\eta_p^2 = .005$, or gender, $F(1, 49) = 1.33$, $p = .25$; $\eta_p^2 = .018$. Furthermore, there were no significant interaction effects for group x gender, $F(1, 49) = 0.57$, $p = .45$; $\eta_p^2 = .008$, group x race, $F(1, 49) = 0.52$, $p = .48$; $\eta_p^2 = .007$, gender x race, $F(1, 49) = 0.06$, $p = .81$; $\eta_p^2 = .001$, or group x gender x race, $F(1, 49) = 1.53$, $p = .22$; $\eta_p^2 = .020$.

Second, we examined preferences for polite smiles (β-polite). There were no significant main effects for group, $F(1, 49) = 2.81$, $p = .10$; $\eta_p^2 = .048$, gender, $F(1, 49) = 1.33$, $p = .25$; $\eta_p^2 = .023$, or race, $F(1, 49) = .97$, $p = .33$; $\eta_p^2 = .017$. There were also no significant interaction effects for group x gender, $F(1, 49) = 0.32$, $p = .57$; $\eta_p^2 = .010$, group x race, $F(1, 49) = 1.34$, $p = .25$; $\eta_p^2 = .023$, gender x race, $F(1, 49) = 0.86$, $p = .36$; $\eta_p^2 = .015$, or group x gender x race, $F(1, 49) = 0.38$, $p = .54$; $\eta_p^2 = .007$. In conclusion, there were no significant effects for race, gender, or diagnostic group in terms of how participants valued polite smiles.

Lastly, we examined preferences for money (β-money). The three-way ANOVA yielded a significant race effect, $F(1,49) = 7.12$, $p = .01$; $\eta_p^2 = .043$, such that non-Caucasian participants ($M = .72$, $SD = .88$) did not value money as much as Caucasian participants ($M = 1.23$, $SD = .77$). There was not a significant main effect for group, $F(1,49) = 0.29$, $p = .59$; $\eta_p^2 = .002$, or gender $F(1,49) = 1.98$, $p = .16$; $\eta_p^2 = .012$, suggesting that diagnostic group and gender did not influence preference for monetary rewards. There was a trend level significant interaction effect for group x gender, $F(1,49) = 3.92$, $p = .05$; $\eta_p^2 = .024$. Specifically, males ($M = 1.41$, $SD = .96$) valued money more

than females (*M* = .75, *SD* = .96) in the control group; however, females (*M* = .91, *SD* = .69) valued money more than males in the schizophrenia group. There was also a trend level significant interaction effect for gender x race, $F(1,49) = 3.89$, $p = .05$; $\eta_p^2 = .024$. Specifically, Caucasian females valued money more than Caucasian males, but non-Caucasian males valued money more than non-Caucasian females (*M* = , *SD* =). There was not a significant interaction effect for group x race x gender $F(1,49) = 0.47$, $p = .50$; $\eta_p^2 = .003$.

Chapter 4: Discussion

The current study extends prior research on social cognitive deficits in schizophrenia to examine whether social cues carry intrinsic reinforcement value in guiding behavior. Secondarily, we investigated whether individual differences in social anhedonia and negative symptoms were related to a subjective undervaluation of social rewards. We adapted a matching pennies game (Shore & Heerey, 2011), based on principles of behavioral economics, which allowed us to evaluate the reinforcement value of social feedback in terms of money. The social stimuli from this study are unique from traditional facial affect perception tasks in that we included nuanced positive expressions of polite and genuine smiles, rather than just one emotion of "happiness." By varying the types of positive emotion, we are able to draw more specific conclusions as to which social cues are most salient in guiding behavior.

Study aims were assessed in two phases: first in the overall sample, then in a reduced sample that excluded participants who exhibited poor learning of monetary reward contingencies. Exclusion of poor learners was critical in order to reliably interpret the value of social rewards. Participants who demonstrated poor learning of monetary reward contingencies during the matching pennies game had lower intelligence and trended towards having less years of education. With that said, analyses in the reduced sample involved participants of similar age, gender, race, and parental education, so it is unlikely that demographic factors contributed to our findings. Clinical characteristics among the schizophrenia group are also comparable between samples. The percentage of participants excluded from the schizophrenia group was not significantly different than

the percentage of participants excluded from the control group. Results from both the full and reduced samples are discussed below.

First, we hypothesized that both groups would exhibit an intact ability to learn the monetary reward contingencies. On average, both groups demonstrated adequate learning of monetary rewards in the full sample. There was a trend suggesting that controls learned monetary reward contingencies better than individuals with schizophrenia. However, when poor learners were excluded from analyses, there was no longer a trend-level significant group difference in learning rates. Thus, conclusions from the reduced sample reflect differences in social valuation rather than an inability to learn reward contingencies among individuals with schizophrenia.

Second, we hypothesized that individuals with schizophrenia would exhibit choice behavior during the matching pennies game that reflected an undervaluation of genuine smile feedback compared with controls. In the full sample, there was a trend-level significant difference indicating that individuals with schizophrenia valued genuine smiles less than controls. Although this difference did not reach statistical significance ($p < .06$), it was in the predicted direction, and represented a small effect size ($\eta^2 = .048$). We also examined the average proportion of times genuinely smiling partners were chosen over partners of a different smile type in test pairs where money was held constant (i.e., 60% genuine vs. 60% partner; 80% genuine vs. 80% partner). There were small effect sizes ($\eta^2 = .026$-$.027$) suggesting that individuals with schizophrenia chose genuinely smiling partners less than controls, but differences were not statistically significant in either test pair. Looking at preferences for the other rewards types, controls trended on valuing money more than individuals with schizophrenia ($\eta^2 = .043$). There

was not a significant difference in preferences for polite smiles ($\eta^2 = .007$). Both groups used monetary reward contingency knowledge to guide choice behavior during the matching pennies game; however, genuine smiles only significantly influenced choice behavior for the control group. Neither group was significantly influenced by polite smiles.

Unfortunately, reward preference estimates from the full sample were confounded by the large amounts of variability in the valuation of social rewards within groups. Variability is likely an artifact of poor learning rates among some participants. When poor learners were removed from the sample, individuals with schizophrenia exhibited choice behavior during the matching pennies game that demonstrated a statistically significant undervaluation of genuine smile feedback compared with controls ($\eta^2 = .110$). It is of note that both genders equally valued genuine smiles among the schizophrenia sample and while collapsing across groups. According to our genuine smile preference estimates, controls were willing to give up 1.15 cents to receive a genuine smile during the matching pennies game, where individuals with schizophrenia were only willing to give up .35 cents to see a genuine smile. In essence, the utility of the genuinely smiling partner for controls was 3.29 times greater than the utility of the genuinely smiling partner for individuals with schizophrenia. More specifically, we found that individuals with schizophrenia were less likely than controls to choose the genuinely smiling partner when both partners in the pair provided a low rate of monetary rewards (i.e., 60%). There were no group differences in the value of genuine smile feedback when monetary payoff was high (i.e., 80%). This further exemplifies the undervaluation of genuine smile

feedback in schizophrenia, demonstrating that individuals were less concerned with who they played against as long as monetary payoff was high.

There was not a significant difference between groups in terms of the valuation of money ($\eta^2 = .021$) or polite smiles ($\eta^2 = .025$), suggesting that controls and individuals with schizophrenia similarly valued these rewards. As in the full sample, both groups used money to guide their choice behavior during the matching pennies game, and controls used genuine smile feedback to guide choices. Unlike the full sample, there was a trend to suggest controls also used polite smiles to guide choices. Individuals with schizophrenia, on the other hand only used genuine smiles to guide choices at the trend level, and did not use polite smiles to guide choice behavior. This result suggests that the deficit in social reinforcement learning is specific to genuine social stimuli and not just a manifestation of a general undervaluation of rewards.

Our third hypothesis was that partner rankings would be consistent with participants' choice behavior, and would reflect an undervaluation of genuine smiles in the schizophrenia sample. In the full sample, analyses on the overall mean rankings revealed that monetary and social feedback independently guided rankings for participants. This is consistent with Shore & Heerey's (2011) findings from the original matching pennies game. There was trend-level significance for a three-way interaction, suggesting that individuals with schizophrenia and controls differentially ranked partners based on money type and smile type ($\eta_p^2 = .061$). According to the mean rankings, both groups ranked the 80% genuinely smiling partner the highest. Controls secondarily ranked the partner associated with a less desirable social cue (i.e., 80% polite), and individuals with schizophrenia selected the partner with no social feedback (i.e., 80%

neutral). Interestingly, controls selected the 60% genuinely smiling partner over the 80% neutral partner for the third position, indicating that the social feedback was more rewarding than a 20% difference in monetary reward. Individuals with schizophrenia ranked first and foremost on monetary rewards.

The reduced sample exhibited a similar pattern in overall mean partner rankings. Monetary and social feedback independently guided rankings for participants. Again, there was trend-level significant difference suggesting that individuals with schizophrenia and controls differentially ranked partners based on money type and smile type (η_p^2 = .083). In the reduced sample, controls ranked the 80% genuinely smiling partner as most rewarding, but individuals with schizophrenia ranked the 80% neutral expression partner as most rewarding. This rank reflects an undervaluation of genuine smiles among individuals with schizophrenia, much like what was demonstrated in their choice behavior. As in the full sample, controls ranked the 60% genuinely smiling partner as more rewarding than the 80% neutral expression partner, showing a preference for a genuine social cue above and beyond a 20% increase in monetary reward. Individuals with schizophrenia still ranked first and foremost based on money.

In terms of individual ranking schemes, we predicted that the majority of individuals with schizophrenia would use a ranking scheme that prioritized money, while the majority of controls would use a ranking scheme that prioritized smiles. In the full sample, groups were comparable in terms of the individual ranking schemes utilized. However, in the reduced sample, individuals with schizophrenia were more likely to utilize a ranking scheme that prioritized money compared with controls, and were less likely to prioritize social feedback while rank ordering partners. Collectively, these

results illustrate an undervaluation of social feedback in participants who learned monetary reward contingencies appropriately.

Our fourth and final hypothesis was that individual differences in social anhedonia and negative symptoms would predict reduced motivation to play against partners associated with genuine smile feedback during the matching pennies game. In the full sample, social anhedonia was significantly correlated with preferences for politely smiling partners. After eliminating poor learners, there was only a trend-level significant difference between social anhedonia and preference for politely smiling partners while collapsing across diagnostic groups (r = .26), and while looking at the schizophrenia sample alone (r = .36). It is likely that we do not have sufficent power to detect a significant effect in the reduced sample due to exclusions of infrequent responders. One interpretation of our findings is that individuals with social anhedonia show a preference for politely smiling partners because they fail to value the more desirable social reward (i.e., genuine smile) over a less desirable social reward (i.e., polite smile). This interpretation indirectly suggests that genuine smiles are less intrinsically motivating for those with social anhedonia. Our findings provide some evidence that individuals with social anhedonia use social cues differently during the matching pennies game.

