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Using Social Outcomes to Inform Decision-Making in Schizophrenia: Relationships With Symptoms and Functioning

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The outcomes of the decisions we make can be used to inform subsequent choices and behavior. We investigated whether and how people with and without schizophrenia use positive and negative social outcomes and emotional displays to inform decisions to place trust in social partners. We also investigated the impact of reversals in social partners' behavior on decisions to trust. Thirty-two people with schizophrenia and 29 control participants completed a task in which they decided how much trust to place in social partners' showing either a dynamic emotional (smiling, scowling) or neutral display. Interactions were predetermined to result in positive (trust reciprocated) or negative (trust abused) outcomes, and we modeled changes in trust decisions over the course of repeated interactions. Compared to controls, people with schizophrenia were less sensitive to positive social outcomes in that they placed less trust in trustworthy social partners during initial interactions. By contrast, 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. People with schizophrenia did not differ from controls in detecting social partner behavior reversals from trustworthy to untrustworthy; however, they had difficulties detecting reversals from untrustworthy to trustworthy. 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.

General Scientific Summary
People with schizophrenia can have difficulties using decision outcomes to guide subsequent decision-making and behavior. This study extends previous work by showing that people with schizophrenia also have difficulties using social interaction outcomes to guide subsequent social decision-making and behavior. These findings have implications for understanding decreased social networks common among people with schizophrenia.

Keywords: schizophrenia, decision-making, social interactions, trust

Decision-making is an important part of daily life, with the outcomes of decisions influencing subsequent choices and decisions. While prior research has shown that people with schizophrenia have difficulty using monetary outcomes to guide subsequent decisions (Heerey & Gold, 2007; Barch & Dowd, 2010), we know considerably less about whether people with schizophrenia have difficulty using *social* outcomes to inform decision-making in the context of social interactions. We investigated the extent to which people with schizophrenia use social outcomes to inform decision-making, and how this is related to motivation/pleasure negative symptoms and psychosocial functioning. Because social interactions often involve emotion, we also examined whether and how people with schizophrenia use social partners' emotional displays to guide learning from social outcomes and inform subsequent decision-making.

Monetary Decision-Making and Reversal Learning in Schizophrenia

Studies using reward-learning paradigms with monetary outcomes have consistently shown that compared to controls, people with schizophrenia have difficulty using positive outcomes to inform decision-making (Strauss et al., 2011; Gold et al., 2012). These difficulties are associated with poorer functioning (Somlai, Moustafa, Kéri, Myers, & Gluck, 2011) as well as greater motivation/pleasure negative symptoms (Strauss et al., 2011; Gold et al., 2012), which are part of the two-factor solution of negative symptoms and refer to diminished engagement in and/or pleasure derived from social, vocational, and recreational life domains (Kring, Gur, Blanchard, Horan, & Reise, 2013). By contrast,

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people with schizophrenia do not exhibit difficulties with using negative outcomes to inform decision-making (Gold et al., 2012; Strauss, Waltz, & Gold, 2014). In short, people with schizophrenia appear to be "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, p. 2).

Investigators have also studied reversal learning, or the ability to flexibly adjust decision-making once an outcome changes, a situation that occurs frequently in daily life. Evidence from both probabilistic (Waltz & Gold, 2007) and nonprobabilistic tasks (Leeson et al., 2009; McKirdy et al., 2009) indicates that compared to controls, people with schizophrenia have difficulty detecting and using reversals to guide decision-making when the reversal goes from a positive to negative outcome. We know much less about whether people with schizophrenia also have difficulties detecting reversals that go from negative to positive outcomes.

Decision-Making in the Social World

Most everyday decisions are social rather than monetary. Much in the same way that we can investigate how gaining or losing money influences subsequent decision-making, we can also investigate how people use positive or negative social outcomes to inform decisions during social interactions. Studying social decision-making in people with schizophrenia is important for several reasons. First, many people with schizophrenia have difficulties in social functioning and limited social networks (e.g., Robertson et al., 2014). Yet, people with schizophrenia often report wanting more social contact (Bengtsson-Tops & Hansson, 2001). Increasing social networks for people with schizophrenia is important because social support is predictive of recovery (e.g., Corrigan & Phelan, 2004). Furthermore, poor social functioning among people with schizophrenia may not necessarily reflect diminished desire for social relationships but instead difficulties in building these relationships.

