



Appearance-based trust processing in schizophrenia

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Objectives. Schizophrenia is characterized by impaired social interactions and altered trust. In the general population, trust is often based on facial appearance, with limited validity but enormous social consequences. The aim was to examine trust processing in schizophrenia and specifically to examine how people with schizophrenia use facial appearance as well as actual partner fairness to guide trusting decisions.

Design. An experimental economic game study.

Methods. Here, we tested how patients with schizophrenia and control participants (each $N = 24$) use facial trustworthiness appearance and partner fairness behaviour to guide decisions in a multi-round Trust Game. In the Trust Game, participants lent money to 'partners' whose facial appearance was either untrustworthy or trustworthy, and who either played fairly or unfairly. Clinical symptoms were measured as well as explicit trustworthiness impressions.

Results. Overall, the patients with schizophrenia showed unimpaired explicit facial trustworthiness impressions and unimpaired facial appearance biases in the Trust Game. Crucially, patients and controls significantly differed so that the patients with schizophrenia did not learn to discriminate in the Trust Game based on actual partner fairness, unlike control participants.

Conclusion. A failure to discriminate trust has important implications for everyday functioning in schizophrenia, as forming accurate trustworthiness beliefs is an essential social skill. Critically, without relying on more valid trust cues, people with schizophrenia may be especially susceptible to the misleading effect of appearance when making trusting decisions.

Practitioner points

Findings

- People with schizophrenia made very similar facial trustworthiness impressions to healthy controls and also used facial appearance to guide trust decisions similarly to controls.

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- However, the patient group were less able to explicitly distinguish between fair and unfair partners based on their behaviour compared with the control group.
- Moreover, people with schizophrenia failed to use actual partner fairness to guide their financial decisions in the Trust Game, unlike controls, and this impairment was specific to a social task.
- People with schizophrenia may be particularly reliant on facial appearance when trusting others, as they may struggle to incorporate more valid trustworthiness information in their decision-making, such as actual partner fairness.

Appearance-based trust processing in schizophrenia

Schizophrenia is characterized by impaired social interactions and altered trust (Brüne & Wischniewski, 2011; Freeman, 2007), particularly for patients with paranoia (Gromann *et al.*, 2013). These differences manifest early, are particularly resistant to intervention, and are especially predictive of everyday functioning (Chan & Chen, 2011; Green, Horan, & Lee, 2015). Moreover, the association between trust and patient symptomology is not always straightforward, requiring further investigation (McIntosh & Park, 2014; Prevost, Brodeur, Onishi, Lepage, & Gold, 2015). Investigating trust impairment in schizophrenia is therefore vital to both understanding and treatment of the disorder.

A new approach to investigating trust in schizophrenia is to employ economic games, which operationalize trust through interactive financial lending (Brüne & Wischniewski, 2011; Chan & Chen, 2011). Although underutilized in psychiatry research, economic games have the benefit of measuring trust unobtrusively, are engaging, and have real-life applicability. Moreover, these games may be especially sensitive to social impairment as they are interactive and occur in real time (Chan & Chen, 2011; Fett *et al.*, 2012).

In economic game studies, individuals with schizophrenia or high schizotypy often show increased mistrust, indicated by lower financial lending (Fett *et al.*, 2012, 2016; Gromann *et al.*, 2013), although not always (van't Wout & Sanfey, 2011), and sometimes patients are hyper-fair (Agay, Kron, Carmel, Mendlovic, & Levkowitz, 2008; Wischniewski & Brüne, 2011). More recently, two studies have examined trust over repeated interactions, finding that individuals with schizophrenia fail to learn partner trustworthiness (Fett *et al.*, 2012, 2016).

However, these economic game studies have largely focused on explicit, top-down cues to trustworthiness, such as partner behaviour or reputational information (e.g., Fett *et al.*, 2012). In doing so, studies have neglected bottom-up, implicit trust cues, such as partner facial appearance. Trust behaviour based on facial appearance is widespread in the general population (Olivola, Funk, & Todorov, 2014), although facial appearance is not a highly accurate trustworthiness cue (Rule, Krendl, Ivcevic, & Ambady, 2013). Trustworthy-looking partners are given more money than untrustworthy-looking partners on real financial websites (Duarte, Siegel, & Young, 2012) and in laboratory-based Trust Games (Chang, Doll, van't Wout, Frank, & Sanfey, 2010; Ewing, Caulfield, Read, & Rhodes, 2015). It is unclear whether people with schizophrenia similarly use facial appearance to guide their trust decisions.

