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Using outcomes to inform social decision-making in schizophrenia: Implications for
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by

Timothy Ryan Campellone

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Abstract

Using outcomes to inform social decision-making in schizophrenia: Implications for motivation and functioning

by

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Doctor of Philosophy in Psychology

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The outcomes of decisions we make are integral for guiding our behavior. In this study, we investigated if and how people with and without schizophrenia use positive and negative social outcomes and social partners' emotional displays to inform decisions to trust as well as whether they could detect reversals in behavior even as emotion displays remained unchanged. Thirty-two people with schizophrenia and 29 control participants completed a task where they decided how much trust to place in social partners showing either a dynamic emotional (smiling, scowling) or neutral display. Interactions were designed to result in either positive (trust reciprocated) or negative (trust abused) outcomes, allowing us to model changes in decisions to trust over the course of repeated interactions. Compared to controls, people with schizophrenia were less sensitive to positive social outcomes as evidenced by their placing less trust in trustworthy social partners during initial interactions. On the other hand, people with schizophrenia were more sensitive to negative social outcomes during initial interactions with untrustworthy social partners, placing less trust in these partners compared to controls. Interestingly, people with schizophrenia were just as able as controls to detect reversals in social partners' behavior as it changed from trustworthy to untrustworthy, but were less able to detect changes in the untrustworthy to trustworthy direction. Importantly, decisions to trust were associated with real-world social functioning. We discuss the implications of these findings for understanding social engagement among people with schizophrenia and the development of psychosocial interventions for social functioning.

Using outcomes to inform social decision-making in schizophrenia: Implications for motivation and functioning

Decision-making is a part of daily life, with the outcomes of the decisions we make influencing our subsequent choices. Decisions that result in positive outcomes, such as receiving a compliment on a shirt you are wearing, will increase the likelihood of that decision being made in the future. However, recent research has shown that people with schizophrenia have difficulty using positive, rewarding outcomes to guide decisions (e.g. Heerey & Gold, 2007; Barch & Dowd, 2010), but appear to have few if any difficulties with using negative, punishing outcomes in decision-making (Gold et al., 2012; Strauss, Waltz, & Gold, 2014). We know considerably less, however, about how people with schizophrenia use *social* outcomes, whether rewarding or not, to inform decision-making in the context of social interactions. Indeed, difficulties using social outcomes to inform decision-making during interactions may contribute to poor social functioning common among people with schizophrenia (e.g. Robertson et al., 2014). In this study, we investigated the extent to which people with schizophrenia use more and less rewarding social outcomes to inform decision-making, and how this relates to motivation/pleasure negative symptoms and psychosocial functioning. Because social interactions often involve emotion, we also examined if and how people with schizophrenia use a social partner's emotional display to guide learning from social outcomes and subsequent decision-making.

Using outcomes to inform decision-making in schizophrenia

Most studies investigating how people with schizophrenia use outcomes, whether positive or negative, to inform decision-making have used reward-learning paradigms with monetary outcomes. Typically in these studies, participants complete a series of trials where the decisions made on a given trial result in either a positive (gain money) or negative (lose money) outcome. Thus, over the course of repeated trials, researchers can investigate the extent to which decision-making and behavior are informed by positive and negative outcomes. Results from these studies have consistently shown that compared to healthy controls, people with schizophrenia are less able to use positive outcomes to inform decision-making, and as a result are less likely to make subsequent decisions that will lead to positive outcomes (Waltz et al., 2007; Strauss et al., 2011; Gold et al., 2012). Difficulties using positive outcomes to inform decision-making may be most pronounced in people with schizophrenia who have more motivation/pleasure negative symptoms (Strauss et al., 2011; Gold et al., 2012). Furthermore, difficulties using positive outcomes to inform decision-making are associated with poorer functioning among people with schizophrenia (e.g. Somlai et al., 2011).

When it comes to negative outcomes, however, evidence suggests that people with schizophrenia are just as able to use these to inform decision-making as healthy controls. For example, when a decision results in a loss of money (negative outcome) in a reward-learning paradigm, people with schizophrenia use these outcomes to guide future decisions aimed at avoiding monetary loss (Gold et al., 2012; Strauss, Waltz, & Gold, 2014). Taken together, intact use of negative outcomes to inform decision-making

coupled with impaired use of positive outcomes has been called a “recipe for avolition” as people with schizophrenia are “capable of learning what *not to do* in order to avoid punishments, but not what *to do* in order to obtain rewards” (Strauss, Waltz, & Gold, 2014).

Although reward-learning paradigms have been integral in bolstering our understanding of how people with schizophrenia use outcomes to inform decision-making, the association between decision and outcome is not always consistent. Thus, researchers have also investigated what happens when the learned associations between decision and outcome switch or reverse such that a decision that once resulted in a positive outcome now results in a negative outcome, known as reversal learning. One important reason for studying reversal learning is to understand whether participants can flexibly adjust their decision-making once outcomes change, a situation that occurs frequently in daily life. For example, if that same shirt is now eliciting more negative comments than compliments, can that person flexibly adjust their decision-making about what to wear? Research suggests that while this type of flexibility in reversing decisions is not particularly difficult for healthy people, people with schizophrenia appear to be less able to flexibly update their decision-making once outcomes reverse (Lesson et al., 2009; McKirdy et al., 2009; Waltz & Gold, 2007).

Reversal learning has typically been investigated using probabilistic learning tasks whereby a highly reinforced (e.g., 80% of the time it is selected) option is reversed such that it is rarely reinforced (e.g., 20%). Using such a paradigm, Waltz & Gold (2007) found that people with schizophrenia detected fewer reversals than did controls. In other words, people with schizophrenia had difficulty altering their decisions when choices that once resulted in positive outcomes reversed and now resulted in negative outcomes. Further evidence for impaired reversal learning among people with schizophrenia comes from studies using non-probabilistic tasks. In these studies, participants chose between two options, with only one of the two options being correct. After several consecutive correct responses, the correct option switched so that the previously incorrect choice was now correct. Compared to controls, people with schizophrenia were more likely to choose the previously correct instead of the currently correct option, suggesting that they were less able to use the reversal in outcomes to guide decision-making (Leeson et al., 2009; McKirdy et al., 2009). Research on reversal learning in schizophrenia has primarily focused on the ability to learn reversals from previously positive outcomes to negative outcomes. However, it is unclear whether people with schizophrenia might also have difficulties learning reversals from previously negative outcomes to positive.

Decision-making in the social world

Of course, not all of the decisions we make in life involve money. Indeed, many everyday decisions are social in nature, yielding social outcomes. For example, if an exchange with a coworker with whom you haven’t spoken to before goes well, you may be more likely to interact with that person in the future. Thus, much in the same way that we can investigate how gaining or losing money influences future decision-making, we can also investigate how people use positive or negative social outcomes to inform decisions during social interactions. Social outcomes can also change over time, with positive social outcomes reversing and becoming negative. For example, if your

exchanges with the coworker sour, it may be adaptive to spend less time with that person, thus seeking them out less often in the future.

One type of decision made in the context of a social interaction is the decision to trust a social partner. Decisions to trust can result in a positive social outcome (e.g. your social partner reciprocates your trust) or a negative social outcome (e.g. your social partner abuses your trust). Furthermore, decisions to trust are not static, but dynamic in nature, changing as a function of whether the trust placed in a social partner is reciprocated or abused (Chang et al., 2010; Campellone & Kring, 2013). The reciprocation of trust by a social partner has been shown to activate similar brain regions as the receipt of other non-social rewards (King-Casas et al., 2005), suggesting that a partner's reciprocation of your decision to trust may be construed as similarly rewarding as receiving money.

Why is it important to study decisions to trust in people with schizophrenia? First, people with schizophrenia often have poor social functioning (e.g. Robertson et al., 2014). Poorer social functioning is linked with social isolation, which is especially important given findings of a recent meta-analysis that reported a link between social isolation and increased mortality (Holt-Lunstad et al., 2015). Thus, understanding factors that contribute to poorer social functioning among people with schizophrenia is a top priority. Second, despite having impoverished social networks, people with schizophrenia often report wanting more social contact (Bengtsson-Tops & Hansson, 2001). Increasing social networks, and by extension the social support available for people with schizophrenia is important because social support is predictive of recovery among people with severe mental illnesses such as schizophrenia (Tew et al., 2011; Corrigan & Phelan, 2004). Taken together, these findings suggest that poor social functioning among people with schizophrenia may necessarily reflect diminished desire for social relationships, but rather difficulties in building these relationships. Indeed, recent research suggests that people with schizophrenia have difficulties both establishing and maintaining trust during social interactions (e.g., Fett et al., 2012; Gromman et al., 2013). That is, people with schizophrenia are less likely to decide to trust a social partner as well as reciprocate the trust placed in them by a social partner. This could be due, in part, to difficulties using social outcomes to inform decisions to trust as well as to reciprocate trust.