One important building block for social relationships is deciding whether or not to trust others. Preliminary research suggests that people with schizophrenia appear to have difficulties with both establishing and maintaining trust during social interactions (Fett et al., 2012; Gromann et al., 2013). In one study (Fett et al., 2012), people with schizophrenia differed from controls in several ways: they placed less trust in social partners presented by name on a computer screen at baseline, less frequently used a priori information about social partners to guide trust decisions, and less frequently reciprocated trust. In another study (Gromann et al., 2013), people schizophrenia exhibited less trust than controls in computer-presented trustworthy social partners across repeated interactions.

Given the importance of trust for social relationships and functioning, our study sought to extend these findings in two ways. First, we examined how decisions to trust unfold across time and how they change in response to a social partner's change in behavior. Second, we examined how emotional displays might influence decisions to trust over the course of repeated interactions.

The Role of Emotional Displays

Emotional displays are a rich source of information in social interactions that can inform decisions to trust. Studies with healthy people have shown that smiles promote decisions to trust (Scharlemann, Eckel, Kacelnik, & Wilson, 2001) and facilitate learning of a social partner's trustworthy behavior during social interactions (Heerey, 2014). Scowls, by contrast, are associated with less trust during social interactions (e.g., Campellone & Kring, 2013).

While people with schizophrenia have difficulties accurately labeling other people's emotional displays (e.g., Kohler, Walker, Martin, Healey, & Moberg, 2010), other evidence indicates that people with schizophrenia can use the information signaled by emotion displays in some circumstances. For example, when asked to make ratings about faces that were preceded by positive or negative stimuli, people with schizophrenia make comparable judgments of facial trustworthiness (Hooker et al., 2011; Kring, Siegel, & Barrett, 2014), as do healthy controls. Thus, people with schizophrenia may use the information signaled by emotional displays to guide their decisions even if they have difficulties explicitly labeling the emotion depicted on the face.

Present Study

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. We tested two hypotheses regarding positive, rewarding interaction outcomes:

> *Hypothesis 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.

> *Hypothesis 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.

We tested two hypotheses regarding negative social interaction outcomes:

> *Hypothesis 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.

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

With respect to the role of emotional display, we tested competing hypotheses:

> *Hypothesis 3a:* Given evidence that people with schizophrenia have difficulty labeling facial emotion displays (Kohler et al., 2010), we hypothesized compared to controls, 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 nonemotional displays.

Hypothesis 3b: Based on emerging evidence that people with schizophrenia can use emotional information to inform social judgments (Hooker et al., 2011; Kring et al., 2014), 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.

Additionally, we examined the relationship between trust placed in trustworthy and untrustworthy social partners, symptoms, and functioning.

Method

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 psychotropic medications (26 with second-generation antipsychotics).

Clinical Assessment

Diagnoses were confirmed using the Structured Clinical Interview for *DSM–IV* (First, Spitzer, Gibbon, & Williams, 2002a), and the absence of diagnoses for the control group was confirmed using the SCID nonpatient version (First, Spitzer, Gibbon, & Williams, 2002b). We assessed negative symptoms using the Clinical Assessment Interview for Negative Symptoms (Kring et al., 2013), and general symptoms using Brief Psychiatric Rating Scale (BPRS; Lukoff, Nuechterlein, & Ventura, 1986). We used the suspiciousness item from the BPRS as an index of current persecutory ideation. Functioning in the areas of work, self-care, family, and social was assessed with the Role Functioning Scale (McPheeters, 1984).

Cognitive Assessment

Previous research has found that difficulties using rewarding outcomes to inform decision-making are related to poor working memory among people with schizophrenia (Heerey, Bell-Warren, & Gold, 2008). To account for any effect of working memory, we administered the digit span from the Wechsler Adult Intelligence Scale–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 backward conditions. Two people with schizophrenia and two controls did not complete the digit span. We also estimated full-scale IQ with the Wechsler Test of Adult Reading (Wechsler, 2001). Demographic, clinical, and cognitive functioning data are presented in Table 1.

Table 1
Demographic and Clinical Variables

	Schizophrenia ($n = 32$) *M* (*SD*)	Controls ($n = 29$) *M* (*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 (male/female)	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)	—

Note. WTAR = Wechsler Test of Adult Reading; FSIQ = full-scale IQ; BPRS = Brief Psychiatric Rating Scale; CAINS = Clinical Assessment Inventory for Negative Symptoms; MAP = Motivation and Pleasure; EXP = Expressivity; RFS = Role Functioning Scale.
[a] Data for 30 people with schizophrenia and 27 controls.