Current study

The overall aim was to examine trust processing in schizophrenia and specifically to examine how people with schizophrenia use facial appearance and actual fairness to guide trusting decisions. We measured trusting behaviour using an economic Trust Game where decisions could be based on partner facial appearance and/or behaviour. In the Trust Game (based on Chang *et al.*, 2010; Ewing *et al.*, 2015), trusting decisions were

indexed by money transferred to four ‘partners’, who looked untrustworthy or trustworthy, and played fairly (returned an equal share of invested money) or unfairly (kept all the money). Participants played multiple rounds of the Trust Game with the same partners. This design allowed us to investigate whether people with schizophrenia differed from controls in their reliance on facial appearance as well as actual partner fairness in guiding trust.

Regarding appearance-based trust, social behaviour in schizophrenia and autism is often similar (Frith & Johnstone, 2003), and boys with autism are less guided by facial appearance in Trust Games than non-autistic boys (Ewing *et al.*, 2015). Following the pattern in autism, we would predict that people with schizophrenia are less guided by appearance than controls. Yet, to the extent that people with schizophrenia may form more extreme impressions from facial appearance than controls (Trémeau *et al.*, 2016), this account would instead predict that people with schizophrenia are relatively *more* guided by appearance. We tested these opposing hypotheses here. We also tested explicit trustworthiness impressions based on facial appearance, to inform the Trust Game results. We did not have a strong prediction for explicit facial impressions as evidence is mixed (Hall *et al.*, 2004, 2010; Haut & MacDonald III, 2010; Marwick & Hall, 2008; McIntosh & Park, 2014; van’t Wout *et al.*, 2007).

Regarding experience-based trust, we predicted that the participants with schizophrenia would be less influenced than controls by partner actual fairness when making trusting decisions (following Fett *et al.*, 2012, 2016). Capacity to learn partner fairness is likely underpinned by ability to utilize experience when reasoning, and theory of mind (ToM), skills that are impaired in schizophrenia (Langdon, 2005; Woodward, Moritz, Cuttler, & Whitman, 2006). As a supplementary analysis (see Appendix S1), we therefore measured cognitive reasoning (Moritz & Woodward, 2005; Woodward *et al.*, 2006) and ToM (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Langdon, 2005) to ascertain any links between these capacities and trust behaviour. Finally, we included a version of the Trust Game with slot machines rather than partners, to control for non-social aspects of gameplay (Chang *et al.*, 2010) in order to understand whether any impairment was specific to a social interaction context.

Methods

Participants

We recruited 24 individuals with schizophrenia or schizoaffective disorder from volunteer registers in the [Department of Cognitive Sciences, Macquarie University and the Schizophrenia Research Institute of Australia, and via the Schizophrenia Fellowship of NSW]. We recruited 24 healthy controls from the general community. Exclusion criteria for all participants included history of brain injury or other neurological disorder, or current or previous persistent substance abuse. Controls with a personal or familial history of psychotic disorder were also excluded. Clinical participants had a DSM5 diagnosis of schizophrenia ($N = 17$) or schizoaffective disorder ($N = 7$) (American Psychiatric Association, 2013). Diagnosis was confirmed using the Diagnostic Interview for Psychosis (Castle, Jablensky, & McGrath, 2006) and clinical history. Current symptoms were rated using the Scales for Assessing Positive and Negative Symptoms of Schizophrenia (SAPS/SANS: Andreasen, 1983, 1984). Thirteen clinical participants had current delusions, and eleven did not. We also measured general proneness to delusional ideation using the Peters *et al.* Delusions Inventory (PDI, Peters, Joseph, Day, & Garety, 2004) and recorded the persecution subscore (Verdoux *et al.*, 1998) given the relevance

of paranoia for trust (Freeman, 2007). All clinical participants were on medication at the time of testing. Of the 24 clinical participants taking antipsychotic medication, two were taking typical antipsychotic medication only, 20 were taking atypical antipsychotic medication only, and two were taking a combination of typical and atypical medications. Additionally, 14 clinical participants were also taking an antidepressant.

Clinical and control groups did not differ in premorbid intelligence (on the National Adult Reading Test: NART), current intelligence (on the Matrix Reasoning component of the Weschler Adult Intelligence Scale), or age at testing (Table 1). Participants gave written informed consent to procedures approved by the Human Research Ethics Committee of [Macquarie University].

Tasks

Facial impressions

Participants rated the trustworthiness of 40 faces in a pseudo-randomized order¹ (after two practice images) using a 9-point scale (1 = not at all trustworthy, 9 = very trustworthy). We measured mean trustworthiness impressions and agreement with consensus trustworthiness impressions (from Hooper *et al.*, 2018). Face images were taken from the US10K (Bainbridge, Isola, & Oliva, 2013) and restricted to Caucasian females to avoid stereotyping (Hooper *et al.*, 2018).