In terms of negative symptoms, social motivation and pleasure deficits (SMAP) trended on significance with preferences for politely smiling partners (r = .26) in the full sample, which is similar to findings pertaining to social anhedonia. In the reduced sample, there were no significant correlations between negative symptom facets and estimates of reward preferences. Although the relationship was nonsignificant in the

reduced sample, social motivation and pleasure deficits (SMAP) were associated with choosing the genuinely smiling partners less often at a magnitude that is considered to be a small effect size (r = -.26). There was also a small effect size suggesting that social motivation and pleasure deficits (SMAP) were related to more preference for politely smiling partners (r = .17). Looking specifically at the proportion of times participants chose to play against genuinely smiling partners in pairs with equivalent money, we found that motivation and pleasure deficits (MAP) and greater overall negative symptoms (CAINS total score) were associated with choosing the 60% genuinely smiling partner less often than another 60% partner. In the reduced sample, the effect size for the relationship was large (r's > -.55). Interestingly, negative symptoms were not significantly correlated with choosing the genuine partner when monetary payoff was high for both partners. These results seem to suggest that individuals with negative symptoms are more indifferent to which partner they play against when monetary payoff is low. Overall, there is a small effect to suggest that negative symptoms are related to less preference for genuine smiles, but we cannot make definite conclusions based on our data.

One interesting finding regarding negative symptoms was that negative symptoms were not significantly correlated with discrimination ability, but were significantly correlated with a bias to classify expressions as more genuine. In other words, they have a lower threshold criteria for what is considered a genuine smile and were therefore more likely to judge an expression as genuine. Individual differences in social anhedonia were not significanly correlated with discrimination ability or categorization bias. One possibility is that individuals with negative symptoms might be biased to call a smile

"genuine" if they are less motivated to seek our social interactions and see smiles less frequenctly on a daily basis. Thus, they may be more inclinced to call a smile genuine when they do see one.

Study Implications

There are several reasons why individuals with schizophrenia may exhibit an undervaluation of positive social feedback. One hypothesis is that individuals with schizophrenia have deficits in facial affect perception and are thus unable to detect nuances in facial expressions during the matching pennies game (Lee et al., 2013). To rule out this possibility, we included a smile discrimination task as part of our experimental design. Analyses from both the full sample and the reduced sample revealed that groups were not significantly different in their overall discrimination ability, nor did they significantly differ in terms of categorization bias. Furthermore, the extent to which individuals with schizophrenia valued social feedback (i.e., genuine and polite smiles) was not correlated with discrimination ability or categorization bias. Therefore, the undervaluation of social cues in the schizophrenia sample does not appear to be a product of poor facial affect perception ability. This finding supports pre-existing literature that individuals with schizophrenia are less impaired at identifying positive affect states (Erwin et al., 1992; Heimberg, Gur, Erwin, Shtasel, & Gur, 1992; Mandal et al., 1998; Edwards et al., 2002; Kohler et al., 2003). We extend past findings to suggest that individuals with schizophrenia can also differentiate between nuanced positive expressions of polite and genuine smiles.

Another explanation as to why individuals with schizophrenia undervalue positive social feedback is that past social experiences have shaped expectations such that social

interactions are assumed to be associated with less rewarding outcomes. Individuals with schizophrenia may have acquired this bias for a number of reasons. First, individuals with schizophrenia may have fewer opportunities to learn about the positive value of smiles by virtue of the fact that they tend to be socially isolated and withdrawn (Vaughn & Leff, 1976), have fewer friends (Goldberg, Rollins, & Lehman, 2003), and have narrower social networks (Pattinson, DeFrancisco, Wood, Frazier, & Crowder, 1975; Westermeyer & Pattinson, 1981). Alternatively, individuals with schizophrenia may not be learning the rewarding aspect of positive social cues because they evoke negative reactions from others. Individuals with schizophrenia have social skill deficits that that interfere with one's ability to initiate and sustain positive relationships (Bellack, Sayers, Mueser, & Bennett, 1994). Overtime, negative reactions from others may create non-rewarding social environments, and less incentive to engage in social interactions. In a similar sense, individuals with schizophrenia who have previously experienced discrimination as a result of stigma may even be skeptical of genuinely smiling faces due to a hostile attribution bias. Social isolation is thus negatively reinforced as a way to avoid rejection and the distress associated with hurtful reactions from others (Link, Struening, Neese-Todd, Asmussen, & Phelan, 2002). In sum, the undervaluation of genuine smile feedback among individuals with schizophrenia may reflect an acquired, preconceived notion that social interactions are less positive and rewarding.

Lastly, it is possible that individuals with schizophrenia undervalue genuine smile feedback because there is an inherent deficit in reward processing at a biological level that inhibits individuals with schizophrenia from experiencing social feedback as rewarding. In the personality literature, individual differences in interpersonal behaviors

are captured by the trait derivation of affiliation—the preference for close personal ties, interpersonal behavior that is gregarious and sociable, and a tendency to turn to others for comfort and support (Tellegen & Waller, 2008; Depue & Morrone-Strupinsky, 2005; Digman, 1990). According to Depue & Morrone-Strupinsky (2005), trait affiliation is driven by distinct neurobiological mechanisms that reflect individual differences in the capacity to experience reward from interpersonal interactions. They postulate that reward sensitive individuals are more likely to engage in social activities because these experiences produce subjective feelings of warmth and affection. Similarly, Bickart and colleagues (2012) delineated an anatomical brain network referred to as the "social affiliation network" that is comprised of connections between known reward regions, including the medial amygdala subregion, and limbic areas such as the ventromedial prefrontal cortex (vmPFC), the subgenual and rostral ACC, the ventromedial striatum (localized largely in the nucleus accumbens), and the ventromedial hypothalamus. They found that individuals who reported having a greater quantity of personal relationships had stronger intrinsic connectivity between the medial amygdala and the ventromedial prefrontal cortex. The authors conclude that individuals with more social relationships are biologically better equipped to derive value from interpersonal relationships.

According to the above research, it seems that the reinforcement of social rewards facilitates the development and maintenance of social relationships by increasing social approach behaviors. Unfortunately, to the best of our knowledge, there is not research in schizophrenia examining the neural correlates of *social* reinforcement learning and reward processing. Research has shown reinforcement learning deficits at the neural level for nonsocial stimuli (Barch & Dowd, 2010); however, it is not clear whether the same

neural mechanisms involved in nonsocial reinforcement learning are implicated in *social* reinforcement learning for individuals with schizophrenia. In conclusion, our current study design does not allow us to determine whether the undervaluation of social feedback in schizophrenia is innate or acquired. This will be an important direction for future research. Nonetheless, positive social cues do not carry the same reinforcement value for individuals with schizophrenia compared with controls.

Limitations

The current study has several limitations. First, it was difficult for individuals with lower overall intelligence and cognitive ability to learn monetary reward contingencies. The matching pennies game is unique from other probabilistic learning tasks because it required participants to learn two forms of reward contingencies—monetary and social rewards—for each of the six partners. As a result, 25.97% (N = 20) of the sample did not adequately learn monetary reward contingencies significantly greater than chance level. It may be beneficial for future implementations of this task to include more learning trials to increase learning rates of monetary rewards. It may also be helpful to decrease the amount of rewards per trial for the low monetary reward condition. The current study design rewarded on 60% of trials for the low monetary reward condition, rather than 70% as in the original task. However, monetary learning rates were still poor. Overall, poor learning rates seemed to be a function of intelligence rather than a phenomenon on schizophrenia, increasing our confidence in the results from the reduced sample.

A second limitation of the experimental paradigm is that the matching pennies game is a simulated computer program that does not involve live interactions with human

partners. Thus, results are based on a proxy of one's social environment. Nonetheless, we replicated findings from Shore & Heerey (2011), suggesting that social feedback alters the utility of computerized partners. We conclude that smiles are in fact salient reinforcers of social behavior, even in artificial settings. Future research regarding social reinforcement learning should explore more naturalistic social interactions.

Third, the social stimuli in the matching pennies game consisted solely of college-aged, Caucasian faces. The cross-race effect (Malpass & Kravitz, 1969), otherwise known as own-race bias, postulates that people have more difficulty with facial identification (Hugenberg, & Sacco, 2008) and emotion recognition (Zebrowitz, Kikuchi, & Fellous, 2010) when faces are of another less familiar race. For this reason, we conducted ancillary analyses to explore whether social feedback from Caucasian partners was undervalued among participants of a non-Caucasian race. We found that there were no significant effects for race suggesting that non-Caucasian individuals differentially valued genuinely or politely smiling partners. Moreover, there were not significant differences between Caucasian and non-Caucasian participants in terms of facial affect perception ability. Preferences for genuine smiles were also not significantly correlated with preference for genuine smiles among the non-Caucasian group. Nonetheless, it may be advantageous for future studies to utilize social stimuli that vary in age and racial background to further explore these relationships.

Lastly, individuals with schizophrenia were prescribed psychotropic medications while participating in the study. There is evidence to suggest that psychotropic medications can alter the communicatory salience of emotional expressions (Blair, 2003). In particular, medications that manipulate levels of serotonin and noradrenaline alter

activation in the amygdala, a brain region that is involved in the appetitive conditioning of happy facial expressions (Blair, 2003). Therefore, it is possible that serotonergic and noradrenergic medications prevented individuals with schizophrenia from attributing more value to genuinely smiling partners. Additionally, antipsychotic medications that target dopaminergic projections in the brain may also have altered the motivational salience of reward cues during the matching pennies game. The process of anticipatory pleasure is mediated by the midbrain dopamine system in the dorsal and ventral striatal regions of the basal ganglia (Salamone, et al., 2007). Dopamine firing is the mechanism by which the motivational value of the reward is transferred from the reward to the reward cue, generating an anticipatory "wanting" response (Salamone, et al., 2007). Thus, medications that target the dopamine system may decrease anticipatory pleasure of genuine smile feedback, causing individuals with schizophrenia to choose to play against genuinely smiling partners less frequently. In sum, medication effects are a recurrent problem in understanding motivational deficits in schizophrenia. It is possible that medication effects played a role in the present results. Future research is needed to clarify whether our results are related to medication side effects, or an innate feature of the illness. With that said, our results generalize to the vast majority of individuals with schizophrenia who take psychotropic medications.

Conclusion

Individuals with schizophrenia experience profound social impairment that impedes daily functioning and decreases overall quality of life. The current study evaluated whether individuals with schizophrenia attribute value to positive social cues that typically guide the motivation and desire to engage in social interactions. Among

those individuals who appropriately learned monetary reward contingencies during the matching pennies task, there was evidence to suggest that individuals with schizophrenia undervalued genuine smile feedback compared with controls. Money was equally valued between groups. The extent to which individuals with schizophrenia valued genuine smiles was not related to the ability to distinguish between these expressions, nor was it related to a decreased ability to learn reward contingencies. We found small effects to suggest that the undervaluation of genuine smile feedback was related to social anhedonia ad negative symptoms, although this relationship did not reach statistical significance.