The role of emotional displays

Social interactions provide additional sources of information to inform decisions to trust, such as a social partner's emotional display. Studies with healthy people have found that smiling displays promote affiliative tendencies in observers (e.g., Keltner & Bonanno, 1997), approach related behaviors (e.g., Knutson, 1996), acceptance (Heerdink et al., 2015), and of most relevance to the current study, decisions to trust during social interactions (e.g., Scharlemann et al., 2001). Smiles have also been shown to facilitate learning of a social partner's trustworthy behavior (Heerey, 2014). Scowling displays, on the other hand, signal rejection (Heerdink et al., 2015) and for others to keep their distance (Marsh et al., 2005). Scowls are also associated with less trust during social interactions (Campellone & Kring, 2013).

Despite being an important source of information for navigating the social world, people with schizophrenia have difficulty accurately labeling other people's emotional displays. A recent meta-analysis of 59 studies comparing people with and without

schizophrenia on tasks that required labeling facial emotion yielded an effect size of $d = .89$ (Kohler et al., 2010), suggesting fairly large group difference in deciphering and labeling emotional displays. Difficulties in accurately perceiving and labeling a social partner's emotional display may impede the ability of people with schizophrenia to utilize the information being signaled by an emotional display to guide decision-making.

Interestingly, however, there is also evidence to suggest that even though labeling emotional displays is problematic for people with schizophrenia, using the information being signaled by an emotional display to inform social judgments may be intact, at least in some circumstances. For example, when participants are asked to make ratings about faces that were preceded by positive or negatively stimuli, people with schizophrenia made comparable judgments of facial trustworthiness (Hooker et al., 2011; Kring et al., 2014) and valence (Lee et al., 2012) as did people without schizophrenia. That is, when faces were preceded by positive stimuli, both groups rated faces as more trustworthy and positive compared to when faces were preceded by negative stimuli. Thus, people with schizophrenia may be able to use the information signaled by emotional displays even if they are less able to explicitly label the emotion depicted on the face. In this study, we sought to elucidate whether people with schizophrenia are able to use the information signaled by an emotional display to inform decisions to trust.

Present Study

We had two overarching goals for the study. First, we sought to investigate how people with and without schizophrenia use positive and negative social interaction outcomes and social partner emotional displays to inform decision-making, specifically decisions to trust other social partners. Second, we examined the associations between decision-making, symptoms, and functioning among people with schizophrenia.

We tested several hypotheses. First, with respect to positive, rewarding interaction outcomes, we tested two hypotheses:

1a. People with schizophrenia will be less influenced by rewarding social interaction outcomes and will thus place less trust in trustworthy social partners compared to controls.

1b. When previously negative social interaction outcomes reverse and become rewarding, people with schizophrenia will be less influenced by these now rewarding social interaction outcomes and place less trust in previously untrustworthy social partners. In other words, people with schizophrenia will exhibit difficulties in learning the change in social partner behavior from untrustworthy to trustworthy, and as a result place comparatively less trust in now trustworthy social partners.

Second, with respect to negative, less rewarding social interaction outcomes, we tested two hypotheses:

2a. People with and without schizophrenia will be similarly influenced by negative social interaction outcomes, as evidenced by placing less trust in untrustworthy social partners.

2b. When previously rewarding social interaction outcomes reverse and become negative, people with schizophrenia will be less influenced by the now negative social interaction outcomes and place more trust in formerly trustworthy, now untrustworthy social partners compared to controls.

Third, with respect to the role of emotional display, we tested competing

hypotheses.

3a. On one hand, given evidence that people with schizophrenia have difficulty perceiving facial emotion (Kohler et al., 2010), we hypothesized that people with schizophrenia will be less influenced by social partners' emotional displays as evidenced by placing similar amounts of trust in social partners with emotional and non-emotional displays compared to controls.

3b. On the other hand, based on the more limited evidence suggesting that people with schizophrenia are able to use emotional information to inform social judgments (e.g. Hooker et al., 2011; Lee et al., 2011; Kring et al., 2013), we hypothesized that people with and without schizophrenia will be similarly influenced by social partners' emotional displays as evidenced by placing comparable amounts of trust in social partners with emotional displays.

Finally, we examined the relationship between trust placed in trustworthy and untrustworthy social partners with motivation/pleasure negative symptoms and real-world functioning.

Methods

Participants

Thirty-two people meeting DSM-IV-TR (American Psychiatric Association, 2000) criteria for schizophrenia (n= 20) or schizoaffective disorder (n= 12)¹ and 29 healthy controls were recruited from outpatient mental health clinics and community advertisements. Participants were between the ages of 18 and 60, had no history of neurological disorders or serious head trauma, were fluent in English, had an estimated IQ > 70, and did not meet criteria for depression, mania, hypomania, or substance abuse in the past month or substance dependence in the last six months. Twenty-nine people in the schizophrenia group were taking medications; of these, 26 were taking atypical anti-psychotics.

Clinical Assessment

Trained interviewers confirmed diagnoses using the Structured Clinical Interview for DSM-IV (SCID; First et al., 1996). For people with schizophrenia, we assessed motivation/pleasure and expressivity negative symptoms using the Clinical Assessment Interview for Negative Symptoms (CAINS; Kring et al., 2013). General symptoms were assessed with the 24-item Brief Psychotic Rating Scale (BPRS; Lukoff et al., 1986). Functioning in the areas of work, self-care, family, and social was assessed with the Role Functioning Scale (RFS; McPheters, 1984).

Cognitive Assessment

Previous research has found that difficulties using rewarding outcomes to inform decision-making were related to poor working memory among people with schizophrenia (e.g. Heerey et al., 2008). To account for any effect of working memory, we administered the Digit Span Test from the Wechsler Adult Intelligence Scale-IV (WAIS-IV; Wechsler, 2008). We computed a digit span total score, which was the sum of the number of correct trials in both the forward and backwards conditions. Two people with schizophrenia and

two controls did not complete the Digit Span Test. We estimated full-scale IQ with the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). Demographic, clinical, and cognitive functioning data are presented in Table 1.

Social Decision-Making Paradigm – Modified Trust Game

After providing informed consent, participants played a modified version of the Trust Game (see Campellone & Kring, 2013) created using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) and presented on a laptop computer. Participants were told that they would be playing a computer game with different social partners, with the purpose of the game being to learn about how people make decisions during social interactions. Prior to beginning the game, participants completed four example trials to help orient them to the game structure and to make sure that they fully understood the instructions.

During the game, participants interacted with four simulated social partners, each identified by name and a dynamic 5s clip of them expressing either an emotional (smile or scowl) or neutral facial display. Social partners were given names (Bill, Jane, Sue, and Dan) in an attempt to increase the social nature of the interaction. After seeing the partner's name and display, participants decided how many points to send to this partner, choosing an amount between 0 and 10 on the keyboard. This part of the task was untimed, allowing participants to take as much time as needed to decide how many points to give (i.e. how much to trust) the social partner. The amount of points sent by the participant was then quadrupled, increasing the total number of available points. At this point, the social partner returned some of the quadrupled amount of points (between 0 and 40 points) to the participant. In the context of this game, the amount of points sent by a participant represents how much he/she trusted that a social partner would honor his/her trust and return points (see Figure 1a).

Social partner behavior was predetermined so that two partners were trustworthy, meaning that the outcomes of these interactions were positive or rewarding. The trustworthy partners returned, on average, double the amount of points sent by a participant. The other two partners were untrustworthy, meaning that outcomes of these interactions were negative or non-rewarding. The untrustworthy partners returned, on average, half of the amount of points sent by a participant. To illustrate, a trustworthy social partner, when given 6 points by a participant, would return an average (i.e., across all trials with this social partner) 12 of the 24 possible points. By contrast, an untrustworthy partner would return an average of 3 of the 24 points. For the purpose of clarity, we will henceforth refer to the amount of points sent to a social partner as the amount of trust placed. The total amount of points a participant received did not accumulate across trials and was reset after each interaction. The order of interactions was pseudo-randomized so that participants never interacted with the same partner on consecutive trials.