Trust Game

Participants played a multi-turn Trust Game previously used with students (Hooper *et al.*, 2018; see Figure 1). After two practice trials with cartoon partners, participants played eight turns with four virtual ‘partners’ (32 trials). On each turn, participants received \$10 of virtual money, then viewed their partner’s face for 3.5 s, and were required to invest between \$0 and \$10 with their partner. Any investment was quadrupled. Partners

Table 1. Mean and SD for demographic and IQ variables for clinical and control groups, and clinical symptomology for the clinical group

	Clinical group	Healthy control group	Significance test
N	24	24	–
Males:females	14:10	14:10	–
Age at testing (years)	51.9 (8.9)	45.6 (13.8)	$t(39.4) = 1.88, p = .068, d = .5$
NART full score	108.0 (9.7)	106.5 (10.1)	$t(46) = 0.51, p = .612, d = .2$
WASI matrix reasoning (raw score)	17.6 (4.3)	19.7 (4.8)	$t(46) = 1.60, p = .116, d = .5$
WASI matrix reasoning (scaled score)	9.3 (3.3)	10.6 (3.2)	$t(46) = 1.36, p = .179, d = .4$
Age at diagnosis (years)	25.7 (9.1)	–	–
SAPS global (mean)	1.2 (0.7)	–	–
SANS global (mean)	2.4 (0.6)	–	–
PDI score (sum of paranoia items: Q1, Q3-5)	2.5 (1.3)	–	–

Note. Effect sizes are Cohen’s *d* values for the group difference.

¹ Due to experimenter error, two patients and two controls were shown the images in a different order.

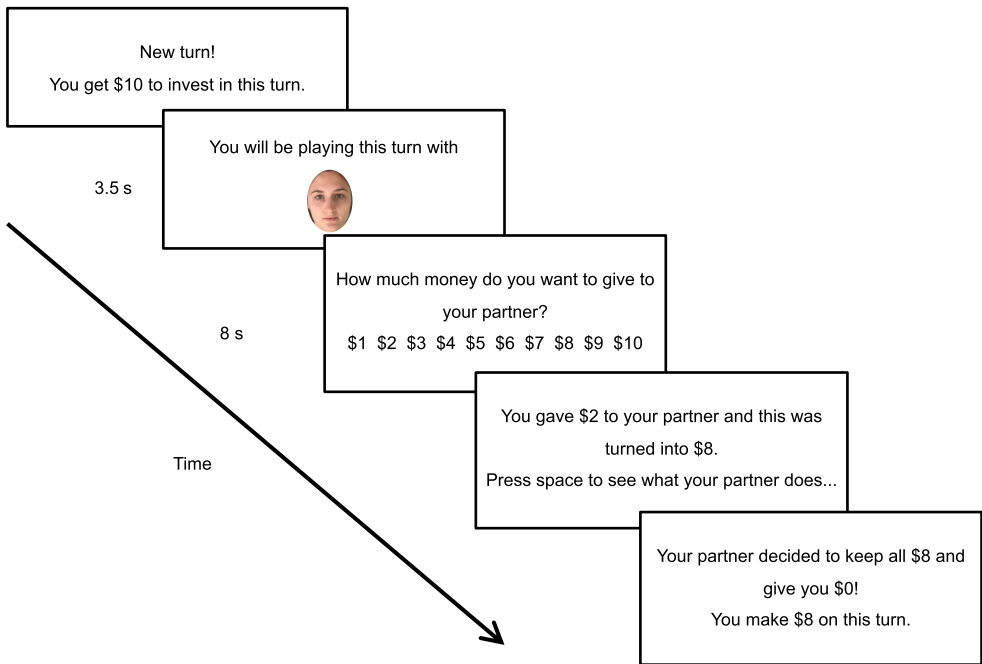


Figure 1. Example of a single Trust Game turn. *Note.* Instead of transferring money, participants could also choose to transfer no money by pressing a key labelled ‘no money’. The face shown in the game here is an example due to copyright reasons and was not one of the faces used in the Trust Game, although it is representative. Figure previously published in Hooper *et al.*, 2018.

returned an equal split of the money (fair behaviour) or kept the money (unfair behaviour). Thus, if the partner was fair, the participant doubled their investment, and if unfair, the participant lost their investment. Participants additionally kept any amount not invested. If participants took longer than 8s to make an offer, they forfeited all their money on that turn (seven and eight turns across both games for clinical and control participants, respectively). These trials were treated as missing data to ensure money transferred was not confounded by impulsivity.