Table 1.
Participant Demographic and Clinical Characteristics

	Schizophrenia (n = 45)	Control (n = 32)	Statistic	*p-value*
Age	37.91 (11.59)	38.00 (11.34)	$F = .00$	$p = .97$
Participant Education	12.80 (2.34)	14.59 (2.06)	$F = 12.10$	$p < .001$
Parental Education	14.43 (2.53)	13.93 (2.37)	$F = .67$	$p = .42$
Male, n(%)	68.90%	68.80%	$\chi^2 = .00$	$p = .99$
Race, n(%)			$\chi^2 = .19$	$p = .91$
African-American	35.60%	37.50%	-	
Caucasian	55.60%	56.30%	-	
Other	8.90%	6.30%	-	
Neuropsychological Tests				
WTAR	98.60 (18.36)	111.22 (9.33)	$F = 12.74$	$p < .001$
WASI-II	94.20 (16.29)	109.25 (10.41)	$F = 21.13$	$p < .001$
MATRICS	31.78 (14.66)	50.06 (9.59)	$F = 37.83$	$p < .001$
Symptom Ratings				
CAINS Total	17.62 (8.90)	-	-	-
SMAP	5.02 (3.22)	-	-	-
MAP	13.04 (6.50)	-	-	-
EXP	4.58 (3.61)	-	-	-
CDSS Total	1.71 (2.50)	-	-	-
BPRS Total	32.24 (8.41)	-	-	-
Positive	1.99 (.98)	-	-	-
Negative	1.73 (.69)	-	-	-
Disorganized	1.18 (.28)	-	-	-
Chapman-RSAS	12.29 (6.71)	7.65 (5.61)	$F = 9.16$	$p < .001$

Note. CAINS = Clinical Assessment Interview for Negative Symptoms; SMAP = Social motivation and pleasure subscale; MAP = Motivation and pleasure subscale; EXP = Expression subscale; CDSS = Calgary Depression Scale for Schizophrenia total score; BPRS = Brief Psychiatric Rating Scale; Chapman RSAS - Chapman Revised Social Anhedonia Scale; WTAR = Wechsler Test of Adult Reading total score; WASI-II = 4-subtest IQ; MATRICS = composite score

Table 2.
Full Sample: Negative Symptoms and Preferences for Reward Types

	SMAP	MAP	EXP	Total
β-money	-0.07	0.06	-0.17	-0.03
β-genuine	-0.14	-0.18	-0.10	-0.17
β-polite	.26^	0.10	0.09	0.11

Note. *$p < 0.05$; ^ $p < 0.10$; SMAP = CAINS social motivation and pleasure score; MAP = CAINS motivation and pleasure score; EXP = CAINS expression score; Total = CAINS total negative symptom score

Table 3.
Full Sample: Negative Symptoms and Proportion of Genuine Choices

	SMAP	MAP	EXP	Total
80% genuine vs. 80% partner	-0.19	-0.18	0	-0.13
60% genuine vs. 60% partner	-0.29	-0.31*	-0.24	-0.32*

Note. *$p < 0.05$; SMAP = CAINS social motivation and pleasure score; MAP = CAINS motivation and pleasure score; EXP = CAINS expression score; Total = CAINS total negative symptom score

Table 4.
Schizophrenia Sample: Included versus Excluded

	Included (n = 31)	Excluded (n = 14)	Statistic	*p-value*
Age	39.00 (10.78)	35.50 (13.31)	F = .88	p = .35
Participant Education	13.19 (2.21)	11.93 (2.46)	F = 2.94	p < .10
Parental Education	14.33 (2.52)	14.70 (2.68)	F = .15	p = .70
Male, n(%)	50%	77.40%	χ^2 = 3.38	p < .10
Race, n(%)			χ^2 = 3.11	p = .21
African-American	50%	29%		
Caucasian	50%	58.10%		
Other	0%	12.90%		
Neuropsychological Tests				
WTAR	102.35 (17.51)	90.29 (18.03)	F = 4.50	p < .05
WASI-II	96.74 (16.96)	88.57 (13.61)	F = 2.51	p = .12
MATRICS			F =	p =
Symptom Ratings				
CAINS Total	17.90 (9.19)	17.00 (8.53)	F = 0.97	p =.76
SMAP	5.13 (2.90)	4.79 (3.97)	F =	p =
MAP	13.65 (6.40)	11.71 (6.78)	F = 0.85	p = .36
EXP	4.26 (3.69)	5.29 (3.47)	F = 0.78	p = .38
CDSS Total	2.13 (2.67)	.79 (1.85)	F = 2.90	p < .10
BPRS Total	32.83 (8.95)	31.50 (7.45)	F = 0.16	p = .70
Positive	2.08 (1.08)	1.80 (.78)	F = 0.72	p = .40
Negative	1.73 (.70)	1.80 (.70)	F = 0.21	p = .65
Disorganized	1.13 (1.7)	1.27 (.43)	F = 2.40	p = .13
Chapman-RSAS	12.44 (7.15)	11.90 (5.78)	F = 0.05	p = .83

Note. CAINS = Clinical Assessment Interview for Negative Symptoms; SMAP = Social motivation and pleasure subscale; MAP = Motivation and pleasure subscale; EXP = Expression subscale; CDSS = Calgary Depression Scale for Schizophrenia total score; BPRS = Brief Psychiatric Rating Scale; Chapman RSAS - Chapman Revised Social Anhedonia Scale; WTAR = Wechsler Test of Adult Reading total score; WASI-II = 4-subtest IQ; MATRICS = composite score

Table 5.
Control Sample: Included versus Excluded

	Included (n = 26)	Excluded (n = 6)	Statistic	*p-value*
Age	37.96 (11.83)	38.17 (9.83)	F = .00	p = .97
Participant Education	14.65 (2.02)	14.33 (2.42)	F = .11	p = .74
Parental Education	14.37 (2.02)	12.25 (3.06)	F = 4.23	p = .05
Male, n(%)	100.00%	61.50%	χ^2 = 3.36	p < .10
Race, n(%)			χ^2 = 2.28	p = .32
African-American	50.00%	34.60%	-	
Caucasian	33.30%	61.50%	-	
Other	16.70%	3.80%	-	
Neuropsychological Tests				
WTAR	111.92 (8.46)	108.17 (12.97)	F = .79	p = .38
WASI-II	110.58 (9.32)	103.50 (13.72)	F = 2.35	p = .14
MATRICS			F =	p =
Symptom Ratings				
Chapman-RSAS	6.88 (5.54)	10.83 (5.12)	F = 2.53	p = .12

Note. CAINS = Clinical Assessment Interview for Negative Symptoms; MAP = Motivation and pleasure subscale; EXP = Expression subscale; CDSS = Calgary Depression Scale for Schizophrenia total score; BPRS = Brief Psychiatric Rating Scale; Chapman RSAS - Chapman Revised Social Anhedonia Scale; WTAR = Wechsler Test of Adult Reading total score; WASI-II = 4-subtest IQ; MATRICS = composite score

Table 6.
Reduced Sample: Negative Symptoms and Preferences for Reward Types

	SMAP	MAP	EXP	Total
β-money	-0.13	-0.04	-0.15	-0.09
β-genuine	-0.26	-0.25	-0.17	-0.24
β-polite	0.17	0.00	0.06	0.03

Note. *$p < 0.05$; ^ $p < 0.10$; SMAP = CAINS social motivation and pleasure score; MAP = CAINS motivation and pleasure score; EXP = CAINS expression score; Total = CAINS total negative symptom score

Table 7.
Reduced Sample: Negative Symptoms and Proportion of Genuine Choices

	SMAP	MAP	EXP	Total
80% genuine vs. 80% partner	-0.09	-0.04	-0.04	-0.04
60% genuine vs. 60% partner	-0.62**	-0.57**	-0.39*	-0.55*

Note. ** $p < .001$; *$p < 0.05$; SMAP = CAINS social motivation and pleasure score; MAP = CAINS motivation and pleasure score; EXP = CAINS expression score; Total = CAINS total negative symptom score

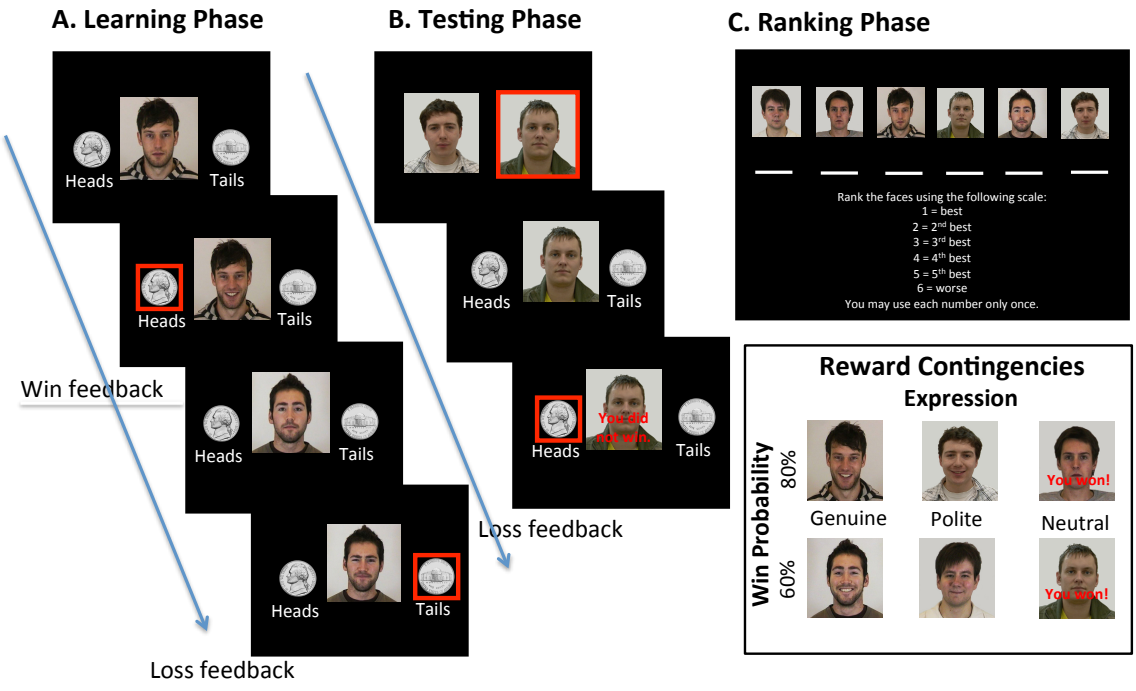

Figure 1. Study Procedure. The matching pennies game was divided into three phases. A: During the learning phase, participants learned monetary and social reward contingencies associated with each opponent. B: During the testing phase, participants chose which partner to play from pairs of partners previously viewed in the learning trials. After selecting the partner, the game preceded as in the learning phase. C: Participants rank ordered each opponent from 1 (most frequently rewarded) to 6 (least frequently rewarded).