Social Decision-Making Paradigm: Modified Trust Game

After providing informed consent, participants played a modified version of the trust game (see also Campellone & Kring, 2013) created using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) and presented on a laptop computer. The trust game is a well-established task for assessing both decisions to trust as well as reciprocity of trust behavior (see Berg, Dickhaut, & McCabe, 1995). 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 sample 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 5-s clip of 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 or

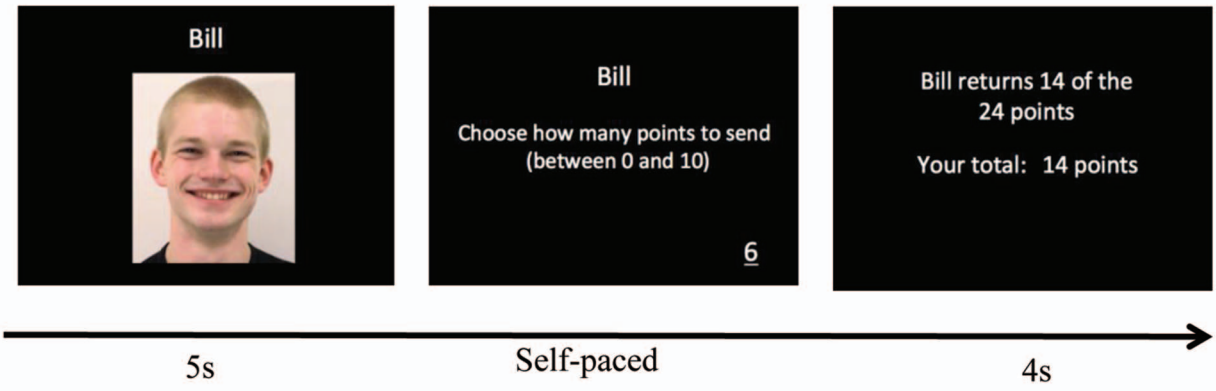
[1] People with schizophrenia and schizoaffective disorder did not differ on any of the clinical variables, cognitive variables, or task performance. We thus refer to this group as the schizophrenia or SZ group throughout the paper.

she trusted that a social partner would honor his or 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, returning, on average, half of the amount of points sent by a participant. 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 pseudorandomized so that participants never interacted with the same partner on consecutive trials.

Many studies using the trust game incentivize performance by having participants play with actual money so that they are invested in the decision outcomes (i.e., each decision results in either a gain and loss of money). We did not use money in our version of the trust game for two reasons. First, previous research has shown that the reciprocation of trust by a social partner activates similar brain regions whether outcomes are expressed as points or money (e.g., King-Casas et al., 2005). Second, the goal of this modified version of the trust game was to allow for the investigation of how participants use *social*

a. Example of Modified Trust Game trial



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

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

Initial Phase		Reversal Phase	
Display	Behavior	Display	Behavior
Smile	Trustworthy	Smile	*Untrustworthy*
Neutral	Trustworthy	Neutral	*Untrustworthy*
Scowl	Untrustworthy	Scowl	*Trustworthy*
Neutral	Untrustworthy	Neutral	*Trustworthy*

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. See the online article for the color version of this figure.

outcomes to inform decision-making. Framing this task as a monetary decision-making task may have unduly influenced participant decision-making (Gneezy, Meier, & Rey-Biel, 2011). By using points as outcomes, participant decision-making was based on social factors (i.e., social partner behavior and emotional displays) rather than earning a monetary reward.

Social partner emotional displays. Social partner emotional displays consisted of dynamic, 5-s video clips of actors from the Amsterdam Dynamic Facial Expression Set (van der Schalk, Hawk, Fischer, & Doosje, 2011). The actors received instruction from coaches trained in the Facial Action Coding System (Ekman, Friesen, & Hager, 2002). We chose four actors (two men, two 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 procedure allowed us to assess trust using a multimethod approach: behaviorally (decision-making) as well as self-report (trustworthiness ratings).

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, fewer 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). 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.

Data Analysis Plan

We conducted two separate piecewise linear mixed effects regression models predicting decisions to trust (a) trustworthy social partners and (b) untrustworthy social partners. A mixed-effect regression model is able to accommodate the nesting that occurs in the repeated measurement of the same individuals over time by modeling the random distribution of individual differences in level (random effect for intercept) and change over time (random effect for slope). These random effects are thus mixed with standard fixed-effects: model predictors, which yield a single regression coefficient for the sample (e.g., group status). 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, while nevertheless including both phases within a single model. Specifically, the initial and reversal trust game phases were modeled as discrete time periods and were represented by separate time variables with separate 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.