Participants viewed one of two possible sets of partners, which were counterbalanced across participants. Partners were Caucasian females only, to avoid stereotyping, and were taken from the US10K (Bainbridge *et al.*, 2013). Two partners were trustworthy-looking, and two were untrustworthy-looking (Hooper *et al.*, 2018).

Assignment of partner behaviour was crossed with facial appearance and counterbalanced across participants. Fair partners returned money to participants on 7/8 turns; unfair partners returned money on 1/8 turns. Behaviour was probabilistic to prevent the game from being too easy and to better replicate real-world interaction (Chang *et al.*, 2010).

Slot Machine game

We included a non-social version of the Trust Game, which was identical except that participants played with four coloured slot machines. Including this game allowed us to control for task-specific aspects of the Trust Game (e.g., reward sensitivity).

Explicit beliefs

At the end of the Trust Game and Slot Machine tasks, we examined participants' beliefs about how trustworthy their partners looked, as well as how fairly the partners or slot machines behaved. Participants were asked to rate each partner's face on their trustworthiness levels between 1 and 10 (1 = not at all trustworthy and 10 = extremely trustworthy). They were also required to rate partners or slot machines on their fairness levels, defined as the percentage of times their partner or the slot machine returned money (0 = 0% to 9 = 90% in 10% increments).

Additional measures

We also measured cognitive biases and theory of mind (see Appendix S1 for more details).

General procedure

Computer-based tasks were performed on a Dell PC running Windows 7. The facial trustworthiness task was completed after the Trust Games to avoid priming participants. No deception was used, and participants were fully debriefed afterwards. Testing sessions lasted 2–3 hrs.

Analysis

We first tested for a clinical difference in explicit trustworthiness facial impressions by correlating each of the clinical and control groups' impressions with independent consensus impressions. We statistically compared the clinical and control groups' correlations using a Fisher z test.

In order to understand whether there was a clinical difference in trusting decisions based on partners' appearance and/or actual fairness over time, we then analysed trusting decisions in the Trust Game (money transferred) with a four-way mixed ANOVA. The ANOVA had Group (clinical or control) as a between-subjects factor, and Partner Appearance (trustworthy or untrustworthy), Partner Behaviour (fair or unfair), and Time (first or last block) as within-subjects factors. The four-way interaction was not significant; thus, we ran a three-way ANOVA for Group, Appearance, and Time after collapsing over Behaviour to examine the effect of Appearance. We then ran a three-way ANOVA for Group, Behaviour, and Time after collapsing over Appearance to examine the effect of Behaviour. We ran an identical ANOVA for the control Slot Machine task, but without the Appearance factor.

Finally, in order to understand whether there was a clinical difference in explicit appearance and fairness beliefs, we ran two-way mixed ANOVAs on the explicit appearance and fairness ratings of the partners in the Trust and Slot Machine Games. These ANOVAs had Group (clinical or control) as a between-subjects factor and either Partner Appearance (trustworthy or untrustworthy) or Partner or Slot Machine Behaviour (fair or unfair) as within-subjects factors.

Across all analyses, we followed up any significant effects for Appearance or Behaviour using paired t -tests to compare trustworthy-looking versus untrustworthy-looking partners or fair versus unfair partners, respectively. Where the clinical Group factor interacted with Appearance or Behaviour conditions, we ran separate paired t -tests for clinical and control groups separately in order to understand the pattern for each group.

Where the Time factor interacted, we ran separate paired *t*-tests for first and last blocks separately in order to understand the pattern at each time point.

Results

Explicit facial trustworthiness impressions

We first examined how people with schizophrenia made explicit trust impressions from faces, in order to contextualize the Trust Game results.

Main facial impressions task

One participant in each group was excluded from the facial impression agreement analysis because they failed to discriminate between the faces. Both groups showed significant agreement with consensus facial trustworthiness judgements: clinical mean $r = .31$, $SD\ r = .20$, $t(22) = 7.06$, $p < .001$, control mean $r = .27$, $SD\ r = .16$, $t(22) = 7.72$, $p < .001$, with no significant group difference; $t(44) = 0.96$, $p = .343$, $d = 0.28$ (all correlations reflect Pearson's r ; t -test after Fisher transformation). We also did not find a difference in mean impressions: clinical mean = 5.31, $SD = 1.12$; control mean = 5.03, $SD = 0.90$; $t(46) = -0.97$, $p = .336$, $d = 0.28$ or in impression variance, $t(46) = 0.48$, $p = .492$. All d values (here and elsewhere) reflect Cohen's d for the group difference and all monetary values are in Australian dollars.