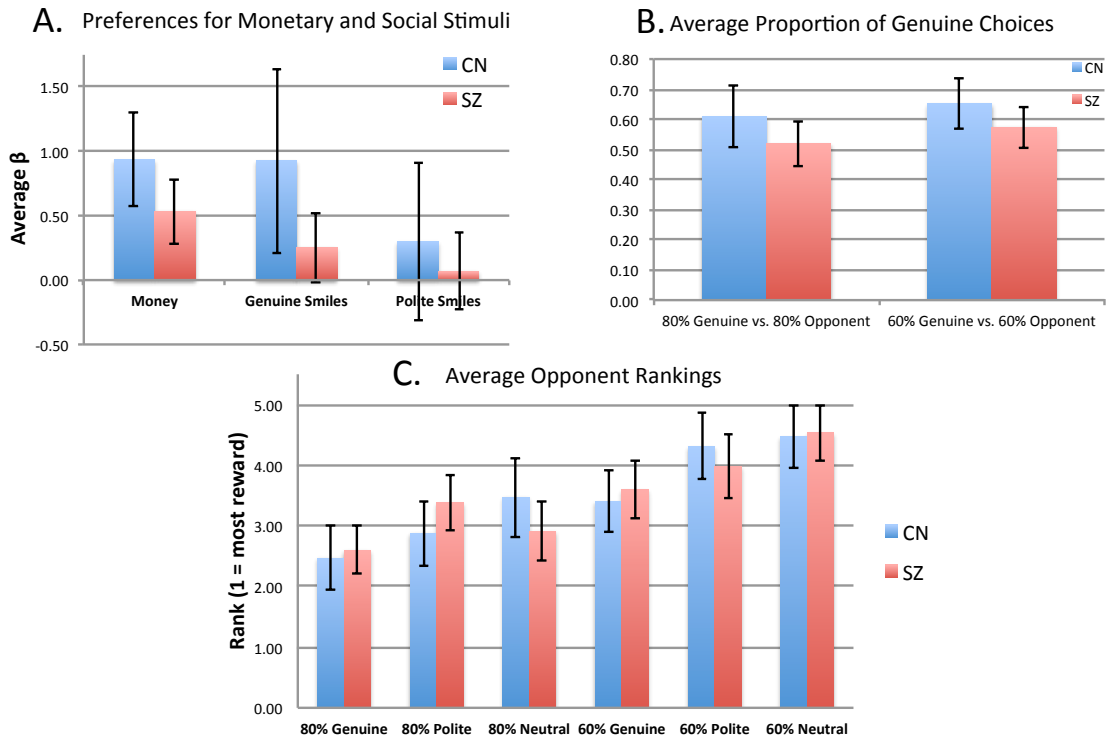

Figure 2. Full Sample: Matching Pennies Results. Panel A: Choice behavior. Bars show mean β's and 95% confidence intervals across groups. Panel B: Average proportion of times genuine partners were chosen in a given test pair. Bars show mean proportions and 95% confidence intervals across groups. Panel C: Average rank order of partners by group. Bars show mean rank and 95% confidence intervals.

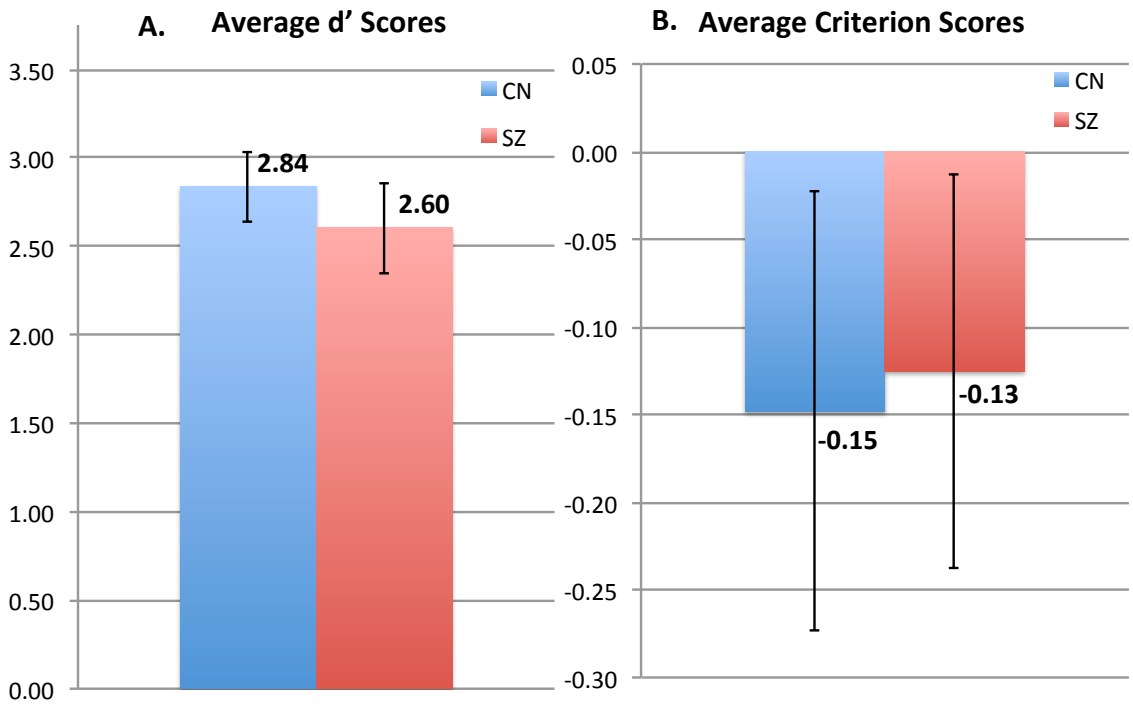

Figure 3. Full Sample: Smile Discrimination Ability by Group. Bars show average discrimination ability (d') (Panel A) and categorization bias (C) (Panel B), and 95% confidence intervals across groups.

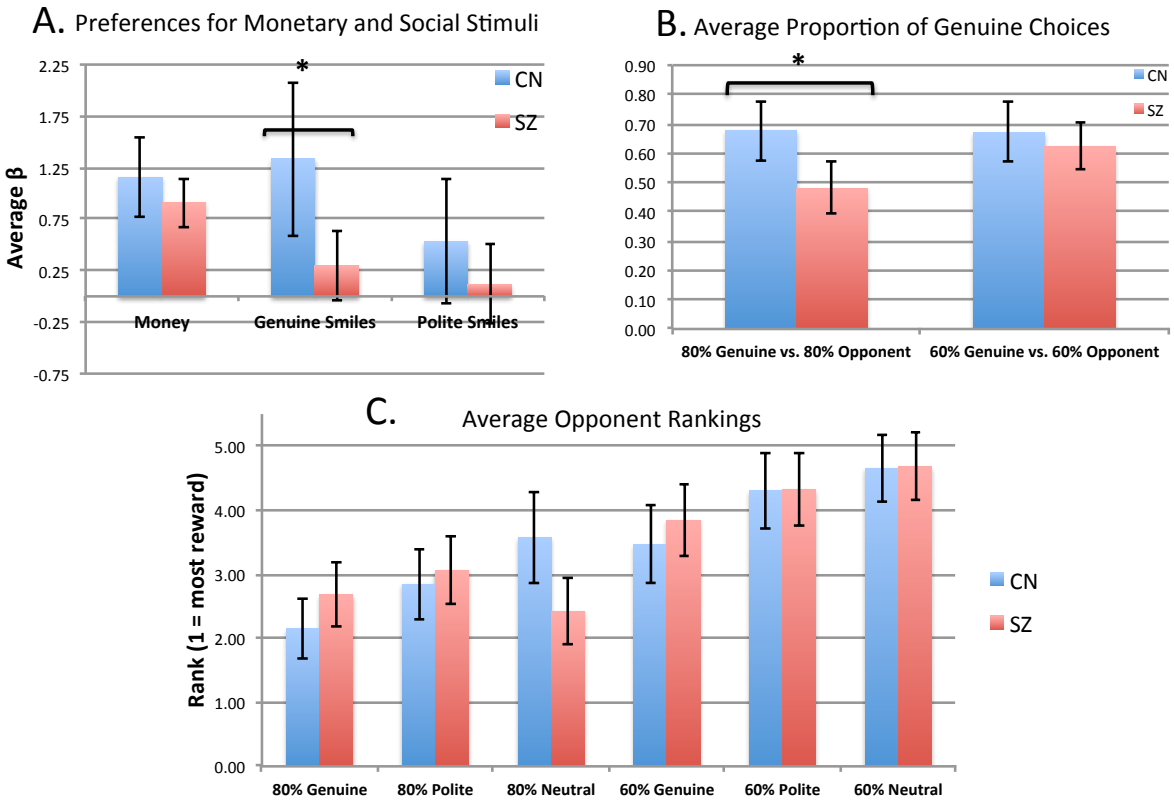

Figure 4. Reduced Sample: Matching Pennies Results. Panel A: Choice behavior. Bars show mean β's and 95% confidence intervals across groups. Panel B: Average proportion of times genuine partners were chosen in a given test pair. Bars show mean proportions and 95% confidence intervals across groups. Panel C: Average rank order of partners by group. Bars show mean rank and 95% confidence intervals.

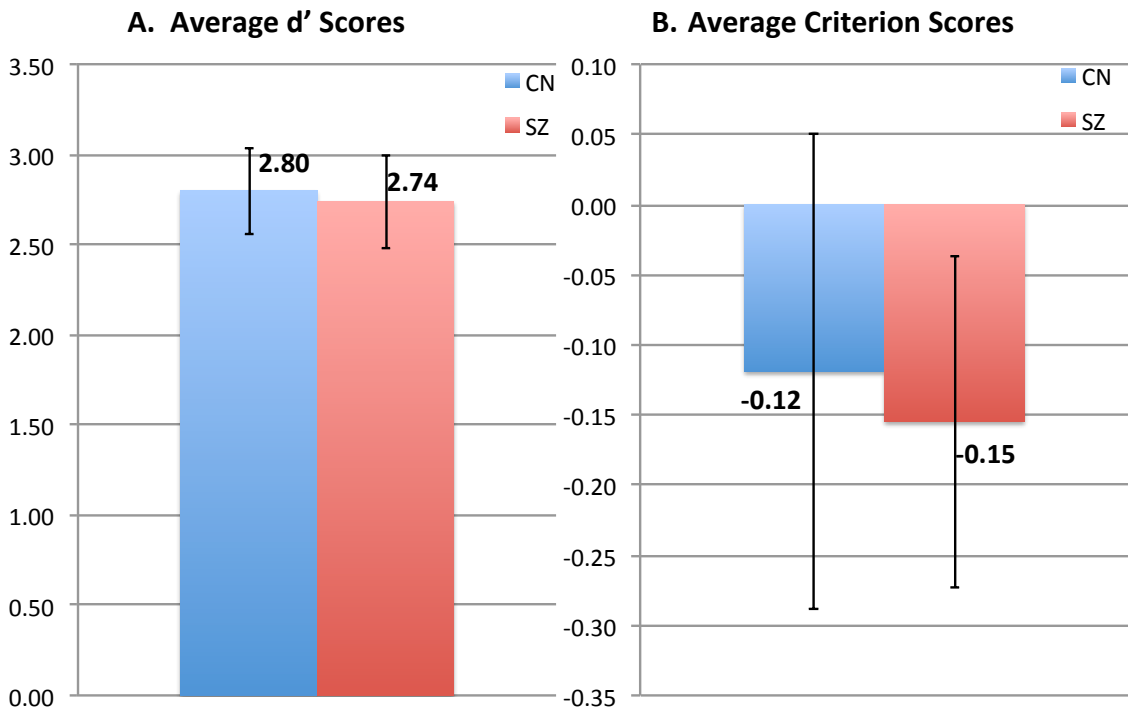

Figure 5. Reduced Sample: Smile Discrimination Ability by Group. Bars show average discrimination ability (d') (Panel A) and categorization bias (C) (Panel B), and 95% confidence intervals across groups.

APPENDIX A:
Clinical Assessment Interview for Negative Symptoms (CAINS)

I. MOTIVATION AND PLEASURE (MAP): SOCIAL ITEMS

1. Motivation for Close Family/Spouse/Partner Relationships:

0 = No impairment: VERY INTERESTED in and highly values close family bonds as one of the most important parts of life. Strongly desires and is highly motivated to be in contact with family. Regularly initiates and persists in interactions with family and actively engages in these interactions; good and bad times are openly discussed. Well within normal limits.

1 = Mild deficit: GENERALLY INTERESTED in and values close family bonds though response suggests some minor or questionable reduction. Generally desires and is motivated to maintain contact with family. Has a close relationship with family member(s) in which good and bad times can be discussed. Mild deficit in initiating and persisting in regular interactions with family – generally actively engaged when interactions occur.