Social Partner Emotional Displays

Social partner emotional displays consisted of dynamic, 5s video clips of actors from the Amsterdam Dynamic Facial Expression Set (ADFES; Van der Schalk et al., 2011). Actors displaying emotions received instruction from coaches trained in the Facial Action Coding System (FACS; Ekman, Friesen, and Hagar, 2002). We chose 4 actors (2 men, 2 women), with one member of each gender expressing an emotion and the other

expressing no emotion (i.e., a neutral display). Pairing of social partner gender and emotional display was counterbalanced so that half the sample saw a male actor scowling and female actor smiling while the other half saw a male actor smiling and female actor scowling. Emotional and neutral actor videos were matched based on ratings from an independent sample (n=12) using a 1 (not at all) to 5 (very much) scale. The male and female videos were comparable on rated attractiveness (Smiling man: M=3.67, Smiling woman: M=3.75, Scowling man: M=2.25, Scowling woman: M=2.25, Neutral man: M=3.08, Neutral woman: M=3.17), trustworthiness (Smiling man: M=3.92, Smiling woman: M=4.00, Scowling man: M=2.00, Scowling woman: M=2.33, Neutral man: M=3.25, Neutral woman: M=3.25), and emotional intensity (Smiling man: M=3.67, Smiling woman: M=3.92, Scowling man: M=2.92, Scowling woman: M=3.25, Neutral man: M=2.25, Neutral woman: M=2.00)

Trust Game Phases

Our modified Trust Game consisted of two phases (see Figure 1b). During the *initial phase*, participants interacted with four different social partners over the course of repeated interactions. Two of the social partners were trustworthy, with one of these exhibiting a dynamic smile and the other exhibiting no emotion (i.e., neutral display). The other two social partners were untrustworthy with one exhibiting a dynamic scowl and the other no emotion. Each social partner exhibited the same display for all interactions. Participants interacted with each social partner 10 times for a total of 40 initial phase trials. At the end of the initial phase, participants rated the trustworthiness of each social partner using a 1 (not at all) to 7 (very much) scale. This allowed us to assess trust using a multi-method approach: behaviorally (decision-making) as well as self-report.

During the *reversal phase*, participants interacted with the same four social partners. However, social partner behavior, and as a result interaction outcomes, reversed. That is, both the smiling and neutral trustworthy partners now behaved in an untrustworthy manner (i.e., they now returned, on average, less than half the points a participant sent), and thus the outcomes of these social interactions were now negative or not rewarding. The scowling and neutral untrustworthy partners, on the other hand, now behaved in a trustworthy manner (i.e., they returned, on average, more than half the points a participant sent), and thus the outcomes of these interactions were now positive or rewarding. Participants interacted with each partner 12 times for a total of 48 reversal phase trials. We included two extra trials in the reversal phase to provide participants additional opportunities to pickup changes in social partner behavior. All participants completed the initial phase first, followed immediately by the reversal phase. At the end of the reversal phase, participants again rated the trustworthiness of each social partner using a 1 (not at all) to 7 (very much) scale.

Statistical Analysis Plan

To investigate how people with and without schizophrenia use social interaction outcomes and partner emotional displays to inform decisions to trust, we conducted two separate piecewise linear mixed effects regression models predicting decisions to trust (1) trustworthy social partners and (2) untrustworthy social partners. Mixed effects refer to our inclusion of both fixed (i.e. time invariant) and random (i.e. time variant) predictors

of the amount of trust placed in social partners (e.g. McArdle & Nesselroade, 2003). Models were based on a piecewise analysis of time, which allowed us to break time into multiple discrete periods rather than as a single coefficient. Specifically, the initial and reversal trust game phases were modeled as discrete time periods and were represented by separate time variables with separate coefficients and slopes. Initial phase data were coded so that we could examine the effect of time in the initial phase while holding the reversal phase constant. Reversal phase data were coded to control for any effects of the initial phase.

Within our models predicting decisions to trust either trustworthy or untrustworthy social partners across the initial and reversal phases, there were two types of predictors: those that were phase-specific and those that were non-phase specific, which are also called reference effects. Reference effects are considered non-phase specific predictors in the model because they provide effect estimates for decisions to trust across *both* phases. In our model, the reference effects were the variables group (control, schizophrenia), display (emotional [smile/scowl], neutral), and the Group X Display interaction. Group is the effect estimate of having schizophrenia on decisions to trust across both the initial and reversal phases and display is the effect estimate of seeing a partner with an emotional display on decisions to trust across both phases. All other main and interaction effects in the models are phase-specific and refer to either the initial or reversal phase. Model analyses were conducted using the lme4 library of R statistical software (R Core Team, 2013). For significant effects, unstandardized beta coefficient estimates, standard errors, and effect sizes (Cohen's *d*) are reported. We computed Cohen's *d* using the between-groups *t*-test value, $d = t(2/n)$, as recommended by Dunlap et al., (1996).

To further investigate how people with and without schizophrenia use social interaction outcomes and partner emotional displays to inform decisions to trust, we investigated whether post-phase ratings of social partner trustworthiness corroborated trust behavior (i.e., points sent) during the modified Trust Game. That is, in addition to investigating our hypotheses by modeling decisions to trust trustworthy and untrustworthy social partners, we also examined trustworthiness ratings made after both the initial and reversal phases.

To investigate the relationships between decision-making, motivation/pleasure negative symptoms, and functioning among people with schizophrenia, we computed zero-order correlations between the amount of trust placed in trustworthy and untrustworthy social partners, CAINS MAP scale, and the RFS for the initial and reversal phases separately.

Results

Gender, education, age, and estimated full-scale IQ were not significantly different between people with and without schizophrenia nor were they related to any study variables. There were neither gender differences within groups in decisions to trust trustworthy or untrustworthy social partners nor any interaction between participant and social partner gender. Further, people with and without schizophrenia did not differ on the digit span, $t(57) = 1.56, p = .12$.

As a manipulation check to see whether participants were able to recognize the differences in social partner behavior, we conducted within-group *t*-tests comparing the

amount of trust participants placed in trustworthy versus untrustworthy social partners during the initial phase of the task. We collapsed across displays and computed the amount of trust placed across initial phase interactions since the primary aim was to examine whether participants were able to ascertain the behavior of social partners. Both people with and without schizophrenia placed significantly greater trust (i.e., sent more points) in trustworthy social partners (HC: $M = 6.35$, $SD=1.56$; SZ: $M = 5.67$, $SD=2.21$) than untrustworthy (HC: $M = 3.91$, $SD=2.10$; SZ: $M = 3.61$, $SD=1.46$) social partners (HC: $t(29) = 5.86$, $p < .01$, SZ: $t(31) = 6.17$, $p < .01$). Thus, both people with and without schizophrenia were able to differentiate between trustworthy and untrustworthy social partners, insofar as they decided to place more trust in trustworthy social partners more than untrustworthy social partners.

Interactions with Trustworthy Social Partners

For the purpose of clarity, we will present the piecewise linear mixed effect regression model results for the reference effects first and then present the model results for the initial phase followed by model results for the reversal phase.

The reference effect of group was not significant for the interactions with trustworthy social partners, suggesting that people with schizophrenia did not differ from controls in their decisions to trust across *both* the initial and reversal phases. The reference effect for display was marginally significant ($p = .06$), suggesting both people with and without schizophrenia tended to trust smiling partners more than neutral partners across both the initial and reversal phases. The Group X Display interaction reference effect was not significant.

Initial Phase. To test our hypothesis that people with schizophrenia would be less influenced by rewarding social interaction outcomes as evidenced by decisions to place less trust in trustworthy social partners compared to controls, we found a significant time main effect ($B = .06$, $SE = .02$, $p = .01$, $d = .09$) that was qualified by a significant Group X Time interaction, $B = -.09$, $SE = .03$, $p = .01$, $d = .09$. As shown in Figure 2a, people with schizophrenia decided to place less trust in smiling and neutral trustworthy social partners over the course of repeated interactions, suggesting that their decisions to trust trustworthy social partners were less influenced by rewarding social interaction outcomes compared to controls, regardless of emotional display. This finding was corroborated by participants' trustworthiness ratings made at the end of the initial phase. Specifically, people with schizophrenia rated both smiling and neutral partners during the initial phase as significantly less trustworthy, (Smiling trustworthy partner: $t(59) = 3.07$, $p < .01$, Neutral trustworthy partner: $t(59) = 2.00$, $p = .05$; see Table 3) than did controls.