Facial impressions of Trust Game partners

As a manipulation check, participants rated the facial trustworthiness of their partners after the Trust Game. We analysed these explicit impressions in a two-way mixed ANOVA with Group (clinical vs. control) as a between-subjects factor and Partner Appearance (Trustworthy vs. Untrustworthy) as a within-subjects factor. The main effect of Appearance was significant, indicating that participants perceived the trustworthy-looking partners as more trustworthy ($M = 4.8$, $SD = 2.1$) than the untrustworthy-looking partners ($M = 3.5$, $SD = 1.6$), as expected: $F(1,46) = 20.30$, $p < .001$, $\eta_p^2 = 0.31$. There was no main effect or interaction with Group: both $F(1,46) < 0.27$, $p > .60$, $\eta_p^2 < 0.01$, thus the clinical group did not show lower overall trust, agreeing with the main trustworthiness impressions task.

Trust Game decisions

Our main aim was to examine how people with schizophrenia use facial appearance and/or experience with actual fairness to guide trusting decisions. We conducted a four-way mixed ANOVA with Group (clinical vs. control) as a between-subjects factor, and Partner Appearance (trustworthy vs. untrustworthy), Partner Behaviour (fair or unfair), and Time (first vs. last block) as within-subjects factors. We could compare the first and last block directly because these trials were identical. The four-way interaction was not significant: $F(1,42) = 0.81$, $p = .37$, $\eta_p^2 = .02$ (note that four participants had to be excluded from this overall analysis due to missing trials). As the overall four-way interaction was not significant, for simplicity, we examined trust based on appearance and behaviour separately (i.e., after collapsing across behaviour/appearance, respectively). These

analyses allowed us to use the whole dataset and paralleled the slot machine game (see the Appendix S1 for the four-way ANOVA results, which were identical).

Appearance-based trust decisions

To test for a group difference in appearance-based trust, we conducted a three-way mixed ANOVA on money transferred in the Trust Game, with Group (clinical vs. control) as a between-subjects factor and Partner Appearance (trustworthy vs. untrustworthy) and Time (first vs. last block) as within-subjects factors (collapsed across Partner Behaviour). Critically, by the last block in the Trust Game, participants should have stopped using facial appearance to guide decision-making, given that it did not accurately cue partner fairness.

Interestingly, the only significant effect was a main effect for Partner Appearance: $F(1,46) = 7.12, p = .011, \eta_p^2 = .13$. On average, participants transferred more money to trustworthy-looking (mean = \$5.34, $SD = \$2.17$) than untrustworthy-looking partners (mean = \$4.64, $SD = \$2.55$) in the Trust Game. No other effects were significant: $F(1,46) < 1.36, p > .25, \eta_p^2 < .03$ (Figure 2). In other words, misleading facial appearance was used to guide decision-making, even when other, more objective information (partner fairness) was available.

Experience-based trust decisions

To test whether the groups learned to discriminate partner fairness, we conducted a three-way mixed ANOVA on money transferred in the Trust Game, with Group (clinical vs. control) as a between-subjects factor and Partner Behaviour (fair vs. unfair) and Time (first vs. last block) as within-subjects factors (collapsed across Partner Appearance). There was a significant main effect of Partner Behaviour: $F(1,46) = 19.89, p < .001, \eta_p^2 = .30$, and two-way interactions between Group and Partner Behaviour, as well as Time and Partner Behaviour: both $F(1,46) > 8.05, p < .007, \eta_p^2 > .15$ (Figure 3).

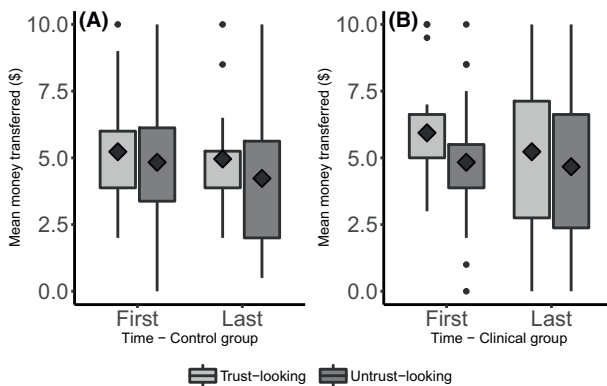


Figure 2. Trust Game and partner appearance. Money transferred in the Trust Game on average for (A) control (left-hand panel) and (B) clinical participants (right-hand panel), based on partner trustworthy (light grey) or untrustworthy (dark grey) appearance in the first and last blocks of the Trust Game. Figures depict boxplots with the mean superimposed. The only significant effect was of partner appearance, so that more money was transferred to trustworthy-looking than untrustworthy-looking partners.