2 = Moderate deficit: SOMEWHAT INTERESTED in family relationships and considers them somewhat important. May occasionally miss close connections with family but is only somewhat motivated to seek out interaction with family. Notable deficit in initiating and persistently engaging in interactions; discussion of good and bad times is limited. Interactions with family members may occur but are largely superficial and participation is best characterized as "going through the motions"; interactions are more likely initiated by family with mostly passive involvement of the person.

3 = Moderately severe deficit: LITTLE INTEREST in family relationships (could "take it or leave it") and does not describe family bonds as important. Describes hardly any motivation and minimal effort to have close family relationships. Rarely has discussion of good and bad times with family members. Contact and engagement with family is superficial and passive with almost all initiation and efforts to engage coming from others.

4 = Severe deficit: NO INTEREST in family relationships and does not consider them at all important. Prefers to be alone and is not at all motivated to be with family. If person does see family, it is done so grudgingly, passively and with no interest.

2. Motivation for Close Friendships/Romantic Relationships:

0 = No impairment: VERY INTERESTED in and highly values friend/romantic relationships as one of the most important parts of life. Strongly desires and is very motivated to engage in friendships. Regularly initiates and persists in interactions with friends/partner and actively engages in these interactions; good and bad times are openly discussed. Well within normal limits.

1 = Mild deficit: GENERALLY INTERESTED in and values friend/romantic relationships though response suggests some minor or questionable reduction. Generally desires and is motivated to engage in friendships. Has friendships/relationship in which good and bad times can be discussed though this may be less consistent. Mild deficit in initiating or persistently engaging during interactions with friends/partner. If no friends/relationship, misses friend/romantic relationships, is motivated to have friends/relationship, and makes efforts to seek out friends/relationship.

2 = Moderate deficit: SOMEWHAT INTERESTED in friend/romantic relationships and considers them somewhat important. May occasionally miss close connections with friends/partner and is somewhat motivated to have friends/partner. Notable deficit in initiating and persistently engaging in interactions; discussion of good and bad times is limited.

Interactions with friends/romantic partner may occur but are largely superficial and participation is best characterized as "going through the motions"; interactions are initiated by others with mostly passive involvement of the person. If no friend/romantic relationships, is only somewhat motivated to have friends/partner and rarely if ever seeks out friends/partner.

3 = Moderately severe deficit: LITTLE INTEREST in friend/romantic relationships (could "take it or leave it") and does not describe friends/partner as important. Describes hardly any motivation to have friendships, and would just as soon be alone. Contact and engagement with others is superficial and passive with almost all initiation and efforts to engage coming from others.

4 = Severe deficit: NO INTEREST in friend/romantic relationships and does not consider them at all important. Prefers to be alone and is not at all motivated to have friends/partner.

3. **Frequency of Pleasurable Social Activities - Past Week**:

0 = No impairment: Pleasure experienced daily.

1 = Mild deficit: Pleasure experienced 5-6 days.

2 = Moderate deficit: Pleasure experienced 3-4 days.

3 = Moderately severe deficit: Pleasure experienced 1-2 days.

4 = Severe deficit: No pleasure reported

4. **Frequency of Expected Pleasurable Social Activities – Next Week**:

0 = No impairment: Expecting MANY (7 or more) pleasurable experiences.

1 = Mild deficit: Expecting enjoyment from SEVERAL (5-6) pleasurable experiences.

2 = Moderate deficit: Expecting enjoyment from a FEW (3-4) pleasurable experiences.

3 = Moderately severe deficit: Expecting a COUPLE (1-2) pleasurable experiences.

4 = Severe deficit: Expecting NO pleasurable experiences.

II. MOTIVATION AND PLEASURE (MAP): WORK AND SCHOOL ITEMS

5. **Motivation for Work and School Activities**:

0 = No impairment: Person is VERY MOTIVATED to seek out work or school, or new opportunities in work or school; initiates and persists in work, school, or job-seeking on a regular basis. Well within normal limits.

1 = Mild deficit: Person is GENERALLY MOTIVATED to seek out work or school or new opportunities in work or school; a mild deficit in initiating and persisting; may report instances of initiating, but with moderate persistence.

2= Moderate deficit: Person is SOMEWHAT MOTIVATED to seek out work or school or new opportunities in work or school; notable deficit in initiating; may have initiated activities, but needed reminders on multiple occasions, and/or not initiated any new activities, and/or not persisted for very long.

3 = Moderately severe deficit: Person is only SLIGHTLY MOTIVATED to seek out work or school or new opportunities in work or school; significant deficit in initiating; may have needed constant reminders, and/or initiated a few activities; did not persist for very long.

4 = Severe deficit: Person is NOT AT ALL MOTIVATED to seek out work / school; nearly total lack of initiation and persistence in work, school, or job seeking.

6. **Expected Pleasurable Work and School Activities – Next Week**:

0 = No impairment: Expecting MANY (7 or more) pleasurable experiences.

1 = Mild deficit: Expecting enjoyment from SEVERAL (5-6) pleasurable experiences.

2 = Moderate deficit: Expecting enjoyment from a FEW (3-4) pleasurable experiences.

3 = Moderately severe deficit: Expecting a COUPLE (1-2) pleasurable experiences.

4 = Severe deficit: Expecting NO pleasurable experiences.

III. MOTIVATION AND PLEASURE (MAP): RECREATION ITEMS

7. Motivation for Recreational Activities:

0 = No impairment: Person is VERY MOTIVATED to seek out hobbies and recreational activities; initiates and persists in hobbies and recreational activities on a regular basis, well within normal limits.

1 = Mild deficit: Person is GENERALLY MOTIVATED to seek out hobbies and recreational activities; a mild deficit in initiating and persisting; may report initiating hobbies, but with moderate persistence.

2 = Moderate deficit: Person is SOMEWHAT MOTIVATED to seek out hobbies and recreational activities; notable deficit in initiating; may have initiated some activities and/or not persisted for very long. Others were somewhat more likely to initiate hobbies or activities.

3 = Moderately severe deficit: Person is only SLIGHTLY MOTIVATED to seek out hobbies and recreational activities; significant deficit in initiating and persisting; may have initiated a few activities and not persisted for very long. Others were much more likely to initiate hobbies or prompt initiation.

4 = Severe deficit: Person is NOT AT ALL MOTIVATED to seek out hobbies and recreational activities; nearly total lack of initiation and persistence in hobbies or recreational activities.

8. Frequency of Pleasurable Recreational Activities - Past Week:

0 = No impairment: At least A FEW (3) different types of pleasurable experiences, experienced daily.

1 = Mild deficit: At least A FEW (3) different types of pleasurable experiences, experienced more days

than not.

2 = Moderate deficit: 1 or 2 different types of pleasurable experiences, experienced more days than not.

3 = Moderately severe deficit: 1 type of pleasurable experience, experienced on just a few days.

4 = Severe deficit: No pleasurable experiences.

9. Frequency of Expected Pleasure from Recreational Activities – Next Week:

0 = No impairment: Expecting MANY (7 or more) pleasurable experiences.

1 = Mild deficit: Expecting enjoyment from SEVERAL (5-6) pleasurable experiences.

2 = Moderate deficit: Expecting enjoyment from a FEW (3-4) pleasurable experiences.

3 = Moderately severe deficit: Expecting a COUPLE (1-2) pleasurable experiences.

4 = Severe deficit: Expecting NO pleasurable experiences.

IV. EXPRESSION (EXP) ITEMS

10. **Facial Expression**:

0 = No impairment: WITHIN NORMAL LIMITS; frequent expressions throughout the interview.

1 = Mild deficit: MILD DECREASE in the frequency of facial expressions, with limited facial expressions during a few parts of the interview.

2 = Moderate deficit: NOTABLE DECREASE in the frequency of facial expressions, with diminished facial expressions during several parts of the interview.

3 = Moderately severe deficit: SIGNIFICANT LACK of facial expressions, with only a few changes in facial expression throughout most of the interview.

4 = Severe deficit: NEARLY TOTAL LACK of facial expressions throughout the interview.

11. **Vocal Expression**:

0 = No impairment: WITHIN NORMAL LIMITS. Normal variation in vocal intonation across interview. Speech is expressive and animated.

1 = Mild deficit: MILD DECREASE in vocal intonation. Variation in intonation occurs with a limited intonation during a few parts of the interview.

2 = Moderate deficit: NOTABLE DECREASE in vocal intonation. Diminished intonation during several parts of the interview. Much of speech is lacking variability in intonation but prosodic changes occur in several parts of the interview.

3 = Moderately severe deficit: SIGNIFICANT LACK of vocal intonation with only a few changes in intonation throughout most of the interview. Most of speech is flat and lacking variability, only isolated instance of prosodic change.

4 = Severe deficit: NEARLY TOTAL LACK OF change in vocal intonation with characteristic flat or monotone speech throughout the interview.

12. **Expressive Gestures**:

0 = No impairment: WITHIN NORMAL LIMITS; uses frequent gestures throughout the interview.

1 = Mild deficit: MILD DECREASE in the frequency of expressive gestures, with limited gestures in a few parts of the interview.

2= Moderate deficit: NOTABLE DECREASE in the frequency of expressive gestures, with lack of gestures during several parts of the interview.

3 = Moderately severe deficit: SIGNIFICANT LACK of expressive gestures, with only a few gestures throughout most of the interview.

4 = Severe deficit: NEARLY TOTAL LACK of expressive gestures.

13. **Quantity of Speech**:

0 = No impairment: NORMAL AMOUNT of speech throughout the interview. Replies provide sufficient information with frequent spontaneous elaboration.

1 = Mild deficit: MILD DECREASE in the quantity of speech, with brief responses during a few parts of the interview.

2= Moderate deficit: NOTABLE DECREASE in speech output, with brief responses during several parts of the interview.

3 = Moderately severe deficit: SIGNIFICANT LACK of speech, with very brief answers (only several words) in responses throughout most of the interview.

4 = Severe deficit: All or nearly all replies are one or two words throughout the entire interview.

APPENDIX B:
Brief Psychiatric Rating Scale (BPRS)

Anchors: 1 = Not present; 2 = Very mild; 3 = Mild; 4 = Moderate; 5 = Moderate/Severe; 6 = Severe; 7 = Very severe

1. SOMATIC CONCERN: **1 2 3 4 5 6 7**
Degree of concern over present bodily health. Rate the degree to which physical health is perceived as a problem by the patient, whether complaints have a realistic basis or not.

2. ANXIETY: **1 2 3 4 5 6 7**
Worry, fear, or over-concern for present or future. Rate solely on the basis of verbal report of patient's own subjective experiences. Do not infer anxiety from physical signs or from neurotic defense mechanisms.

3. EMOTIONAL WITHDRAWAL: **1 2 3 4 5 6 7**
Deficiency in relating to the interviewer and to the interview situation. Rate only the degree to which the patient gives the impression of failing to be in emotional contact with other people in the interview situation.

4. CONCEPTUAL DISORGANIZATION: **1 2 3 4 5 6 7**
Degree to which the thought processes are confused, disconnected or disorganized. Rate on the basis of integration of the verbal products of the patient; do not rate on the basis of patient's subjective impression of his own level of functioning.

5. GUILT FEELINGS: **1 2 3 4 5 6 7**
Over-concern or remorse for past behavior. Rate on the basis of the patient's subjective experiences of guilt as evidenced by verbal report with appropriate affect; do not infer guilt feelings from depression, anxiety or neurotic defenses.