Reversal Phase. To test our hypothesis that people with and without schizophrenia would be similarly influenced by negative outcomes from interactions with now untrustworthy social partners, we modeled decisions to trust during the reversal phase during which the behavior of trustworthy social partners reversed such that they now behaved in an untrustworthy manner. We found a significant time main effect ($B = -.18$, $SE = .03$, $p < .01$, $d = .20$), but the Group X Time interaction was not significant. We did, however, find a significant Time X Display interaction, $B = -.07$, $SE = .02$, $p < .01$, $d = .10$, as well as a significant Group X Time X Display interaction, $B = .08$, $SE = .03$, $p = .01$, $d = .09$ ². Despite the change in partner behavior, people with schizophrenia did not place less trust in smiling now untrustworthy partners over the course of repeated

interactions during the reversal phase, whereas controls did (see Figure 2b). That is, compared to controls, people with schizophrenia appeared to be less influenced by the change in the smiling social partner's behavior, and as a result placed comparatively greater trust in now untrustworthy smiling social partners.

This interaction was not supported by trustworthiness ratings made at the end of the reversal phase. Specifically, both groups rated the smiling and neutral formerly trustworthy social partners as being equally trustworthy (Smile: $t(59) = -.11, p = .91$, Neutral: $t(59) = 1.28, p = .21$; see Table 3). Thus, we observed a disconnection between the amount of trust placed in social partners during the reversal phase and ratings of partner trustworthiness among people with schizophrenia.

Both groups, however, rated the now untrustworthy social partners as less trustworthy than when they behaved in trustworthy manner. That is, both people with and without schizophrenia rated currently untrustworthy social partners as less trustworthy than when those same players behaved in a trustworthy manner during the initial phase (HC: Smiling, $t(28) = 6.59, p < .01$, Neutral, $t(28) = 4.38, p < .01$; SZ: Smiling, $t(31) = 2.57, p < .01$, Neutral, $t(31) = 3.39, p < .01$).

Interactions with Untrustworthy Social Partners

We conducted another piecewise linear mixed effects regression model for interactions with untrustworthy social partners. The reference effect of group was marginally significant ($p = .08$), indicating that controls tended to place greater trust in scowling and neutral social partners, regardless of their behavior. The reference effect of display was not significant nor was the Group X Display interaction.

Initial Phase. Inconsistent with our hypothesis that both groups would be similarly influenced by negative social outcomes during the initial phase, we found a significant time main effect ($B = .06, SE = .02, p = .01, d = .09$) that was qualified by a significant Group X Time interaction, $B = -.11, SE = .03, p < .01, d = .10$ (see Figure 2c). Compared to controls, people with schizophrenia placed *less* trust in untrustworthy social partners over the course of repeated interactions. Stated differently, people with schizophrenia appeared to demonstrate greater sensitivity than controls to negative social interaction outcomes. The Group X Display X Time interaction was not significant, $B = -.02, SE = .03, p = .59$.

Our finding of greater sensitivity to negative social interaction outcomes among people with schizophrenia was partially corroborated by ratings of trustworthiness made at the end of the initial phase. Compared to controls, people with schizophrenia rated the scowling, but not neutral social partners, as less trustworthy, $t(59) = 2.68, p = .01$. Thus, while people with schizophrenia placed comparatively less trust in both untrustworthy social partners over the course of repeated interactions compared controls, only their ratings of the scowling social partner's trustworthiness was significantly different from ratings of the controls.

Reversal Phase. To investigate our hypothesis that people with schizophrenia would place less trust in now trustworthy social partners compared to controls, we modeled decisions to trust during the reversal phase, where the untrustworthy behavior of social partners reversed such that these partners now behaved in a trustworthy manner, resulting in interactions with rewarding outcomes. We found a significant time main effect, $B = .16, SE = .03, p < .01, d = .16$, but no significant Group X Time interaction

(see Figure 2d). Contrary to expectations, people with and without schizophrenia did not differ in their decisions to trust now trustworthy social partners over the course of repeated interactions in the reversal phase. This suggests that people with and without schizophrenia were equally sensitive to the reversal of partner behavior. In other words, both groups detected that formerly untrustworthy partners were now behaving in a trustworthy manner. The Group X Time X Display interaction was not significant.

The lack of group differences in trust behavior was supported by ratings of social partner trustworthiness, which showed that both people with and without schizophrenia rated the now trustworthy social partners comparably. In addition, both people with and without schizophrenia reported trusting the now trustworthy partners more after the reversal phase than when they behaved in an untrustworthy manner during the initial phase, (HC: Scowling, $t(28) = -5.12, p < .01$, Neutral, $t(28) = -4.87, p < .01$; SZ: Scowling, $t(31) = -4.56, p < .01$; Neutral, $t(31) = -2.24, p = .03$).

Correlations between Trust, Symptoms, and Functioning

The amount of trust placed in smiling or neutral trustworthy social partners during either the initial or reversal phase was not associated with digit span performance, or general symptoms as measured by the BPRS (see Table 3). Interestingly and unexpectedly, illness duration (measured as the number of years since a person with schizophrenia reported first seeking treatment for symptoms or was first hospitalized) was associated with negatively correlated with trust placed trustworthy social partners during both the initial and reversal phase. This suggests that there may be something about the experience of having schizophrenia for longer periods of time that is related to difficulties using rewarding social outcomes to inform decision to trust, a point we expand upon in the discussion.

We computed correlations between the average amount of trust placed in trustworthy and untrustworthy social partners during each phase, negative symptoms, and real-world functioning for people with schizophrenia. As shown in Table 3, greater trust placed in trustworthy social partners during both the initial and reversal phases was associated with fewer motivation/pleasure negative symptoms. Greater trust during both phases was also associated with greater social network functioning. Further, greater trust placed in a formerly untrustworthy social partner during the reversal phase was associated with greater family functioning. Given that we found an inverse relationship between the amount of trust placed in trustworthy social partners and duration of illness, we also computed these same correlations partialing out the effect of illness duration. These correlations remained significant even after partialing out the illness duration. Thus, greater ability to use positive outcomes to inform decision-making in both phases was associated with greater motivation/pleasure negative symptoms and social functioning for people with schizophrenia.

By contrast, the relationship between the amount of trust placed in untrustworthy social partners during the initial and reversal phases was not associated with motivation/pleasure negative symptoms (see Table 4). However, greater trust placed in untrustworthy social partners in both phases was associated with greater social network functioning. While unexpected, this finding suggests that participants who placed more trust in social partners, regardless of whether the partners were trustworthy or untrustworthy, are likely to function better in their social networks.

Discussion

In this study, we investigated how people with and without schizophrenia used social interaction outcomes to inform decisions to trust, and whether a social partner's emotional display would help guide decision-making. People with schizophrenia often have poor social functioning and decreased social networks despite a desire for more social contact in their everyday lives. By using a social decision-making paradigm, we were able to study one aspect of social functioning and assess whether difficulties using social interaction outcomes and emotional displays to inform decisions to trust is problematic for people with schizophrenia. Further, we investigated whether people with schizophrenia are able to flexibly adjust their decision-making when social partner behavior changes, which is another adaptive aspect of healthy social functioning.

We found that people with schizophrenia were less influenced than controls by positive social interaction outcomes while first interacting with trustworthy social partners as indicated by their decisions to place less trust in these trustworthy social partners. Furthermore, people with schizophrenia had difficulty updating their decisions when the behavior of smiling, trustworthy partners changed and became untrustworthy. Placing less trust in trustworthy social partners was associated with more motivation/pleasure negative symptoms and a longer duration of illness.

We also found that people with schizophrenia were more sensitive to negative social interaction outcomes as evidenced by deciding to place less trust in untrustworthy social partners over the course of repeated interactions. Unexpectedly, however, people with schizophrenia were just as influenced as controls by the outcomes of interactions with formerly untrustworthy partners whose behavior changed and became trustworthy. Greater amounts of trust placed in social partners, regardless of behavior, was related to greater real-world social network functioning.

Positive Social Interactions Outcomes

In support of our hypothesis, we found that people with schizophrenia were less influenced than controls by the positive, rewarding outcomes from interactions with trustworthy social partners. This finding was corroborated by ratings of trustworthiness, as people with schizophrenia rated both smiling and neutral trustworthy partners as less trustworthy than did controls. Thus, using behavioral (decision-making) and self-report (ratings) methods, we found that people with schizophrenia were comparatively less able to use the positive outcomes from social interactions with trustworthy partners to inform decision-making and ratings. Interestingly, we did not find any group differences in decisions to trust neutral versus smiling trustworthy social partners, suggesting that difficulties in using positive outcomes to inform decision-making among people with schizophrenia were not necessarily due to a failure to use the information signaled by emotional displays. In fact, both groups tended to place more trust in smiling compared to neutral social partners, regardless of partner behavior, suggesting that the information signaled by a smile may have helped guide decisions in both groups. Stated differently, seeing a smiling social partner during the set of initial interactions similarly influenced decisions to trust made by people with and without schizophrenia.