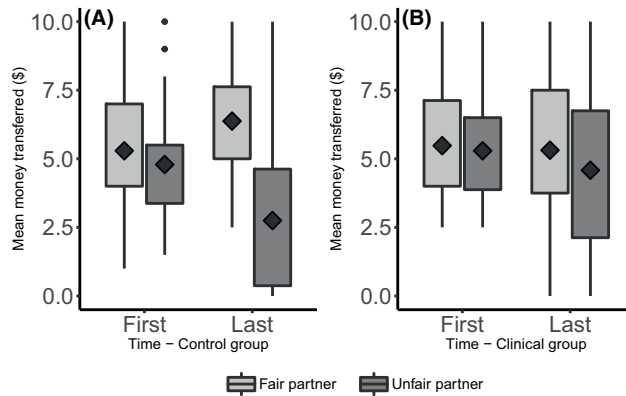


Figure 3. Trust Game and partner fairness. Money transferred in the Trust Game on average for (A) control (left-hand panel) and (B) clinical participants (right-hand panel), based on fair (light grey) or unfair (dark grey) partner behaviour in the first and last blocks of the Trust Game. Figures are boxplots with the mean superimposed. In the first block, participants have not experienced the unfair or fair behaviour of their partners, thus neither control nor clinical participants discriminate based on partner behaviour. By the last block, control participants have successfully learnt which partners are trustworthy, as they discriminate based on fair or unfair partner behaviour. Crucially, participants with schizophrenia fail to learn which partners are trustworthy.

Critically, there was also a significant three-way interaction, suggesting that the groups had different responses to partner behaviour over time: $F(1,46) = 6.13$, $p = .017$, $\eta_p^2 = .12$ (Figure 3). We ran paired t -tests to follow up on this interaction. As expected, neither the control nor clinical group discriminated based on fair versus unfair partner behaviour in the first block, before partner behaviour was known: control $t(23) = 1.18$, $p = .251$, $d = 0.22$, clinical: $t(23) = 0.51$, $p = .613$, $d = 0.09$. Strikingly, whereas controls did discriminate based on fair versus unfair partner behaviour by the last block: $t(23) = 5.81$, $p < .001$, $d = 1.47$, the clinical group did not: $t(23) = 1.05$, $p = .303$, $d = 0.23$. Thus, unlike controls, the patients with schizophrenia failed to learn to use partner behaviour to guide their trust decisions.

Non-social control task

The clinical group struggled to discriminate partner actual fairness in the Trust Game, raising the question of whether this effect is specific to a social task involving human partners, or whether it reflects a more general problem. To answer this question, we examined whether the groups learned to discriminate between rewarding and non-rewarding slot machines over the course of the Slot Game. Thus, we conducted a three-way mixed ANOVA on money transferred, with Group (clinical vs. control) as a between-subjects factor and Slot Machine (rewarding vs. unrewarding) and Time (first vs. last block) as within-subjects factors (Figure 4). There was a significant main effect of Slot Machine: $F(1,46) = 24.55$, $p < .001$, $\eta_p^2 = .35$, reflecting more money transferred to the rewarding slot machine ($M = \$6.44$, $SD = \$2.54$) versus the unrewarding slot machine ($M = \$4.88$, $SD = \$3.09$). There was also a main effect of Group: $F(1,46) = 6.06$, $p = .018$, $\eta_p^2 = .12$, reflecting a tendency for the clinical participants to transfer more money on average ($M = \$6.28$, $SD = \$2.95$) than controls ($M = \5.04, $SD = \$2.79$).

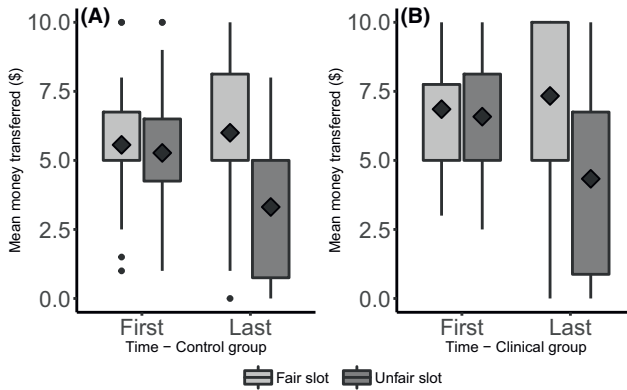


Figure 4. Slot machine game. Money transferred in the Slot Machine Game on average for (A) control (left-hand panel) and (B) clinical participants (right-hand panel), based on fair (light grey) or unfair (dark grey) partner behaviour in the first and last blocks of the Slot Machine Game. Figures are boxplots with the mean superimposed. In the first block, participants have not experienced the unfair or fair behaviour of their partners, thus neither control nor clinical participants discriminate based on partner behaviour. By the last block, clinical and control groups have successfully learnt which slot machines are fair or unfair.