6. TENSION: **1 2 3 4 5 6 7**
Physical and motor manifestations of tension, "nervousness," and heightened activation level. Tension should be rated solely on the basis of physical signs and motor behavior and not on the basis of subjective experiences of tension reported by the patient.

7. MANNERISMS AND POSTURING: 1 2 3 4 5 6 7

Unusual and unnatural motor behavior, the type of motor behavior which causes certain mental patients to stand out in a crowd of normal people. Rate only abnormality of movements; do not rate simple heightened motor activity here. Do not rate movements of Tardive Dyskinesia.

8. GRANDIOSITY: 1 2 3 4 5 6 7

Exaggerated self-opinion, conviction of unusual ability or powers. Rate only on the basis of patient's statements about himself or self-in-relation-to-others, not on the basis of his demeanor in the interview situation.

9. DEPRESSIVE MOOD: 1 2 3 4 5 6 7

Despondency in mood, sadness. Rate only degree of despondency; do not rate on the basis of inferences concerning depression based upon general retardation and somatic complaints.

10. HOSTILITY: 1 2 3 4 5 6 7

Animosity, contempt, belligerence, disdain for other people outside the interview situation. Rate solely on the basis of the verbal report of feelings and actions of the patient toward others; do not infer hostility from neurotic defenses, anxiety nor somatic complaints. (Rate attitude toward interviewer under "uncooperativeness.")

11. SUSPICIOUSNESS: 1 2 3 4 5 6 7

Belief (delusional or otherwise) that others have now, or have had in the past, malicious or discriminatory intent toward the patient. On the basis of verbal report, rate only those suspicions which are currently held whether they concern past or present circumstances.

12. HALLUCINATORY BEHAVIOR: 1 2 3 4 5 6 7

Perceptions without normal external stimulus correspondence. Rate only those experiences which are reported to have occurred within the last week and which are described as distinctly different from the thought and imagery processes of normal people.

13. MOTOR RETARDATION: 1 2 3 4 5 6 7

Reduction in energy level evidenced in slowed movements. Rate on the basis of observed behavior of the patient only; do not rate on basis of patient's subjective impression of own energy level.

14. UNCOOPERATIVENESS: 1 2 3 4 5 6 7

Evidence of resistance, unfriendliness, resentment, and lack of readiness to cooperate with the interviewer. Rate only on the basis of the patient's

attitude and responses to the interviewer and the interview situation; do not rate on basis of reported resentment or uncooperativeness outside the interview situation.

15. UNUSUAL THOUGHT CONTENT: **1 2 3 4 5 6 7**
Unusual, odd, strange, or bizarre thought content. Rate here the degree of unusualness, not the degree of disorganization of thought processes.

16. BLUNTED AFFECT: **1 2 3 4 5 6 7**
Reduced emotional tone, apparent lack of normal feeling or involvement.

17. EXCITEMENT: **1 2 3 4 5 6 7**
Heightened emotional tone, agitation, increased reactivity.

18. DISORIENTATION: **1 2 3 4 5 6 7**
Confusion or lack of proper association for person, place or time.

19. POVERTY OF SPEECH: **1 2 3 4 5 6 7**
Conversation and answers to questions are either vague or meaningless, or tend to be brief, concrete, and unelaborated.

20. INAPPROPRIATE AFFECT: **1 2 3 4 5 6 7**
Affect expressed is inappropriate or incongruous.

Appendix C:
Calgary Depression Scale for Schizophrenia

Interviewer: Ask the first question as written. Use the following probes of qualifiers at your discretion. Time frame refers to last 2 weeks unless stipulated. The last item, # 9, is based on observations of the entire interview.

1. **Depressed Mood**: How would you describe your mood over the past 2 weeks? Do you keep reasonably cheerful or have you been very depressed or low spirited recently. In the last 2 weeks, how often have you *(own words)* every day? All day?
   0 = Absent (No depressed mood.)
   1 = Mild (Expresses some sadness or discouragement on questioning.)
   2 = Moderate (Distinct depressed mood persisting up to half the time over the past 2 weeks; present daily.)
   3 = Severe (Markedly depressed mood persisting daily over half the time interfering with normal motor and
   social functioning.)

2. **Hopelessness**: How do you see the future for yourself? Can you see any future, or has life seemed quite hopeless? Have you given up or does there still seem some reason for trying?
   0 = Absent (No hopelessness.)
   1 = Mild (Has at times felt hopeless over the last week but still has some degree of hope in the future.)
   2 = Moderate (Persistent, moderate sense of hopelessness over the last week. Can be persuaded to acknowledge possibility of things being better.)
   3 = Severe (Persisting and distressing sense of hopeless.)

3. **Self-Depreciation**: What is your opinion of yourself compared to other people? Do you feel better or not as good or about the same as most? Do you feel inferior or even worthless?
   0 = Absent (No self-depreciation.)
   1 = Mild (Some inferiority; not amounting to feeling of worthlessness.)
   2 = Moderate (Subject feels worthless, but less than 50% of the time.)
   3 = Severe (Subject feels worthless, more than 50% of the time. May be challenged to acknowledge otherwise.)

4. **Guilty Ideas of Reference**: Do you have the feeling that you are being blamed for something or even wrongly accused? What about? (Do not include justifiable blame or accusation; exclude delusions of guilt)
   0 = Absent (No guilty ideas of reference.)
   1 = Mild (Subject feels blamed but not accused less than 50% of the time.)
   2 = Moderate (Persisting sense of being blamed, and/or occasional sense of being accused.)
   3 = Severe (Persistent sense of being accused. When challenged acknowledges that it is ***not*** so.)

5. **Pathological Guilt**: Do you tend to blame yourself for little things you may have done in the past? Do you think that you deserve to be so concerned about this?
   0 = Absent (No pathological guilt.)
   1 = Mild (Subject sometimes feels over guilty about minor peccadillo, but less than 50% of the time.)
   2 = Moderate (Subject usually feels (over 50% of the time) guilty about past actions, the significance of which he/she exaggerates.)
   3 = Severe (Subject usually feels he/she is to blame for everything that has gone wrong, even when not his/her fault.)

6. **Morning Depression**: When have you felt depressed over the last 2 weeks; have you noticed the depression being worse at any particular time of day?
   0 = Absent (No depression.)
   1 = Mild (Depression present but no diurnal variation.)
   2 = Moderate (Depression spontaneously mentioned to be worse in the morning.)
   3 = Severe (Depression markedly worse in the morning, with impaired functioning which improves in afternoon.)

7. **Early Wakening:** Do you wake earlier in the morning than is normal for you? How many times a week does this happen?
   0 = Absent (No early wakening.)
   1 = Mild (Occasionally wakes (up to twice weekly) one hour or more before normal time to wake or alarm time.)
   2 = Moderate (Often wakes early (up to 5 times weekly) one hour or more before normal time to wake or alarm time)
   3 = Severe (Daily wakes one hour or more before normal time to wake or alarm time)

8. **Suicide**: Have you felt that life isn't worth living? Did you ever feel like ending it all? What did you think that you might do? Did you actually try?
   0 = Absent (No suicidal ideation (behavior).)
   1 = Mild (Frequent thoughts of being better off dead, or occasional thoughts of suicide.)
   2 = Moderate (Deliberately considered suicide with a plan, but made no attempt.)
   3 = Suicidal attempt apparently designed to end in death (i.e. accidental discovery or inefficient means.)

Based on interviewer's observations during entire interview:

9. **Observed Depression**: The question "Do you feel like crying?" Used at appropriate points in the interview, this may elicit information useful to this observation.
   0 = Absent
   1 = Mild (Subject appears sad and mournful even during parts of the interview involving affectively neutral discussion.)
   2 = Moderate (Subject appears sad and mournful throughout the interview, with gloomy monotonous voice and is tearful or close to tears at times.)
   3 = Severe (Subject chokes on distressing topics, frequently sighs deeply and cries openly, or is persistently in a state of frozen misery.)

Appendix D:
Revised Social Anhedonia Scale

Instructions: Please mark each item true or false. Please do not skip any items. It is important that you answer every item, even if you are not quite certain which is the best answer. An occasional item may refer to experiences that you have had only when taking drugs. Unless you have had the experience at other times (when not under the influence of drugs), mark it as if you have not had that experience.

Some items may sound like others, but all of them are slightly different. Answer each item individually, and don't worry about how you answered a somewhat similar previous item.

Circle the answer that best describes you.

1.	There are things that are more important to me than privacy.	TRUE	FALSE
2.	Sometimes when walking down the sidewalk, I have seen children playing.	TRUE	FALSE
3.	Although I know I should have affection for certain people, I don't really feel it.	TRUE	FALSE
4.	Driving from New York to San Francisco is generally faster than flying between these cities.	TRUE	FALSE
5.	There are few things more tiring than to have a long, personal discussion with someone.	TRUE	FALSE
6.	There have been a number of occasions when people I know have said hello to me.	TRUE	FALSE
7.	People are usually better off if they stay aloof from emotional involvements with most others.	TRUE	FALSE
8.	My relationships with other people never get very intense.	TRUE	FALSE
9.	I find that I often walk with a limp, which is the result of a skydiving accident.	TRUE	FALSE
10.	I have often found it hard to resist talking to a good friend, even when I have other things to do.	TRUE	FALSE
11.	I cannot remember a single occasion when I have ridden on a bus.	TRUE	FALSE
12.	I'm much too independent to really get involved with other people.	TRUE	FALSE
13.	On some occasions I have noticed that some other people are better dressed than myself.	TRUE	FALSE
14.	Although there are things that I enjoy doing by myself, I usually seem to have more fun when I do things with other people.	TRUE	FALSE
15.	Knowing that I have friends who care about me gives me a sense of security.	TRUE	FALSE
16.	I prefer watching television to going out with other people.	TRUE	FALSE
17.	People sometimes think that I am shy when I really just want to be left alone.	TRUE	FALSE
18.	If given the choice, I would much rather be with others than be alone.	TRUE	FALSE
19.	I don't really feel very close to my friends.	TRUE	FALSE
20.	When things are going really good for my close friends, it makes me feel good too.	TRUE	FALSE
21.	People who try to get to know me better usually give up after awhile.	TRUE	FALSE

22.	In many ways, I prefer the company of pets to the company of people.	TRUE	FALSE
23.	I am usually content to just sit alone, thinking and daydreaming.	TRUE	FALSE
24.	I have always enjoyed looking at photographs of friends.	TRUE	FALSE
25.	When someone close to me is depressed, it brings me down also.	TRUE	FALSE
26.	There have been times when I have dialed a telephone number only to find that the line was busy.	TRUE	FALSE
27.	I feel pleased and gratified as I learn more and more about the emotional life of my friends.	TRUE	FALSE
28.	When things are bothering me, I like to talk to other people about it.	TRUE	FALSE
29.	I cannot remember a time when I talked with someone who wore glasses.	TRUE	FALSE
30.	I go at least once every two years to visit either northern Scotland or some part of Scandinavia.	TRUE	FALSE
31.	I find that people too often assume that their daily activities and opinions will be interesting to me.	TRUE	FALSE
32.	When others try to tell me about their problems and hang-ups, I usually listen with interest and attention.	TRUE	FALSE
33.	I like to make long distance phone calls to friends and relatives.	TRUE	FALSE
34.	Making new friends isn't worth the energy it takes.	TRUE	FALSE
35.	People often expect me to spend more time talking with them than I would like.	TRUE	FALSE
36.	It made me sad to see all my high school friends go their separate ways when high school was over.	TRUE	FALSE
37.	I prefer hobbies and leisure activities that do not involve other people.	TRUE	FALSE
38.	I attach very little importance to having close friends.	TRUE	FALSE
39.	I have never combed my hair before going out in the morning.	TRUE	FALSE
40.	At times when I was ill or tired, I have felt like going to bed early.	TRUE	FALSE
41.	Just being with friends can make me feel really good.	TRUE	FALSE
42.	Playing with children is a real chore.	TRUE	FALSE
43.	I could be happy living all alone in a cabin in the woods or mountains.	TRUE	FALSE
44.	I never had really close friends in high school.	TRUE	FALSE
45.	I believe that most light bulbs are powered by electricity.	TRUE	FALSE
46.	When I am alone, I often resent people telephoning me or knocking on my door.	TRUE	FALSE
47.	My emotional responses seem very different from those of other people.	TRUE	FALSE
48.	I sometimes become deeply attached to people I spend a lot of time with.	TRUE	FALSE
49.	Having close friends is not as important as many people say.	TRUE	FALSE
50.	On some mornings, I didn’t get out of bed immediately when I first woke up.	TRUE	FALSE
51.	It's fun to sing with other people.	TRUE	FALSE
52.	When I move to a new city, I feel a strong need to make new friends.	TRUE	FALSE
53.	A car ride is much more enjoyable if someone is with me.	TRUE	FALSE

Appendix E:
Evaluation to Sign Consent

PROCEDURE:
Make a subjective judgment regarding item 1 below. Ask the patient questions 2-6. The evaluator may select the language to use in asking the questions in order to help the patient understand them.