Previous research indicates that people with schizophrenia can have difficulties establishing trust with a social partner (Fett et al., 2012; Gromman et al., 2013), and our

results suggest that this may be due in part to difficulties using positive social interaction outcomes to inform and guide decisions to trust during these initial interactions. Trust is an important building block for social relationships, and difficulties using positive interaction outcomes to inform decisions to trust may impede the formation of relationships among people with schizophrenia. Indeed, we found that less trust placed in trustworthy partners was associated with poorer social network functioning, suggesting that difficulties establishing trust has implications for the real-world social lives of people with schizophrenia. That is, our findings suggest that people with schizophrenia may be reluctant to trust when meeting someone for the first time, and as a result may miss an opportunity to establish a relationship with a potentially trustworthy person.

We also found that difficulties using positive interaction outcomes to inform decisions to trust were associated with more motivation/pleasure negative symptoms. Negative symptoms have been shown to be a strong predictor of social functioning (e.g. Robertson et al., 2014), and our findings suggest the intriguing possibility that the relationship between negative symptoms and social functioning may be moderated by difficulties in using positive outcomes to guide decisions to trust. Future studies should seek to further elucidate the relationships between decisions to trust, social functioning and negative symptoms among people with schizophrenia.

Equally important as establishing trust is the ability to flexibly adjust decision-making, such as when previously untrustworthy social partners start behaving in a trustworthy manner. In this study, we were able to not only assess how much people with schizophrenia decide to trust trustworthy social partners initially, but also whether they could detect the change from untrustworthy to trustworthy behavior and adjust their trust decisions accordingly. Unexpectedly and contrary to our hypothesis, people with schizophrenia were just as able to look past a social partner's history of untrustworthy behavior and use now positive interaction outcomes to inform their decisions to trust. In other words, people with schizophrenia placed just as much trust in formerly untrustworthy social partners as did controls once they started behaving in a trustworthy manner, and this was true whether the social partner was scowling or neutral. This finding was corroborated by people with schizophrenia rating the trustworthiness of previously untrustworthy, but now trustworthy social partners at the same level as controls. Moreover, less trust placed in the now trustworthy social partners was associated with more motivation/pleasure negative symptoms and worse social functioning among people with schizophrenia. Thus, whether a social partner has always been trustworthy or is "trying to change their ways," people with more motivation/pleasure negative symptoms placed less trust in trustworthy social partners, and this diminished trust may negatively impact daily social life.

At first glance, these findings appear inconsistent with reversal learning studies with monetary outcomes, which have consistently observed impairments in people with schizophrenia (e.g., Waltz & Gold, 2007). However, our study differs from these prior studies in two key ways. First, most prior reversal learning studies have assessed changes in decision outcomes as they switch from more positive to less positive. In our study, we extended the investigation of reversal learning to include social outcomes as well as reversals from negative to positive, and we found that people with schizophrenia were able to update their decisions when social outcomes reversed from negative (untrustworthy) to positive (trustworthy). Second, our reversal created a mismatch

between the information signaled by social partner emotional display and behavior. That is, during the reversal phase, social partners' behavior changed but their emotional displays did not (i.e., scowling untrustworthy partners reversed and became scowling trustworthy partners). Our findings indicate that both people with and without schizophrenia were able to look past the scowling emotional displays and base trust decisions on the now trustworthy behavior. Furthermore, that decisions to trust did not differ between scowling versus neutral trustworthy partners suggest that reversal learning was not impacted by the mismatch between display and behavior but was instead guided by behavior.

Broadly speaking, these results suggest that people with schizophrenia are able, to the same extent as healthy controls, place trust in someone with a history of untrustworthy behavior, regardless of their emotional display. This raises the question of why people with schizophrenia are impaired in their ability to initially build trust with trustworthy social partners, but not in their ability to give formerly untrustworthy social partners a "second chance."

To summarize, people with schizophrenia were less sensitive to positive social interaction outcomes during initial encounters with a social partner. One consequence of this could be a failure of these positive outcomes to guide decisions and behavior towards future interactions with positive social partners. Thus, people with schizophrenia may be missing opportunities to expand their social networks and increase social support. Interestingly, people with schizophrenia appear able to look past a history of negative interaction outcomes and embrace social partners whose behavior changed to become more positive. This suggests an intact ability to flexibly adjust social decision-making, which may prove to be adaptive for both establishing and maintaining social relationships.

Negative Social Interaction Outcomes

While people with schizophrenia were comparatively less sensitive to positive, rewarding outcomes when first interacting with trustworthy social partners, our results suggest that they were *more* sensitive to negative outcomes as indicated by their deciding to trust untrustworthy social partners less than controls over the course of repeated interactions. While studies using reward-learning paradigms with monetary outcomes have found no group differences (Gold et al., 2012; Strauss, Waltz, & Gold, 2014) our findings suggest that people with schizophrenia are comparatively better at using negative *social* interaction outcomes to inform decision to trust. Consistent with our findings for positive social interaction outcomes, emotional display did not appear to influence decisions to trust as both people with and without schizophrenia placed less trust in untrustworthy social partners, regardless of emotional display. However, social partner emotional displays did influence ratings as people with schizophrenia rated the scowling, but not neutral partner, as less trustworthy compared to controls. Thus, these findings provide evidence from both behavioral (decision-making) and self-report (ratings) methods for greater sensitivity to negative outcomes among people with schizophrenia.

Decisions to trust untrustworthy social partners, even if misplaced, were also related to real-world social network functioning among people with schizophrenia. In other words, placing more trust in *untrustworthy* social partners was associated with

better social functioning among people with schizophrenia. Why would placing more trust in untrustworthy social partners be associated with better social functioning? Future work is needed to untangle this paradoxical finding. It may be the case, for example, that people with schizophrenia who place greater trust in other people, regardless of their behavior, will better be able to form social relationships, and thus have greater opportunities for social interactions. Indeed, work in healthy people suggests that placing trust in and reciprocating the trust of others contribute to the formation and maintenance of healthy, close social relationships (van Winden, Stallen, & Ridderinkhof, 2008; Fareri & Delgado, 2014).

We also assessed whether or not people with schizophrenia could flexibly adjust their decisions when previously trustworthy social partners start behaving in an untrustworthy manner. Unexpectedly, we found that people with schizophrenia placed comparatively *greater* trust in now untrustworthy-behaving social partners, but only for those who were also smiling. Indeed, the groups did not differ in the amount of trust placed in neutral, now untrustworthy partners. These findings were not supported by ratings, which showed people with schizophrenia rated the trustworthiness of smiling and neutral untrustworthy social partners at the same level as controls. Even though people with schizophrenia were just as able as controls to look past a scowl to adjust decisions to trust a now trustworthy social partner, they appeared less able to look past a smile to adjust their decisions to place less trust in a now untrustworthy social partner.

Whereas people with schizophrenia were just as able as controls to pick-up on reversals going from negative (untrustworthy) to positive (trustworthy) direction, our findings suggest that difficulties in reversal learning may lie only in the positive to negative direction, which is consistent with other studies of reversal learning (e.g. Leeson et al., 2009; McKirdy et al., 2009). However, we only found group differences in reversal learning during interactions with social partners where there was a mismatch between emotional display (smile) and behavior (untrustworthy), suggesting that reversal-learning difficulties among people with schizophrenia may have been in part due to the mismatch between display and behavior. Given the magnitude of reversal learning impairments reported by previous studies (e.g. Leeson et al., 2009; McKirdy et al., 2009), it will be important for future studies to replicate our findings as they suggest that reversal learning of social interaction outcomes to inform decision-making among people with schizophrenia is not as severely impaired.

Why did people with schizophrenia continue to trust smiling social partners even after these partners changed course and began behaving in an untrustworthy manner? One possibility is that the mismatch between the information signaled by emotional display (smile) and behavior (untrustworthy) may have been hard for people with schizophrenia to look past. Indeed, we found a trend for smiling (but not scowling) displays to influence decisions to trust in both people with and without schizophrenia. It will be important for future research to investigate whether people with schizophrenia are better able to look past negative emotional stimuli to use positive outcomes to guide behavior compared to looking past positive emotional stimuli to use negative outcomes using this or a related paradigm (e.g. Emotional Go/No Go Task; Murphy et al., 1999; Schulz et al., 2007). By better understanding whether people with schizophrenia are better at inhibiting certain kinds of emotional information when making decisions, we might better be able to predict what kinds of social interactions will be most problematic. A somewhat trivial but

nevertheless real-life example of this scenario is buying a used car. Indeed, difficulties looking past a smile paired with untrustworthy behavior could make buying a used car more challenging for people with schizophrenia as the salesman uses their smiling display to hide their untrustworthy intention of getting you to overpay for your car.