There were two types of predictors: phase-specific versus non-phase specific (the latter are also called reference effects, 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 × 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, referring to either initial or reversal phase. Model analyses were conducted using the lme4 package in R Version 3.1.0 (R Core Team, 2013). For significant effects, we report unstandardized beta coefficient estimates, standard errors, and effect sizes (Cohen's d).

We also 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 relations between decision-making, symptoms, and functioning among people with schizophrenia, we computed zero-order correlations between the amount of trust placed in trustworthy and untrustworthy social partners, the BPRS suspiciousness item, the Clinical Assessment Interview for Negative Symptoms Motivation and Pleasure scale, and Role Functioning Scale separately for each phase.

Results

Gender, education, age, and estimated full-scale IQ did not significantly different between people with and without schizophrenia, nor were they significantly related to any study variables. There were neither gender differences within groups in decisions

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*	*t*	*d* [95% CI]	*B*	*SE*	*t*	*d* [95% CI]
Intercept	5.14	.42	12.17	—	3.51	.36	9.68	—
	Trustworthy				Untrustworthy			
Reference effects								
Group	.56	.58	.95	.17 [−.18, .52]	.89†	.50	1.78	.31 [−.03, .67]
Display	.60†	.31	1.95	.35 [−.01, .70]	−.40	.32	−1.23	−.22 [−.58, .13]
Group × Display	−.57	.42	−1.36	−.24 [−.59, .11]	−.45	.45	−1.01	−.18 [−.53, .17]
	Trustworthy				Untrustworthy			
Initial phase								
Time	.06**	.02	2.63	.47 [.20, .90]	−.07**	.02	2.73	.49 [−.98, −.28]
Group × Time	−.09**	.03	−2.70	−.48 [−.87, .16]	−.11**	.03	−3.20	−.57 [−1.01, −.31]
Display × Time	−.001	.02	−.06	−.01 [−.36, .34]	.01	.03	.22	.04 [−.29, .41]
Group × Display × Time	.02	.03	.05	.01 [−.25, .45]	.02	.03	.71	.13 [−.23, .47]
	Untrustworthy				Trustworthy			
Reversal phase								
Time	−.19***	.03	−6.12	−1.10 [−1.46, −.76]	.16***	.03	4.98	.89 [.61, 1.31]
Group × Time	.07	.04	1.59	.29 [−.06, .65]	−.05	.04	−1.20	−.21 [−.58, .13]
Display × Time	−.07**	.02	−3.14	−.56 [−.97, −.27]	.03	.02	1.15	.21 [−.08, .62]
Group × Display × Time	.08**	.03	2.62	.47 [.13, .83]	−.02	.03	−.54	−.10 [−.47, .23]

Note. CI = confidence interval.
† $p = .06$. * $p < .05$. ** $p < .01$. *** $p < .001$.

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 significantly on the digit span, $t(57) = 1.56$, $p = .120$.

As a manipulation check to see whether participants recognized 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, given the primary aim of examining whether participants ascertained the behavior of social partners. Both people with and without schizophrenia placed significantly greater trust in trustworthy (healthy control [HC]: $M = 6.35$, $SD = 1.56$; schizophrenia [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: $t(28) = 5.86$, $p < .001$, $d = 2.17$, SZ: $t(31) = 6.17$, $p < .001$, $d = 2.21$.

Interactions With Trustworthy Social Partners

We 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 approached significance ($p = .06$), 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 × Display interaction reference effect was not significant. See Table 2 for all model coefficients and effect sizes.

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 main effect for time that was qualified by a significant Group × Time interaction. 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 than were those of controls, regardless of emotional display. This finding was corroborated by the result that people with schizophrenia, relative to controls, rated both smiling and neutral partners during the initial phase as significantly less trustworthy, smiling trustworthy partner: $t(59) = 3.07$, $p = .003$, neutral trustworthy partner: $t(59) = 2.00$, $p = .050$. Descriptive statistics for social partner ratings are presented in Table 3.

Reversal phase. To test our hypothesis that people with and without schizophrenia would be similarly influenced by negative outcomes from interactions with currently 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 main effect for time, but the Group × Time interaction was not significant. We did, however, find a significant Time × Display interaction, as well as a significant Group × Time × Display interaction.[2] Despite the change in partner behavior, people with schizophrenia did not place less trust in ini-

[2] Although display is a reference effect, the Time × Display and Group × Time × Display interactions refer to a specific phase (initial or reversal) and diagnostic group (people with schizophrenia).