There was a significant two-way interaction between Slot Machine and Time, reflecting learning which slots were rewarding: $F(1,46) = 20.24, p < .001, \eta_p^2 = .31$. Importantly, the three-way interaction was not significant, $F(1,46) = 0.09, p = .771, \eta_p^2 = .002$. At the start, neither group discriminated between rewarding and unrewarding slot machines: both $t(23) < 1.03, p > .314, d < 0.12$. By the end, both groups had learnt to discriminate between rewarding and unrewarding slot machines: both $t(23) > 3.54, p < .002, d > 0.94$ (Figure 4).

Explicit fairness beliefs

Finally, given the suggestion of possible dissociations between explicit and implicit social cognitive processes in schizophrenia (e.g., Frith, 2004), we investigated whether the clinical group's inability to distinguish partner fairness in the Trust Game reflected an explicit or implicit problem in distinguishing fairness. To measure their explicit fairness beliefs, participants rated the perceived fairness of their partners and slot machines at the end of the games. We analysed the Trust Game fairness ratings in a two-way mixed ANOVA with Group (clinical vs. control) as a between-subjects factor and Partner Behaviour (fair vs. unfair) as a within-subjects factor. There was a significant main effect of Behaviour, thus participants correctly distinguished fair and unfair partners: $F(1,46) = 38.10, p < .001, \eta_p^2 = .45$; however, this pattern was qualified by a significant interaction with Group: $F(1,46) = 10.07, p = .003, \eta_p^2 = .18$. Both the clinical and control participants correctly judged the fairness of their partners in the Trust Game, although fairness discrimination was weaker in the clinical group, fair $M = 5.2, SD = 1.7$, unfair $M = 4.1, SD = 1.7, t(23) = 2.45, p < .023, d = 0.64$, compared with the control group, (fair $M = 6.2, SD = 1.5$, unfair $M = 2.9, SD = 1.7, t(23) = 5.91, p < .001, d = 2.09$). Thus, the clinical participants were less able to explicitly distinguish fair and unfair partners than controls, mirroring the pattern for money transferred. The main effect of Group was not significant, thus the clinical and control groups did not differ in absolute fairness ratings: $F(1,46) = 0.04, p = .842, \eta_p^2 < .00$.

In the Slot Game, there was only a significant main effect of Behaviour, $F(1,46) = 46.25$, $p < .001$, $\eta_p^2 = .50$, with no other significant effects: both $F(1,46) < 0.47$, $p > .50$, $\eta_p^2 < .01$. Overall, all participants correctly distinguished rewarding ($M = 6.0$, $SD = 1.7$) and unrewarding slot machines ($M = 3.3$, $SD = 1.7$) in their fairness ratings. Thus, as for money transferred, the group difference in correctly judging fairness was specific to the social Trust Game.

Discussion

Overall, individuals with schizophrenia and healthy controls formed very similar explicit facial trustworthy impressions. Both groups also relied on facial trustworthy appearance to guide financial decisions in the Trust Game. Crucially, however, the participants with schizophrenia failed to use actual partner fairness to guide their financial decisions in the Trust Game, unlike controls, and this impairment was specific to a social task. Moreover, the clinical group were also less able to explicitly distinguish between fair and unfair partners based on their behaviour compared with the control group. Our findings agree with two recent studies on trust reciprocation, which have also shown impairments in trust updating in schizophrenia and psychosis (Fett *et al.*, 2012, 2016). Critically, here we also show that people with schizophrenia appear to anchor on an initial, potentially misleading trust decision based on appearance, and then, unlike control participants, fail to update their strategy to incorporate more valid information about actual partner trustworthiness.

A failure to learn trustworthiness in schizophrenia

Our Trust Game results are also strikingly similar to cognitive reasoning biases found previously in schizophrenia (Moritz & Woodward, 2005; Woodward *et al.*, 2006), suggesting that reasoning biases may be contributing to social impairment in this disorder. Our distinction between appearance-based and experience-based trust is also consistent with recent theories of low- and high-level processes of predictive coding and their potential disturbance in psychosis (see Sterzer *et al.*, 2018; Sterzer, Voss, Schlagenhauf, & Heinz, 2019 for reviews). In predictive coding accounts of schizophrenia, psychosis may reflect a problem with weaker prior expectations for lower-level visual input (here, appearance), which in turn may cause stronger prior expectations for higher-level beliefs, or conceptual input (here, learning from experience). This account would likely predict less strong visual appearance biases, which we did not find (nor did other recent predictive coding studies: Kaliuzhna *et al.*, 2018; Palmer, Caruana, Clifford, & Seymour, 2018); nevertheless, it would also predict less updating of conceptual beliefs based on actual experience, which is consistent with our results.