Previous reversal learning studies have tended to use dichotomous measures of reversal learning, assessing whether participants did or not successfully pick up on outcome reversals (e.g. Waltz et al., 2007; Leeson et al., 2009; McKirdy et al., 2009). That is, prior probabilistic and non-probabilistic reversal learning studies typically include the number of correct/incorrect reversals (e.g., the number of trials participants chose the reversed option once the outcomes reversed) or number of reversal errors (e.g. number of trials where the previously rewarded option was chosen). This reversal learning metric can answer *if* participants can learn reversals in outcomes, but not necessarily the degree to which participants use changes in outcomes to inform decision-making on subsequent trials. In this study, our metric for reversal learning was not whether participants chose to interact with Bill or Sue, but rather the amount of trust that they placed in each social partner following the reversal in outcomes. That is, rather than showing that people with schizophrenia learned to choose Sue over Bill following a reversal in decision outcomes, we were able to show the amount of trust placed in each social partner over the course of repeated interactions. In other words, we were able to show how reversal learning impacted decision-making in terms of the amount of change in 1 behavior (e.g. the amount of trust placed in a social partner) instead of just whether the decision was correct or incorrect.

To summarize, in contrast to decreased sensitivity to positive outcomes, people with schizophrenia appear to be more sensitive to negative social interaction outcomes. Greater sensitivity to negative outcomes may be adaptive as this might help people with schizophrenia avoid relationships with negative social partners. However, greater sensitivity to negative outcomes, especially during initial interactions, may also thwart opportunities to establish relationships with social partners who might ultimately end up being positive. Fortunately, an intact ability among people with schizophrenia to “look past” a history of negative outcomes when social partners start behaving in a positive manner may help minimize the occurrence of missed social opportunities. However, when social partners with a history of positive behavior changed and began behaving in a negative manner, people with schizophrenia were only partially able to successfully update their decision-making. That is, people with schizophrenia had a hard time picking up on changes in behavior only during interactions with a smiling social partner. Thus, the ability of people with schizophrenia to flexibly update their decision-making during social interactions may be impeded by the presence of a conflict between social partner’s emotional display and behavior.

The role of emotional displays

For the most part, we found few group differences in the use of emotional displays to inform behavior (decision-making) and self-report (ratings). These findings add to a growing literature indicating that people with schizophrenia are able, in certain circumstances, to use information signaled by emotional displays to inform decision-making and ratings (Hooker et al., 2011; Kring et al., 2014; Lee et al., 2012). Importantly, our findings suggest that decreased sensitivity to positive and increased

sensitivity to negative social interaction outcomes were not due solely to differences in using the information signaled by a social partner's emotional display. That is, difficulties among people with schizophrenia in using positive social interaction outcomes to inform decisions to trust were not due to differences in using the information signaled by positive emotional displays to guide decision-making. Similarly, greater ability among people with schizophrenia to use negative social interactions outcomes to inform decisions to trust were not due to due differences in using negative emotional information to guide decision-making. Future studies should seek to expand the scope of decisions being made, such as whether to approach or avoid a social partner, to better understand the which aspects of the ability to use emotional information to inform decision-making is intact and impaired among people with schizophrenia.

We did, however, find two group differences in the use of the information signaled by emotional displays to inform decision-making that are noteworthy. First, people with schizophrenia rated scowling, untrustworthy social partners as less trustworthy than did controls, highlighting the sensitivity of people with schizophrenia to negative social outcomes. Thus, while the information signaled by scowling displays did not influence trust decisions per se, it did influence how people with schizophrenia rated the trustworthiness of untrustworthy social partners. Interestingly, this suggests that people with schizophrenia were more sensitive to the information signaled by a negative (scowl), but not positive (smile) emotional display compared to controls..

Second, people with schizophrenia placed more trust in smiling, but untrustworthy social partners suggesting that the information signaled by this display coupled with mismatched (untrustworthy) behavior was difficult for this group. An important question for future studies will be to further assess whether this was due to difficulties inhibiting the information signaled by the smile, which is what our findings would suggest given the lack of group differences in decisions to trust neutral, untrustworthy social partners, or difficulties in detecting the reversal in outcomes from positive to negative. Interestingly, people with schizophrenia did not differ from controls in their trustworthiness ratings of smiling untrustworthy social partners, suggesting that the effect of the information signaled by a smile was limited to decisions to trust. Thus, future studies examining differences in the ability of people with schizophrenia to inhibit the information signaled by positive and negative emotional displays should continue to take a mixed-method approach so as to better understand how decision-making and judgments (such as trustworthiness) are related and influence behavior.

Broader Implications

Taken together, the combination of less sensitivity to positive social interaction outcomes and greater sensitivity to negative social interaction outcomes are likely to impede the establishment of trusting relationships and suggest a potential target for interventions aimed at boosting social engagement in schizophrenia. Put another way, attempts to establish trusting relationships by people with schizophrenia may be shaped more by avoiding negative social interaction outcomes rather than approaching or seeking out positive social interaction outcomes. Indeed, if decisions to trust made people with schizophrenia are more shaped by avoiding negative outcomes, then negative experiences over the course of illness may actually strengthen social avoidance motivation. This is especially important given our post-hoc findings of a significant

positive relationship between trust placed in trustworthy social partners and duration of illness. This finding was specific to trustworthy partners and suggests that the longer a person has schizophrenia, the less likely they are to trust people with whom a positive social relationship could be established. Future work should longitudinally assess the relationship between decisions to trust and life events to better understand changes as a function of experiences over the course of illness.

Our findings of a relationship between trust and real-world social functioning suggests that interventions aimed at strengthening sensitivity to positive social interaction outcomes to inform and guide decisions to trust may help people with schizophrenia become more socially engaged. One approach could be to pair adaptive computerized cognitive training, which has been shown to improve cognition in people with schizophrenia (Fisher et al., 2013), and more recently has been expanded to target social cognition as well (Sacks et al., 2013; Dodell-Feder, Tully, & Hooker, 2015), with a psychosocial skills-based intervention. Computerized cognitive training could focus on strengthening the association between positive social interaction outcomes and decisions. Taking an adaptive approach to the presentation of feedback regarding the relationship between decision and outcome, a potential training module could start by making this very explicit and steadily decrease the available cues as the ability to associate decision and social interaction outcome improves. Ideally, this would help people with schizophrenia make more positive appraisals about interactions with positive outcomes, which has been shown to be a predictor of real-world social engagement (Granholm et al., 2013).

The psychosocial skills-based intervention, on the other hand, could be used to address increased sensitivity to negative social interaction outcomes. Several studies have found a link between negative cognitions, namely defeatist performance beliefs, and motivation/pleasure negative symptoms (e.g. Green et al., 2012). While not previously explored, it may be that such negative cognitions are also linked with sensitivity to negative social interaction outcomes, making negative cognitions among people with schizophrenia a potentially important target for increasing decisions to trust. One example of an intervention for targeting negative cognitions is a recent randomized control trial of a skills-based intervention that combined cognitive, social, and problem-solving skills training. Compared to the beginning of the trial, people with schizophrenia reported decreases in negative cognitions related to performance and had improved social competence at the end of the trial (Granholm et al., 2014). By challenging negative cognitions related to social interactions and role-playing social situations where decisions to trust are reciprocated, a psychosocial intervention like this may help people with schizophrenia be more willing to place trust in others.

As with any study, it is important to acknowledge limitations. To date, the majority of studies investigating decisions during social interactions have used static images to represent social partners (e.g. van t' Wout et al., 2008; Chang et al., 2010), which can limit the social nature of the interaction. In this study, we sought to increase the social nature of the interactions by using dynamic displays to represent social partners. However, there is no substitute for the “real thing”, and future studies should consider using live social interactions. Another approach would be to simulate interactions in the context of a virtual environment (Blascovich et al., 2002), which is already being used for children with autism (e.g. Kandalaf et al., 2013). Another

limitation of our study is that the interaction outcomes were not wholly social. In the context of this task, the amount of points sent to a social partner was a proxy for how much a participant trusted that partner. Thus, while the interaction outcomes were social in that the social partner either reciprocated or abused the trust placed in them, these outcomes were expressed in terms of points. One way to increase the social nature of the decisions and outcomes would be to remove the points altogether. For example, both the decisions and outcomes could be about the social partner, with decisions made during the interaction resulting in an outcome that would increase or decrease the likelihood of seeing or interacting with a particular social partner again. Another possibility could be to use displays as the outcomes, an approach that has been used before in healthy people (e.g. Vrticka et al., 2008).