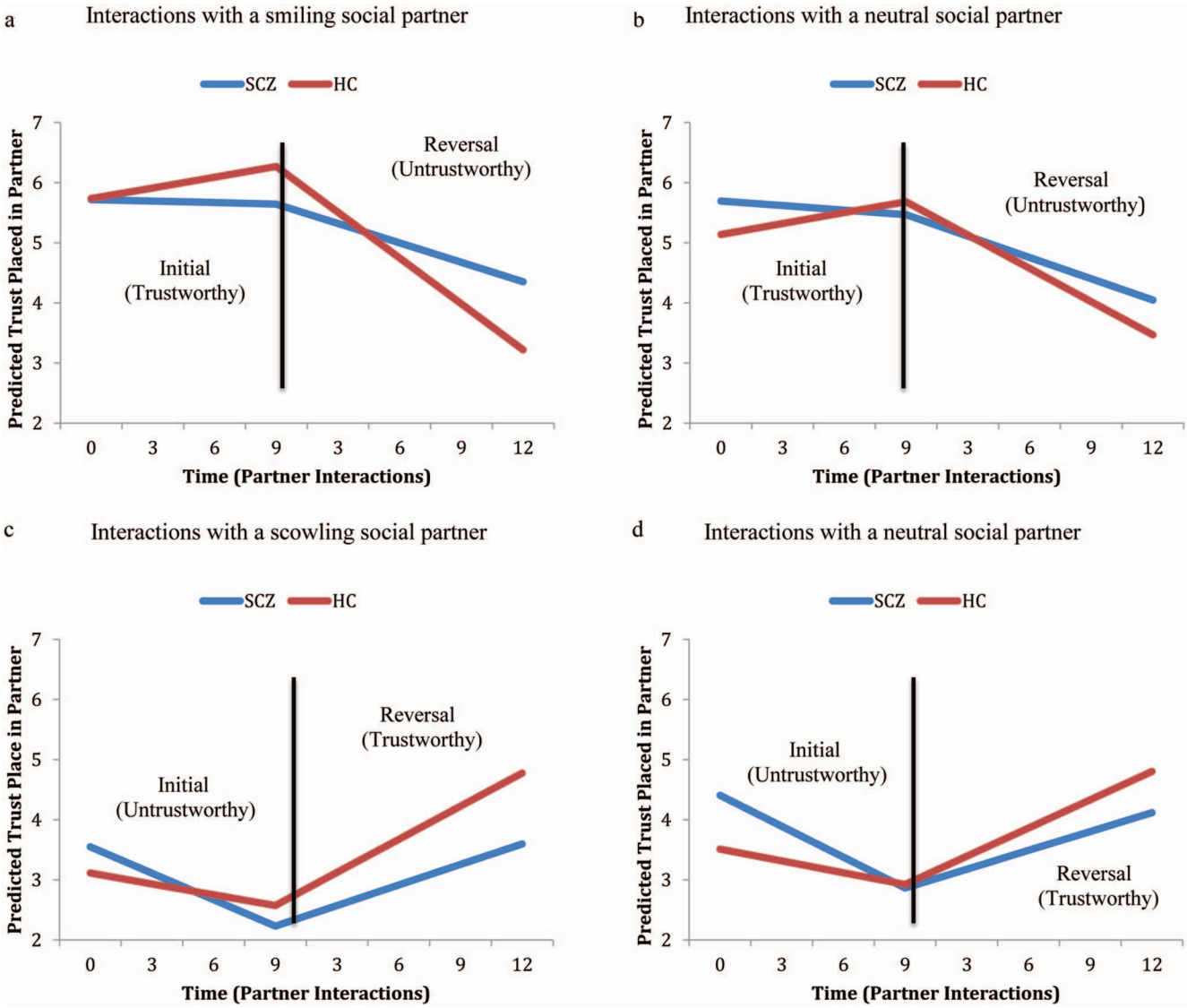


Figure 2. Graphs showing the predicted amount of trust placed in a social partner over the course of repeated interactions as predicted by the piecewise linear mixed effects regression model. (a) Smiling social partner with trustworthy behavior that reverses and becomes untrustworthy. (b) Neutral social partner with trustworthy behavior that reverses and becomes untrustworthy. (c) Scowling social partner with untrustworthy behavior that reverses and becomes trustworthy. (d) Neutral social partner with untrustworthy behavior that reverses and becomes trustworthy. SCZ = schizophrenia; HC = healthy control. See the online article for the color version of this figure.

tially smiling but subsequently untrustworthy partners during the reversal phase, whereas controls did (Figure 2b).