ITEMS: **SCORE**

1. Is the patient alert and able to communicate with the examiner? _____
   yes = 2 no = 0

2. Ask the patient to name at least two (2) potential risks incurred as a result of participating in the study. **0=not able to list potential risks, 1= able to list one risk, 2 =able to list two risks** _____

_____

_____

3. Ask the patient to name at least two (2) things that will be expected of him/her in terms of patient cooperation during the study. **0=not able to list expectations, 1= able to list one expectation, 2=able to list two expectations** _____

_____

_____

4. Ask the patient to explain what he/she would do if he/she decides that they no longer wish to participate in the study. **0=doesn't know, 1=answers but not the most appropriate response, 2=talk to any staff member** _____

_____

_____

5. Ask the patient to explain what he/she would do if he/she is experiencing distress or discomfort. **0=doesn't know, 1=answers but not the most appropriate response, 2=talk to any staff member** _____

_____

_____

6. Ask the patient to explain how medications (or treatments) are assigned during the study. 0=doesn't know, 1=answers but not the most appropriate response, 2=talk to any staff member _____

_____

_____

SIGNATURES:
I hereby certify that the above patient is alert, able to communicate and able to give acceptable answers to items 2,3,4,5 and 6 above.

Total Score _____

_____ __ __/__ __/__ __ __ __
(Evaluator Signature) (Date signed)

References

Addington, D., Addington, J., & Atkinson, M. (1996). A psychometric comparison of the Calgary Depression Scale for Schizophrenia and the Hamilton Depression Rating Scale. *Schizophrenia Research*, *19*, 205-212.

Addington, D., Addington, J., Maticka-Tyndale, E., & Joyce, J. (1992). Reliability and validity of a depression rating scale for schizophrenics. *Schizophrenia Research*, *6*, 201-208.

Addington, D., Addington, J., & Maticka-Tyndale, E. (1994). Specificity of the Calgary Depression Scale for schizophrenics. *Schizophrenia Research, 11*(3), 239–244.

Addington, J., Saeedi, H., Addington, D. (2006). Facial affect recognition: A mediator between cognitive and social functioning in psychosis? *Schizophrenia Research, 85*(1-3), 142-150.

Aguinis, H., Gottfredson, R. K., & Culpepper, S. A. (2013). Best-practice recommendations for estimating cross-level interaction effects using multilevel modeling. *Journal of Management, 39*, 1490-1528.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Anderson, J., Larsen, J. K., Schultz, V., Nielsen, B. M., Korner, A., Behnke, K., et al. (1989). The Brief Psychiatric Rating Scale: Dimension of schizophrenia— reliability and construct validity. *Psychopathology*, *22*, 168-176.

Archer, J., Hay, D.C., Young, A.W., 1994. Movement, face processing, and schizophrenia: evidence of a differential deficit in expression analysis. *British Journal of Clinical Psychology 33*, 517–528.

Ballon, J. S., Kaur, T., Marks, II, & Cadenhead, K. S. (2007). Social functioning in young people at risk for schizophrenia. *Psychiatry Research*, *151*(1-2), 29-35.

Behrens, T. E. J., Hunt, L. T., Woolrich, M. W., & Rushworth, M. F. S. (2008). Associative learning of social value. *Nature, 456*(7219), 245-249.

Blair, R. (2003). Facial expressions, their communicatory functions and neuro-cognitive substrates. *Philosophical Transactions of the Royal Society B: Biological Sciences, 358,* 561-572.

Blanchard, J. J., & Cohen, A. S. (2006). The structure of negative symptoms within schizophrenia: Implications for assessment. *Schizophrenia Bulletin, 32*(2), 238-245.

Blanchard, J.J., Horan, W.P., & Brown, S.A. (2001). Diagnostic difference in the temporal stability of social anhedonia: a longitudinal study of schizophrenia and major depressive disorder. *Journal of Abnormal Psychology, 110*, 363-317.

Blanchard, J. J., & Mueser, K. T., & Bellack, A. S. (1998). Anhedonia, positive and negative affect and social functioning in schizophrenia. *Schizophrenia Bulletin, 24(3),* 413-424.

Brekke, J., Kay, D. D., Lee, K. S., & Green, M. F. (2005). Biosocial pathways to functional outcome in schizophrenia. *Schizophrenia Research, 80*, 213-225.

Brothers, L. (1990). The social brain: A project for integrating primate behavior and neurophysiology in a new domain. *Concepts in Neuroscience, 1*, 27–61.

Cannon, M., Jones, P., Gilvarry, C., Rifkin, L., McKenzie, K., Foerster, A., & Murray, R. M. (1997). Premorbid social functioning in schizophrenia and bipolar disorder: Similarities and differences. *American Journal of Psychiatry, 154*, 1544-1550.

Carey, S., & Diamond, R. (1977). From piecemeal to configurational representation of faces. *Science, 195*, 312–314.

Chan, R. C., Li, H., Cheung, E. F., & Gong, Q. (2010). Impaired facial emotion perception in schizophrenia: A meta-analysis. *Psychiatry Research, 178*(2), 381–390.

Chapman, L.J., & Chapman, J.P. (1983). *The Infrequency Scale*. Unpublished test.

Chung, Y. S., Barch, D. M. (2011). The effect of emotional context on facial emotion ratings in schizophrenia. *Schizophrenia Research, 13*(1–3), 235–241.

Collaborative Working Group on Clinical Trial Evaluations (1998). Atypical antipsychotics for treatment of depression in schizophrenia and affective disorders. *Journal of Clinical Psychiatry, 59* (S 12), 41–45.

Collins, A. A., Remington, G., Coulter, K. , & Birkett, K. (1996). Depression in schizophrenia: a comparison of three measures. *Schizophrenia Research, 20*, 205–209.

Couture, S. M., Penn, D. L., & Roberts, D. L. (2006). The functional significance of social cognition in schizophrenia: A review. *Schizophrenia Bulletin, 32*(1), S44-S63.

Davidson, M., Reichenberg, A., Rabinowitz, J., Weiser, M., Kaplan, Z. & Mark, M. (1999). Behavioral and intellectual markers for schizophrenia in apparently healthy male adolescents. *American Journal of Psychiatry, 156,* 1328-1335.

Depue, R. A., & Morrone-Strupinsky, J. V. (2005). A neurobehavioral model of affiliative bonding: Implications for conceptualizing a human trait of affiliation. *Behavioral and Brain Sciences, 28*, 313-395.

DeRenzo, E. G., Conley, R. R. & Love, R. (1998). Assessment of capacity to give consent to research participation. *Journal of Health Care Law and Policy, 66*(1), 66-87.

Digman, J. (1990). Personality structure: Emergence of the five-factor model. *Annual Review of Psychology, 41*, 417–440.

Dworkin, R. H., Cornblatt, B. A., Friedmann, R., Kaplansky, L. M., Lewis, J. A., Rinaldi, A., … & Erienmeyer-Kimling, L. (1993). Childhood precursors of affective vs. social deficits in adolescents at risk for schizophrenia. *Schizophrenia Bulletin, 19*(3), 563-577.

Eack, S. M., Greeno, C. G., Pogue-Geile, M. F., Newhill, C. E., Hogarty, G. E., & Keshavan, M. S. (2010). Assessing social-cognitive deficits in schizophrenia with the Mayer-Salovey-Caruso emotional intelligence test. *Schizophrenia Bulletin, 36*(2), 370-380.

Eckblad, M. L., Chapman, L. J., Chapman, J. P., & Mishlove, M. (1982). *The Revised Social Anhedonia Scale*. Unpublished test, University of Wisconsin, Madison, WI.

Edwards, J., Jackson, H. J., & Pattison, P. E. (2002). Emotion recognition via facial expression and affective prosody in schizophrenia: A methodological review. *Clinical Psychology Review, 22,* 789-832.

Ekman, P. (2003). *Emotions revealed: Recognizing faces and feelings to improve communication and emotional life.* New York, NY: Times Books.

Ekman, P., Friesen, W. V. (1975). *Unmasking the Face*. Englewood Cliffs, NJ: Prentice-Hall.

Ekman, P., Roper, G., & Hager, J. C., (1980). Deliberate facial movement. *Child Development, 51*, 886-891.

Feldman Barrett, L., Mesquita, B., & Gendron, M. (2011). Context in Emotion Perception. *Current Directions in Psychological Science, 20*(5), 286-290.

Fett, A. J., Viechtbauer, W., Dominguez, M., Penn, D. L., van Os, J., & Krabbendam, L. (2011). The relationship between neurocognition and social cognition with functional outcomes in schizophrenia: A meta-analysis. *Neuroscience and Biobehavioral Reviews, 35*, 573-388.

First, M.B., Spitzer, R.L., Gibbon, M. & Williams, J.B.W. (1995). Structured clinical interview for DSM-IV axis I disorders. New York: New York State Psychiatric Institute.

Fiske, S. T. & Taylor, S. E. (1991). Social cognition (2nd ed.). New York: McGraw-Hill.

Frank, M. G., & Ekman, P. (1993). Not all smiles are created equal: The differences between enjoyment and nonenjoyment smiles. *Humor: The International Journal of Research in Humor, 6,* 9-26.

Frank, M. G., Ekman, P., & Friesen, W.V. (1993). Behavioral markers and recognizability of the smile of enjoyment. *Journal of Personality and Social Psychology, 64*, 83-93.

Gaebel, W., & Wolwer, W. (1992). Facial expression and emotional face recognition in schizophrenia and depression. *European Archives of Psychiatry and Clinical Neuroscience, 242*, 46-52.

Goldberg, R. W., Rollins, A. L., & Lehman, A. F. (2003). Social network correlates among people with psychiatric disabilities. *Psychiatric Rehabilitation Journal, 26*(4), 393-402.