In summary, we sought to address how people with schizophrenia use positive and negative *social* interaction outcomes and social partner emotional displays to inform decisions to trust others. Our findings suggest that people with schizophrenia use some types of social interaction outcomes more than others when making decisions to trust. Specifically, people with schizophrenia were less able than controls to use positive social interaction outcomes to inform trust decisions, and they were less able to detect and use reversals in outcomes as they changed from positive (trustworthy) to negative (untrustworthy). These findings are broadly consistent with reward learning studies that have used monetary outcomes. In short, people with schizophrenia are less sensitive to positive outcomes, whether social or monetary, and they have difficulty acting upon changes from positive outcomes to negative outcomes. Our findings extend the literature on decision making in two additional ways. First, compared to controls, people with schizophrenia were better able to use negative social interaction outcomes to inform decisions (not) to trust, and second, people with schizophrenia were just as able as controls to detect and act upon reversals in social outcomes that changed from negative (untrustworthy) to positive (trustworthy). Finally, our findings extend previous work by illuminating certain conditions under which people with schizophrenia can use the information signaled by emotional displays to inform decision-making.

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Footnotes

¹ People with schizophrenia and schizoaffective disorder did not differ on any of the clinical variables, cognitive variables or task performance. Further, people with a diagnosis of schizoaffective disorder were not in a current mood episode at the time of testing. We thus refer to this group as the schizophrenia or SZ group throughout the paper.

² While Display is a reference effect, the Time X Display and Group X Time X Display interactions refer to a reversal phase and diagnostic group (people with schizophrenia). In other words, the Display coefficient represents the effect estimate of an emotional display on decisions to trust social partners across both the initial and reversal phases, but the Time X Display interaction refers to the effect of seeing an emotional display on trust during a specific phase.

Table 1. Demographic and Clinical variables

	Schizophrenia (n = 32)	Controls (n = 29)
	Mean (SD)	Mean (SD)
Age	47.5 (11.9)	46.2 (10.7)
Education	14.7 (2.6)	15.3 (1.8)
Parental Education	14.7 (2.5)	13.3 (3.3)
Sex (M/F)	17/15	14/15
WTAR FSIQ	105.4 (13.0)	106.1 (9.9)
Digit Span Total ^a	17.3 (3.9)	18.8 (3.3)
Duration of illness (years)	23.7 (14.0)	--
BPRS Total Score	46.5 (13.7)	--
CAINS		
MAP scale	15.0 (5.7)	--
EXP scale	5.7 (3.7)	--
RFS		
Work	4.2 (2.0)	--
Self-Care	5.5 (1.2)	--
Family	4.9 (1.9)	--
Social Networks	4.7 (1.7)	--

^a Data for 30 people with schizophrenia and 27 controls

WTAR = Wechsler Test of Adult Reading, BPRS = Brief Psychiatric Rating Scale;
CAINS = Clinical Assessment Inventory for Negative Symptoms; MAP = Motivation
and Pleasure; EXP = Expressivity; RFS = Role Functioning Scale

Table 2. Main and interaction effects for the Piecewise Mixed Effects Regression models predicting the amount of trust placed in trustworthy and untrustworthy social partners during the initial and reversal phases.

	B	SE	<i>d</i>	B	SE	<i>d</i>
Intercept	5.14	.42	--	3.51	.36	--
	<u>Trustworthy</u>			<u>Untrustworthy</u>		
<u>Reference effects</u>						
Group	.56	.58	.03	.89 [^]	.50	.06
Display	.60 [^]	.31	.06	-.40	.32	.04
Group X Display	-.57	.42	.03	-.45	.45	.03
	<u>Trustworthy</u>			<u>Untrustworthy</u>		
<u>Initial Phase</u>						
Time	.06**	.02	.09	-.07**	.02	.09
Group X Time	-.09**	.03	.09	-.11**	.03	.10
Display X Time	-.00	.02	.001	.01	.03	.01
Group X Display X Time	.02	.03	.01	.02	.03	.02
	<u>Untrustworthy</u>			<u>Trustworthy</u>		
<u>Reversal Phase</u>						
Time	-.19**	.03	.20	.16**	.03	.16
Group X Time	.07	.04	.05	-.05	.04	.04
Display X Time	-.07**	.02	.10	.03	.02	.04
Group X Display X Time	.08**	.03	.09	-.02	.03	.02

[^] $p = .06$, * $p < .05$, ** $p < .01$

Table 3. Correlations between the average amount of points sent to trustworthy social partners during the initial and reversal phases, symptoms, and functioning.

	Initial Phase	Reversal Phase
CAINS-MAP scale	-.44**	-.33*
CAINS-EXP scale	-.15	-.24
Role Functioning Scale		
Work Productivity	.25	.25
Independent Living	.19	.15
Family Relationships	.25	.37*
Social Networks	.58**	.58**
Duration of Illness	-.42*	-.40*
Digit Span Total	.15	.17
BPRS Total	-.20	-.18

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

Note. BPRS = Brief Psychiatric Rating Scale; CAINS = Clinical Assessment Inventory for Negative Symptoms; MAP = Motivation and Pleasure; EXP = Expressivity

Table 4. Correlations between the average amount of points sent to untrustworthy social partners during the initial and reversal phases, symptoms, and functioning.

	Initial Phase	Reversal Phase
CAINS-MAP scale	-.23	-.15
CAINS-EXP scale	-.06	-.09
Role Functioning Scale		
Work Productivity	.03	-.12
Independent Living	.13	-.05
Family Relationships	.25	.13
Social Networks	.51**	.38*
Duration of Illness	-.23	-.10
Digit Span Total	-.11	-.13
BPRS Total	-.16	-.02

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

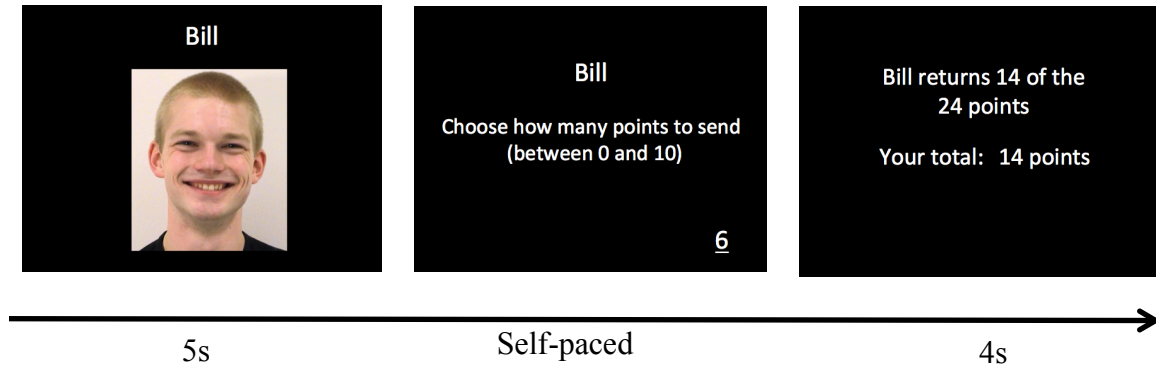
Note. BPRS = Brief Psychiatric Rating Scale; CAINS = Clinical Assessment Inventory for Negative Symptoms; MAP = Motivation and Pleasure; EXP = Expressivity

Table 5. Ratings of trustworthy and untrustworthy social partner trustworthiness made by people with and without schizophrenia after the initial and reversal phase.

	Schizophrenia Mean (SD)	Controls Mean (SD)
<u>Initial Phase</u>		
Smiling Trustworthy**	4.16 (2.05)	5.55 (1.40)
Neutral Trustworthy*	4.13 (1.98)	5.00 (1.33)
Scowling Untrustworthy**	1.81 (1.33)	2.83 (1.63)
Neutral Untrustworthy	2.56 (1.56)	2.79 (1.59)
<u>Reversal Phase</u>		
Smiling Untrustworthy	3.19 (1.91)	3.13 (1.55)
Neutral Untrustworthy	2.94 (1.90)	3.48 (1.35)
Scowling Trustworthy	3.69 (2.42)	4.69 (1.65)
Neutral Trustworthy	3.63 (2.02)	4.52 (1.60)

Note. Ratings made on a 1 to 7 scale with 1 = not at all and 7 = very much

Figure 1a. Example of Modified Trust Game trial



Note. In this task, the amount of points sent represented how much a participant trusted a social partner.