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 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 an initially trustworthy manner, HC: smiling, $t(28) = 6.59$, $p < .001$, neutral, $t(28) = 4.38$, $p < .001$; SZ: smiling, $t(31) = 2.57$, $p = .02$, neutral, $t(31) = 3.39$, $p = .002$.

Interactions With Untrustworthy Social Partners

We conducted another piecewise linear mixed effects regression model for interactions with untrustworthy social partners. The

Table 3
Ratings of Trustworthiness for Trustworthy and Untrustworthy Social Partners During the Initial and Reversal Phase for People With and Without Schizophrenia

	Schizophrenia *M* (*SD*)	Controls *M* (*SD*)	Cohen's *d*
Initial phase			
Smiling trustworthy**	4.16 (2.05)	5.55 (1.40)	.79
Neutral trustworthy*	4.13 (1.98)	5.00 (1.33)	.51
Scowling untrustworthy**	1.81 (1.33)	2.83 (1.63)	.69
Neutral untrustworthy	2.56 (1.56)	2.79 (1.59)	.15
Reversal phase			
Smiling untrustworthy	3.19 (1.91)	3.13 (1.55)	−.03
Neutral untrustworthy	2.94 (1.90)	3.48 (1.35)	.33
Scowling trustworthy	3.69 (2.42)	4.69 (1.65)	.48
Neutral trustworthy	3.63 (2.02)	4.52 (1.60)	.49

Note. Ratings made on a 1-to-7 scale with 1 = *not at all* and 7 = *very much*.
* $p < .05$. ** $p < .01$.

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 × 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 main effect for time that was qualified by a significant Group × Time interaction (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 × Display × Time interaction was not significant ($p = .59$).

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, whereas 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 changed, such that these partners now behaved in a trustworthy manner, resulting in interactions with rewarding outcomes. We found a significant main effect for time, but no significant Group × 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. In other words, both groups detected that formerly untrustworthy partners were now behaving in a trustworthy manner. The Group × Time × Display interaction was not significant.

With respect to trustworthy ratings, people with schizophrenia tended to rate the now trustworthy social partners as less trustworthy than did controls, scowling, $t(59) = 1.87$, $p = .07$; neutral, $t(59) = -2.24$, $p = .06$. While not significant, group difference effect sizes were moderate (scowling, $d = .48$; neutral, $d = .49$). In addition, 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, $t(28) = -5.12$, $p < .001$, neutral, $t(28) = -4.87$, $p < .001$; SZ: scowling, $t(31) = -4.56$, $p < .001$; neutral, $t(31) = -2.24$, $p = .03$.

Correlations Between Trust, Symptoms, and Functioning

The amount of trust placed in trustworthy social partners during either the initial or reversal phase was not associated with digit span performance or with total symptoms. The amount of trust placed in a trustworthy social partner was, however, negatively correlated the suspiciousness item of the BPRS. Further, illness duration (the number of years since a person with schizophrenia reported first seeking treatment for symptoms or was first hospitalized) was negatively correlated with trust placed trustworthy social partners during both the initial and reversal phase (see Table 4).

We computed correlations between the average amount of trust placed in trustworthy and untrustworthy social partners during each phase, negative symptoms, and functioning for people with schizophrenia. As shown in Table 4, greater trust placed in trustworthy social partners during both 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. Furthermore, greater trust placed in formerly untrustworthy social partners during the reversal phase was associated with better family functioning. Given that the amount of trust placed in trustworthy social partners was negatively correlated with illness duration and BPRS suspiciousness, we recomputed these correlations between trust, motivation/pleasure negative symptoms, and functioning controlling for the effects of illness duration and suspiciousness. Importantly, the correlations remained significant.

In contrast, the amount of trust placed in untrustworthy social partners during the initial and reversal phases was not associated

Table 4
Correlations Between Trust Placed in 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
BPRS suspiciousness item	−.36*	−.31

Note. Trust operationalized as the average number of points sent to trustworthy social partners. CAINS = Clinical Assessment Inventory for Negative Symptoms; MAP = Motivation and Pleasure; EXP = Expressivity; BPRS = Brief Psychiatric Rating Scale.
* $p < .05$. ** $p < .01$.

with motivation/pleasure negative symptoms but it was linked to greater social network functioning (initial phase: $r = 0.51$, $p < .01$; reversal phase: $r = 0.38$, $p = .03$).