The clinical group did not show a failure in experience-based trust for the control (non-social) slot machine game. Why not? Certainly, there is a wealth of literature showing aberrant non-social reward processing in schizophrenia (see Strauss, Waltz, & Gold, 2014 for a review). Some predictive coding accounts argue that social processing may be particularly disrupted in psychosis as aberrant predictive coding would make other people's intentions seem unreliable (Sterzer *et al.*, 2018). Given that we can never truly verify another's intentions, social cues may be relatively more uncertain than non-social ones (Sterzer *et al.*, 2018). Potentially, forming (and overcoming) an initial impression is also critical: in the social Trust Game, it is possible to base a decision on the initial and

misleading evidence of partner facial appearance, in contrast to the slot machine game. Similarly, non-social learning studies have found that habitual decision-making is less disrupted in schizophrenia than flexible decision-making (Culbreth, Westbrook, Daw, Botvinick, & Barch, 2016; Strauss *et al.*, 2014). Finally, it is also possible that the slot machine game may simply have been easier or influenced by practice, given that it was presented after the Trust Game to avoid influencing performance on our measure of key interest. Future research should tease apart these explanations, because successful learning in the slot machine game could provide a useful therapeutic tool if it is indeed easier and training generalizes.

Interestingly, there was no evidence of overall higher suspiciousness for the clinical group in the Trust Game. The clinical group transferred as much money as did controls and rated their partners equally in fairness. Previous studies measuring gameplay in schizophrenia and psychosis have been mixed (Agay *et al.*, 2008; Fett *et al.*, 2012; Gromann *et al.*, 2013; van't Wout & Sanfey, 2011; Wischniewski & Brüne, 2011). Overall, previous studies are heterogeneous in both patient symptoms and gameplay, including incentive structure and live versus pre-programmed gameplay. For this reason, we deliberately chose a game design which has been used in previous work with neurotypical adults (Chang *et al.*, 2010; Hooper *et al.*, 2018). However, future research should systematically test these factors and could also use more complex and/or naturalistic Trust Game designs.

Unimpaired trustworthiness appearance processing in schizophrenia

The group with schizophrenia made very similar explicit facial impressions to healthy participants and also used facial appearance to guide trust decisions. The finding of unimpaired facial trustworthiness impressions contradicts some previous studies (Hall *et al.*, 2004; Haut & MacDonald III, 2010; Pinkham, Hopfinger, Pelphrey, Piven, & Penn, 2008; Trémeau *et al.*, 2016) but agrees with others (Marwick & Hall, 2008; McIntosh & Park, 2014; Mukherjee *et al.*, 2014). Our study used naturalistic face images, which have greater ecological validity and likely preserve more trustworthiness cues relative to laboratory-based images used in some studies (e.g., Pinkham *et al.*, 2008). Moreover, even studies that find clinical impairments observe stronger differences in judgements other than trust (e.g., intelligence: Hall *et al.*, 2004), suggesting that any such differences are not specific to trust *per se*. Interestingly, the pattern here also contrasts with the pattern found in autism (Ewing *et al.*, 2015) and for men with high autistic traits (Hooper *et al.*, 2018), who showed less appearance-based trust decisions but similar experience-based trust compared with controls, suggesting important social processing differences between schizophrenia and autism.

Future research

Future research should test whether the interpersonal trust issues found here are also present at other stages of illness (e.g., early psychosis) and in other clinical samples (e.g., more functionally impaired groups). Effects on everyday social functioning and implications for treatment likewise warrant further research. A promising future direction will be to establish whether training on economic games can improve everyday social interaction problems in schizophrenia (Chan & Chen, 2011). Anecdotally, these games show promise as a therapeutic tool, as the participants with schizophrenia reported enjoying the tasks, which did not take long (15 min).

Conclusions

Facial appearance guides trust across a wide variety of social contexts, although it is often misleading (Olivola *et al.*, 2014). Critically, people with schizophrenia may be particularly subject to the misleading effect of appearance when making everyday trusting decisions, as they may struggle to incorporate more valid information in their decision-making, such as the actual fairness of their social partners.

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Supporting Information

The following supporting information may be found in the online edition of the article:

Appendix S1. Additional measures and supporting analyses.