Figure 1b. Social partner behavior and displays during each Trust Game phase

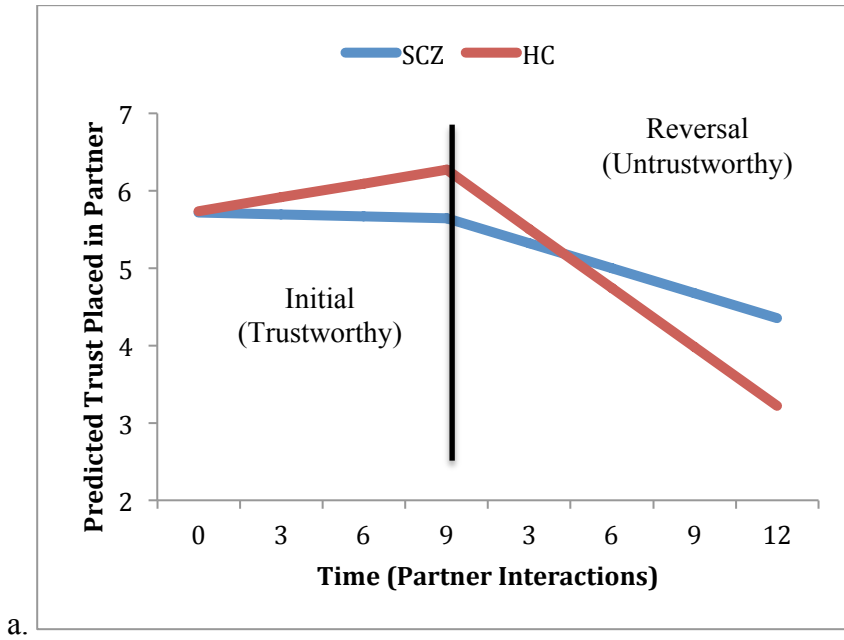
<u>Initial Phase</u>		<u>Reversal Phase</u>	
Display	Behavior	Display	Behavior
Smile	Trustworthy	Smile	<i>Untrustworthy</i>
Neutral	Trustworthy	Neutral	<i>Untrustworthy</i>
Scowl	Untrustworthy	Scowl	<i>Trustworthy</i>
Neutral	Untrustworthy	Neutral	<i>Trustworthy</i>

Note. Italicized words represent changes in social partner behavior from initial to reversal phases.

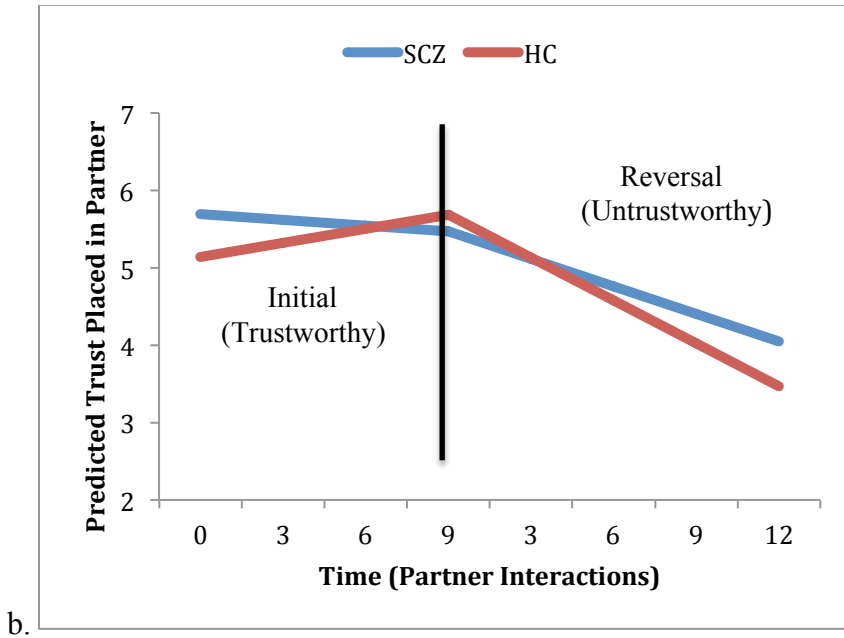
Figure 1. a) Example of a Trust Game trial. Participants first saw a dynamic clip and name of a social partner. Next, participants decided how many points to send to that partner, choosing a number between 0 and 10. Finally, participants saw the outcome of the interaction, which showed the number of points returned by the social partner. b) Table showing the two different Trust Game phases.

Figure 2.

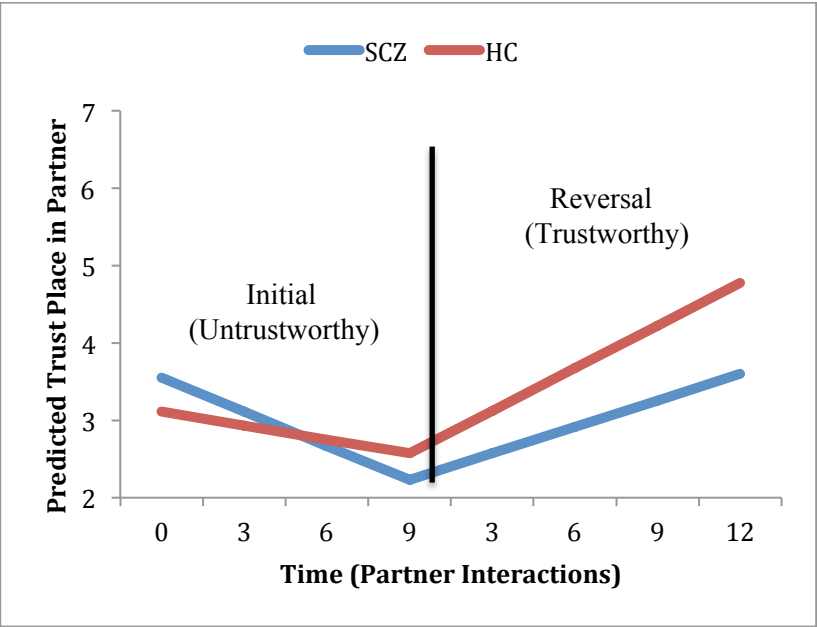
Interactions with a smiling social partner



Interactions with a neutral social partner

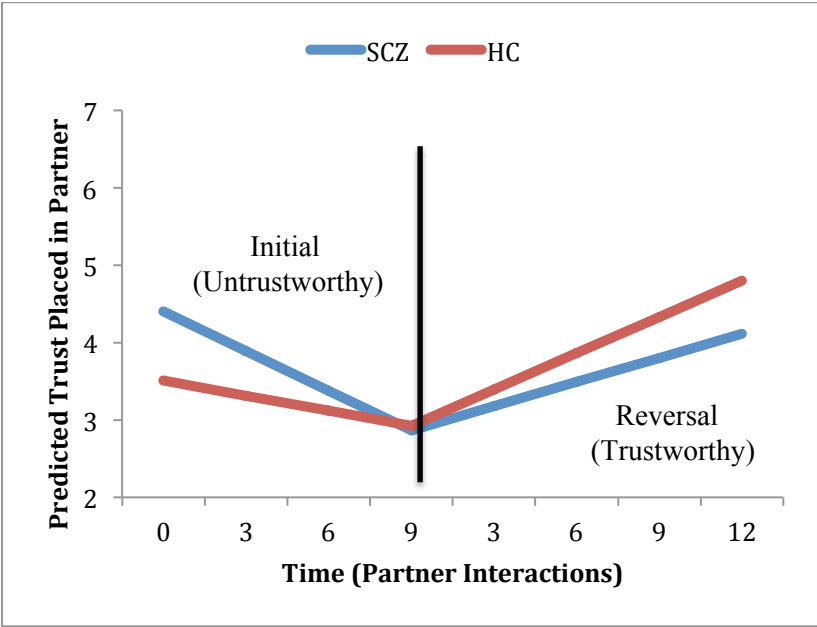


Interactions with a scowling social partner



c.

Interactions with a neutral social partner



d.

Figure 2. Graphs showing the predicted amount of trust (i.e. points sent) placed in a social partner during interaction as predicted by the piecewise linear mixed effects regression model. a) Smiling social partner who starts off being trustworthy during the initial phase and becomes untrustworthy during the reversal phase. b) Neutral social partner who starts off being trustworthy during the initial phase and becomes untrustworthy during the reversal phase. c) Scowling social partner who starts off being untrustworthy during the initial phase and becomes trustworthy during the reversal phase. d) Neutral social partner who starts off being untrustworthy during the initial phase and becomes trustworthy during the reversal phase.