Discussion

We investigated how people with and without schizophrenia used positive and negative social interaction outcomes and the information signaled by social partners' emotional displays to guide decision-making. We found that people with schizophrenia were less sensitive than controls to positive social interaction outcomes during initial interactions with trustworthy social partners, but nevertheless updated their decisions to place trust in partners who reversed and became trustworthy social partners in a manner that was similar to controls. We also found that people with schizophrenia were *more* sensitive than controls to negative social interaction outcomes during initial interactions with untrustworthy social partners. However, people with schizophrenia placed comparatively less trust in social partners who reversed and became untrustworthy. Across all interactions, greater trust placed in social partners, whether trustworthy or untrustworthy, was related to greater social network functioning among people with schizophrenia.

Positive Social Interactions Outcomes

Across both behavioral (points given to social partners) and self-report (trustworthiness ratings) measures, our results suggest that people with schizophrenia have difficulties using positive social interaction outcomes over the course of repeated interactions to inform decisions to trust. Trust is an important building block for social relationships, and our finding that less trust placed in trustworthy partners was related to poorer social network functioning suggests that difficulties establishing trust has real-world implications for people with schizophrenia. For example, people with schizophrenia may be reluctant to trust someone when meeting 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 social interaction outcomes to inform decisions to trust were associated with more motivation/pleasure negative symptoms as well as more suspiciousness. Given that our index of suspiciousness was a single item, future work should seek to further unpack this relationship.

Equally important as establishing trust is the ability to flexibly adjust decision-making, such as when previously untrustworthy people start behaving in a trustworthy manner. While seemingly inconsistent with previous reversal learning studies (e.g., Waltz & Gold, 2007), our study extended the investigation of reversal learning to include social interaction (rather than monetary) outcomes as well as reversals from negative to positive. We found that people with schizophrenia had no problem updating their decision-making when social outcomes reversed from negative (untrustworthy) to positive (trustworthy), but struggled to do so when social outcomes reversed from positive to negative. While not significant, we found moderate effect sizes for group differences in trustworthiness ratings of previously untrustworthy, now trustworthy social partners. Thus, even though people with schizophrenia detected the reversal in behavior that changed from negative to positive, they did not as readily update their ratings of social partner trustworthiness.

The reversals in our study created a mismatch between the information signaled by a social partner's emotional displays and their behavior. Our findings indicate that people with and without schizophrenia looked past social partners' scowling emotional displays and base trust decisions on their now trustworthy behavior. Moreover, less trust placed in the now trustworthy social partners was associated with greater motivation/pleasure negative symptoms and poorer social functioning among people with schizophrenia. Thus, whether a social partner has always been trustworthy or is "trying to change their ways," people with schizophrenia with greater motivation/pleasure negative symptoms placed less trust in trustworthy social partners.

Negative Social Interaction Outcomes

While people with schizophrenia were comparatively less sensitive to positive, rewarding social interaction outcomes, our findings suggest that they were comparatively *more* sensitive to negative social interactions. This was partially corroborated by trustworthiness ratings as people with schizophrenia rated the scowling (but not neutral) untrustworthy partner as less trustworthy compared to controls. Taken together, these findings provide evidence for greater use of negative social interaction outcomes to inform both behavioral and self-report indices of trust among people with schizophrenia.

Decisions to trust untrustworthy social partners, even if misplaced, were also related to 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 be more open to establishing social

relationships, and thus have greater opportunities for social interactions.

Unexpectedly, we found that people with schizophrenia placed comparatively *greater* trust in social partners whose behavior reversed from trustworthy to untrustworthy, but only for those partners displaying a smile. Although the mismatch between display (scowl) and behavior (trustworthy) did not appear to influence reversals going from untrustworthy to trustworthy for either group, it appears this was not the case for reversals going in the opposite direction, at least for people with schizophrenia. That is, the mismatch between display (smile) and behavior (untrustworthy) may have been more difficult for people with schizophrenia to look past. Indeed, we found that smiling (but not scowling) displays tended to influence decisions to trust in both people with and without schizophrenia, suggesting that, overall, smiles may have been more influential than scowls in the context of this modified trust game.

The Role of Emotional Displays

For the most part, we found few group differences in the use of emotional displays to inform behavior (decisions to trust) and self-report (trustworthiness ratings), thus adding to a growing literature indicating that people with schizophrenia can, in certain circumstances, use information signaled by emotional displays to guide behavior (e.g., Hooker et al., 2011; Kring et al., 2014). Importantly, our findings suggest that less sensitivity to positive and more sensitivity to negative social interaction outcomes was not solely due to differences in using the information signaled by a social partner's emotional display. Future studies should seek to expand the scope of decisions being made, such as whether to approach or avoid a social partner, to assess other circumstances where emotional displays to inform decision-making may be intact or impaired among people with schizophrenia.