Gosselin, P., Kirouac, G., & Doré, F. Y. (1995). Components and recognition of facial expression in the communication of emotion by actors. *Journal of Personality and Social Psychology, 68*(1), 83-96.

Green, M. F. (1996). What are the functional consequences of neurocognitive deficits in schizophrenia? *American Journal of Psychiatry, 153*, 321–330.

Green, M. F., Kern, R. S., Braff, D. L., & Mintz, J. (2000). Neurocognitive deficits and functional outcome in schizophrenia: Are we measuring the ‘‘right stuff’’? *Schizophrenia Bulletin, 26*, 119–136.

Green, M. F., Penn, D. L., Bentall, R., Carpenter, W. T., Gaebel, W., Gur, R. C., … Heinseen, R. (2008). Social cognition in schizophrenia: An NIMH workshop on definitions, assessment, and research opportunities. *Schizophrenia Bulletin, 34*(6), 1211-1220.

Green D.M., Swets, J.A. (1966). Signal detection theory and psychophysics. New York Wiley.

Harvey, P. D., Helldin, L., Bowie, C. R., Heaton, R. K., Olsson, A.K., Hjarthag, F., et al. (2009). Performance-based measurement of functional disability in schizophrenia: A cross-national study in the United States and Sweden. *American Journal of Psychiatry, 166*, 821–827.

Hans, S. L., Auerbach, J. G., Asarnow, J. R., Styr, B., and Marcus, J. (2000). Social Adjustment of Israeli Adolescents At-Risk for Schizophrenia: The Jerusalem Infant Development Study. *Journal of American Academy of Child and Adolescent Psychiatry, 39,* 11, 1406-1414.

Heimberg, C., Gur, R. E., Erwin, R. J., Shtasel, D. L., & Gur, R. C. (1992). Facial emotion discrimination: III. Behavioral findings in schizophrenia. *Psychiatry Research, 42*(3), 253-265.

Heerey, E. A. (2014). Learning from social rewards predicts individual differences in self-reported social ability. *Journal of Experimental Psychology: General, 143*(1), 332-229.

Horan, W. P., Kring, A. M., & Blanchard, J. J. (2006). Anhedonia in schizophrenia: A review of assessment strategies. *Schizophrenia Bulletin, 32*(2), 259-273.

Horan, W. P., Kring, A. M., Gur, R. E., Reise, S. P., & Blanchard, J. J. (2011). Development and psychometric validation of the Clinical Assessment Interview for Negative Symptoms (CAINS). *Schizophrenia Research, 132*(2-3), 140-145.

Hugenberg, K., & Sacco, D. F. (2008). Social categorization and stereotyping: How social categorization biases person and perception in face memory. *Social and Personality Psychology Compass*, *2*, 1052-1072.

Joshua, N., & Rossell, S. (2009). Configural face processing in schizophrenia. *Schizophrenia Research, 112*, 99-103.

Kee, K. S., Horan, W. P., Salovey, P., Kern, R. S., Sergi, M. J., Fiske, A. P., … Green, M. F. (2009). Emotional disturbances in schizophrenia. *Schizophrenia Research, 107*, 61-68.

Kirouac, G. & Doré, F. Y. (1983). Accuracy and latency of judgment of facial expressions of emotions. *Perceptual and Motor Skills, 57*, 683-686.

Kirkpatrick, B., Fenton, W., Carpenter, W. T., & Marder, S. R. (2006). The NIMH-MATRICS consensus statement on negative symptoms. *Schizophrenia Bulletin, 32*, 296–303.

Kohler, C. G., Turner, T. H., Bilker, W. B., Brensinger, C. M., Siegel, S. J., Kanes, S. J., … Gur, R. C. (2003). Facial emotion recognition in schizophrenia: Intensity effects and error pattern. *American Journal of Psychiatry, 160*(10), 1768-1774.

Kohler, C. G., Walker, J. B., Martin, E. A., Healey, K. M., & Moberg, P. J. (2010). Facial emotion perception in schizophrenia: A meta-analytic review. *Schizophrenia Bulletin, 36*(5), 1009-1019.

Kopelowicz, A., Ventura, J., Liberman, R. P., & Mintz, J. (2008). Consistency of Brief Psychiatric Rating Scale factor structure across a broad spectrum of schizophrenia patients. *Psychopathology*, *41*, 77-84.

Kraepelin, E. (1971). Dementia praecox and paraphrenia (1919). *Translated by Barclay RM. Huntingdon, NY, RE Krieger*.

Kring, A. M., & Campellone, T. R. (2012). Emotion perception in schizophrenia: Context matters. *Emotion Review, 4*(2), 182-186.

Kring, A., Gur, R., Blanchard, J. J., Horan, W. P., & Reise, S. (2013). The Clinical Assessment Interview for Negative Symptoms (CAINS): Final development and validation. *American Journal of Psychiatry, 170*, 165-172.

Kwapil, T. R. (1998). Social anhedonia as a predictor of the development of schizophrenia-spectrum disorders. *Journal of Abnormal Psychology, 107(4)*, 558- 565.

Lancon, C., Auquier, P., Reine, G. Bernard, D., & Addington, D. (2001). Relationships between depression and psychotic symptoms of schizophrenia during an acute episode and stable period. *Schizophrenia Research, 47*, 135–140.

Lee, J., Kern, R. S., Harvey, P-O, Horan, W. P., Kee, K. S., Ochsner, K., … & Green, M. F. (2013). An intact social cognitive process in schizophrenia: Situational context effects on perception of facial affect. *Schizophrenia Bulletin, 39*(3), 640-647.

MacCabe, J. H., Koupil, I., & Leon, D. A. (2009). Lifetime reproductive output over two generations in patients with psychosis and their unaffected siblings: The Uppsala 1915–1929 Birth Cohort Multigenerational Study. Psychological Medicine, 39, 1667–1676.

Malpass, R.S., & Kravitz, J. (1969). Recognition for faces of own and other race. *Journal of Personality and Social Psychology*, 13, 330–334.

Mandal, M. K., Pandey, R., & Prasad, A. B. (1998). Facial expressions of emotions and schizophrenia: A review. *Schizophrenia Bulletin, 24*(3), 399-412.

Matsumoto, D., & Hwang, H-S. (2010). Judging faces in context. *Social and Personality Psychology Compass, 3*, 1-10.

Mehta, U. M., Thirthalli, J., Subbakrishna, D. K., Gangadhar, B. N., Eack, S. M., & Keshavan, M. S. (2013). Social and neuro-cognition as distinct cognitive factors in schizophrenia: A systematic review. *Schizophrenia Research, 148*, 3-11.

Mishlove, M., & Chapman, L. J. (1985). Social anhedonia in the prediction of psychosis proneness. *Journal of Abnormal Psychology, 94*, 384-396.

Morlan, K. K., & Tan, S. (1998). Comparison of the Brief Psychiatric Rating Scale and the Brief Symptom Inventory. *Journal of Clinical Psychology*, *54*, 885-894.

Morris, S. E., Heerey, E. A., Gold, J. M., & Holroyd, C. B. (2008). Learning-related changes in brain activity following errors and performance feedback in schizophrenia. *Schizophrenia Research, 99*, 274–285.

Nuechterlein, K. H., & Green, M. F. (2006). MATRICS Consensus Cognitive Battery, Manual. Los Angeles, CA: MATRICS Assessment Inc.

Overall, J. E., & Gorham, D. R. (1962). The brief psychiatric rating scale. *Psychological Reports*, *10*, 799-812.

Pattinson, E. M., DeFrancisco, D., Wood, P., Frazier, H., & Crowder, J. (1975). A psychological kinship model for family therapy. *American Journal of Psychiatry, 132*, 1246-1251.

Penn, D. L., Corrigan, P. W., Bentall, R. P., Racenstein, J. M., & Newman, L. (1997). Social cognition in schizophrenia. *Psychological Bulletin, 121*(1), 114-132.

Penn, D. L., Sanna, L. J., & Roberts, D. L. (2008). Social cognition in schizophrenia: An overview. *Schizophrenia Bulletin, 34*(3), 408-411.

Poole, J. H., Tobias, F. C., Vinogradov, S. (2000). The functional relevance of affect recognition errors in schizophrenia. *Journal of the International Neuropsychological Society, 6*(5), 649-658).

Salamone, J. D., Correa, M., Farrar, A., & Mingote, S. M. (2007). Effort-related functions of nucleus accumbens dopamine and associated forebrain circuits. *Psychopharmacology, 191*, 461-482.

Sergi, M. J., Rassovsky, Y., Nuechterlein, K. H., & Green, M. F. (2006). Social perception as a mediator of the influence of early visual processing on functional status in schizophrenia. *Schizophrenia Research*, *163*, 448-454.

Shore, D. M., & Heerey, E. A. (2011). The value of genuine and polite smiles. *Emotion, 11*(1), 169-174.

Strauss, G. P., Keller, W. R., Buchanan, R. W., Gold, J. M., Fischer, B. A., McMahon, R. P., … Kirkpatrick, B. (2012). Next-generation negative symptom assessment for clinical trials: Validation of the Brief Negative Symptom Scale. *Schizophrenia Research, 142*(1-3), 88-92.

Tarbox, S., & Pogue-Geile, M. (2008). Development of social functioning in preschizophrenia children and adolescents: A systematic review. *Psychological Bulletin*, *134*(4), 561-583.

Tellegen, A., & Waller, N. (2008). Exploring personality through test construction: Development of the multidimensional personality questionnaire. In G. Boyle, G. Matthews, & D. Saklofske (Eds.), *The SAGE handbook of personality theory and assessment: Volume 2 — Personality measurement and testing* (pp. 261-293). London: SAGE Publications Ltd.

Twamley, E.W., Doshi, R.R., Nayak, G.V., & Palmer, B. (2002). Generalized cognitive impairments, ability to perform everyday tasks, and level of independence in community living situations of older patients with psychosis. *American Journal of Psychiatry, 159*, 2013–2020.

Van Den Stock, J., De Jong, S., Hodiamont, P., & De Gelder, B. (2011). Perceiving emotions from bodily expressions and multisensory integration of emotion cues in schizophrenia. *Social Neuroscience, 6*(5–6), 537–547.

Vaughn, C. E., & Leff, J. P. (1976). The influence of family and social factors on the course of psychiatric illness. A comparison of schizophrenic and depressed neurotic patients. *The British Journal of Psychiatry, 129*, 125-137.

Ventura, J., Lukoff, D., Nuechterlein, K. H., Liberman, R. P., Green, M., & Shaner, A. (1993). Appendix 1: Brief Psychiatric Rating Scale (BPRS) Expanded Version (4.0) scales, anchor points and administration manual. *International Journal of Methods in Psychiatric Research*, *3*, 227-243.

Westermeyer, J., & Pattinson, E. M. (1981). Social networks and mental illness in a peasant society. *Schizophrenia Bulletin, 7*, 125-134.

Wiersma, D., Wanderling, J., Dragomirecka, E., Ganev, K., Harrison, G., An Der Heiden, A., … Walsh, D. (2000). Social disability in schizophrenia: Its development and prediction over 15 years in incidence cohorts in 6 European centres. *Psychological Medicine, 30*, 1155-1167.

Zebrowitz, L. A., Kikuchi, M., & Fellous, J-M. (2010). Facial resemblance to emotions: Group differences, impression effects, and race stereotypes. *Journal of Personality and Social Psychology, 98*(2), 175-189.