We did, however, find two noteworthy group differences in the use of emotional displays. As noted earlier, 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 decisions to trust per se, it did influence how people with schizophrenia rated the trustworthiness of untrustworthy social partners. Second, people with schizophrenia placed more trust in smiling, but untrustworthy social partners. An important question for future studies will be to disentangle whether this was due to difficulties inhibiting the information signaled by the smile, or difficulties in detecting the reversal in outcomes from positive to negative.

Broader Implications

Taken together, the combination of less sensitivity to positive social interaction outcomes and greater sensitivity to negative social interaction outcomes suggests that 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. Negative experiences over the course of illness may further strengthen social avoidance motivation. This admittedly speculative notion is supported by our post hoc findings of a 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. Of course, diminished trust in the course of daily social interactions may be adaptive and even well-placed depending upon the circumstances and social context. It may also be the case, however, that compared to those with a history of negative social encounters, people with schizophrenia who are functioning better socially, and as a result have a more robust social network are more receptive to the trustworthy behavior of others compared. Future work should longitudinally assess the relationship between decisions to trust and life events to better understand changes as a function of positive and negative experiences over the course of illness.

Our findings should also be considered in the context of recent work investigating effort-based decision-making in schizophrenia (e.g., Barch & Dowd, 2010). Compared to controls, people with schizophrenia have difficulty using information regarding monetary reward probability and magnitude to inform decisions to expend effort, resulting in fewer decisions to expend greater effort to obtain larger monetary rewards (e.g., Gold et al., 2013; Barch, Treadway, & Schoen, 2014). One possible reason for difficulties matching decisions to expend effort with changing monetary rewards, as our findings would suggest, could be difficulties using rewarding outcomes to inform decision-making. While speculative, it may be the case that people with schizophrenia also struggle to use positive social interaction outcomes to inform decisions to expend effort for future social interactions, suggesting a common mechanism of impairment for decisions to expend effort for both social and nonsocial rewards.

Our findings also suggest that interventions aimed at strengthening sensitivity to positive social interaction outcomes to inform and guide decisions to trust may be useful treatment development directions. One approach could be to pair adaptive computerized cognitive training, which has been shown to improve cognition in people with schizophrenia (Fisher, Loewy, Hardy, Schlosser, & Vinogradov, 2013)—and which has recently has been expanded to target social cognition as well (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 relation between decision and outcome, a potential training module could start by making this link explicit and then steadily decrease available cues when the ability to associate decision and social interaction outcome improves. This procedure could guide people with schizophrenia to make positive appraisals about interactions with positive outcomes, a known predictor of real-world social engagement (Granholm, Ben-Zeev, Fulford, & Swendsen, 2013).

As with any study, it is important to acknowledge limitations. 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. One such approach would be to simulate interactions in the context of a virtual environment (e.g., Blascovich et al., 2002), a method that has been used in studies of autism (Kandalaft, Didehbani, Krawczyk, Allen, & Chapman,

2013). Another limitation of our study is that although the interaction outcomes were social in that the social partner either reciprocated or abused the trust placed in them (as indicated by the amount of points returned), 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 and have decisions made during the interaction result in outcomes that would increase or decrease the likelihood of seeing or interacting with a particular social partner again. Finally, we did not assess for group differences in the valuation of outcomes in this study. While our findings are largely consistent with paradigms using monetary outcomes (which also tend to not assess for individual differences in outcome valuation), it may be the case that the degree to which participants valued gaining or losing points may have contributed to their decision to trust. Future studies should explicitly assess participant valuation of decision outcomes to account for this potentially important individual difference.

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 are broadly consistent with reward learning studies with monetary outcome: people with schizophrenia were less sensitive to positive outcomes, whether social or monetary, and they had difficulty acting upon changes from positive to negative outcomes. However, our findings extend the literature on social decision-making in two ways. First, compared to controls, people with schizophrenia were more sensitive to negative social interaction outcomes to inform decisions (not) to trust, Second, people with schizophrenia detected and acted upon reversals in social outcomes that changed from negative (untrustworthy) to positive (trustworthy) similarly to controls. Furthermore, people with schizophrenia used the information signaled by emotional displays to inform decision-making during social interactions in much the same way as did controls. Finally, our findings illustrate the promise of using computerized social interaction tasks to tap into constructs like trust insofar as performance on the task was linked with real-world social functioning.

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