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Interactive decision-making in people with schizotypal traits: A game theory approach

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ABSTRACT

Studies that have investigated whether deficits in social cognition observed in schizophrenia are also present in schizotypal individuals have largely been inconclusive, and none of these studies have examined social *interactive* behavior. Here, we investigated interactive decision-making behavior in individuals differing in the amount of schizotypal symptoms using tasks derived from Game Theory. In total 1691 undergraduate students were screened with the Schizotypal Personality Questionnaire-Brief version. We selected 69 people distributed across the full schizotypal continuum to participate in Ultimatum and Dictator Games in which they played against human and non-human, computer partners. The results showed that higher levels of schizotypal symptoms, particularly positive and disorganized schizotypy, were related to proposing higher offers to all partners. Additionally, the amount of interpersonal schizotypal symptoms was associated with an increased acceptance rate of very unfair offers from human partners, possibly reflecting a blunted emotional response to such offers. We conclude that positive and disorganized schizotypal symptoms are associated with less adequate bargaining behavior, similar to what has been recently observed in patients with schizophrenia. The observed similarities on Ultimatum Game behavior between patients with schizophrenia and individuals with more schizotypal symptoms contribute to the growing evidence that social cognitive deficits may represent a marker of vulnerability to schizophrenia.

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1. Introduction

Apparent social dysfunction is one of the major classifications of the diagnosis of schizophrenia (A.P.A., 2000) and these dysfunctions often precede the onset of the illness (Hans et al., 1992; Baum and Walker, 1995), which have led to the suggestion that social dysfunction can serve as vulnerability marker for schizophrenia. Given that the perception, interpretation and processing of social–emotional information is crucial for appropriately navigating social environments, numerous studies have examined social–emotional information processing in schizophrenia (see Green et al., 2005 for an overview of social cognition domains investigated in schizophrenia). These studies reported social cognitive deficits measured with various tasks and include impairments in emotion processing such as recognition of facial emotional expressions and tone of voice (Edwards et al., 2002; Kohler and Brennan, 2004; Van 't Wout et al., 2007); theory of mind and the attribution of mental states to others (Corcoran et al, 1995; Greig et al., 2004) social perceptions and impaired social judgments (Corrigan and Green, 1993; Toomey et al., 2002; Baas et al., 2008) and social knowledge or understanding social schema (Corrigan and Addis, 1995; Penn et al., 2002).

Equivalent aberrations, although to a lesser degree, have been reported in individuals with schizophrenia-like, or so-called schizotypal symptoms (Poreh et al., 1994; Langdon and Coltheart, 1999; Waldeck and Miller, 2000; Henry et al., 2008). However, findings are inconsistent, and other studies have reported no deficits in social–emotional processing in schizotypal individuals (Toomey and Schuldberg, 1995; Van 't Wout et al., 2004; Jahshan and Sergi, 2007). Schizotypy is the basis of schizotypal personality disorder (Raine, 1991) and is thought to be a continuous phenomenon that can be detected in the general population. Schizotypal traits have been associated with increased risk for developing psychotic disorders including schizophrenia (Lenzenweger, 1994) and relatives of patients with schizophrenia report having more schizotypal symptoms (Vollema et al., 2002). The examination of individuals with high levels of schizotypal symptoms is informative as it allows researchers to study schizophrenia-related traits without confounding factors such as medication, severe psychopathology, and institutionalization. Additionally, (cognitive) aberrations in schizotypal individuals that parallel those seen in schizophrenia might point to a vulnerability marker for the disease (Gottesman and Gould, 2003).

Despite the important findings of social–emotional processing deficits in schizophrenia and schizotypal individuals, the majority of

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studies have investigated people placed outside an actual social interaction. In these situations, actions have no direct consequences for participants or others, for instance when asked to label facial affective expressions. However, social behavior can best be thought of as an interaction between two or more individuals in which the outcome of the interaction has consequences for all parties. Consequently, an important, though currently understudied, question is whether schizophrenia and schizotypy can be associated with abnormalities in social interactive behavior in which decisions made have actual consequences.

To investigate consequential social interactive behavior, the field of Economic Game Theory provides a set of useful, widely-used tasks that allow the investigation of strategic decision-making in a social interactive context (Camerer, 2003). More specifically, these tasks show how people's decision-making behavior consistently deviates from the economically self-interested behavior predicted by standard Economic Theory. Instead, a growing body of research using these tasks has shown that emotional and social aspects of the environment are also crucial in decision-making. Take, for instance, the Ultimatum Game (Guth et al., 1982) in which two players must agree on the division of a sum of money provided by the experimenter. Player 1, the proposer, makes a proposal as to how the money should be split, and Player 2, the responder, has the opportunity to either accept or reject this proposal. If it is accepted, the money gets divided as proposed, but if the responder rejects this offer, neither receives any money, but in both cases the game is over. This is a one-shot game, in which players only play once with each other. Contrary to economic theory, many low, unfair, offers are rejected, demonstrating that motivations other than financial self-interest come into play when engaged in social interactions.

These rejections of unfair offers have been shown to be related to feelings of anger (Pillutla and Murnighan, 1996), to neural activation in areas associated with disgust, i.e. insula (Sanfey et al., 2003), and psychophysiological responses of emotional arousal (Van 't Wout et al., 2006). Furthermore, the insula activation and emotional arousal reported above was specific for unfair offers made by human partners, as compared to non-human, computer partners, which highlights the social nature of decision-making in this game. Therefore, the administration of tasks from Game Theory to participants that are thought to show social–emotional disturbances could give more insight in the deficits in social *interactions*.

In one example of this approach, Agay et al. (2008) recently showed that patients with schizophrenia did not fully exploit the typical strategy of offering a slightly unfair offer to the other player. For example, many players when dividing a $10 pot will make offers of $3 or $4 to their partners, as these slightly unfair offers are usually accepted (Camerer, 2003). The behavior observed in patients with schizophrenia on the other hand, was suggestive of a deficit in understanding social bargaining strategies.

However, to draw firm conclusions about deficits in *social bargaining* strategies it is important to rule out other reasons for giving high offers, such as experiencing positive feelings of altruism, being inequity averse, or implementing a social rule of giving fair shares. Additionally, it is important to examine whether these deficits only occur in a social setting or whether bargaining is also different in non-social situations. These issues can be addressed by comparing behavior on the Ultimatum Game with a game in which responders have no opportunity to reject unfair offers, and by introducing non-social interactions such as computer partners. More specifically, in the Ultimatum Game proposers understand that responders can reject unfair offers, thereby punishing them. To prevent offers from being rejected, proposers offer higher amounts of money. However, when a responder cannot punish a proposer for an unfair offer, proposers can take advantage of the situation by offering lower, i.e. more unfair offers. This latter game is called the Dictator Game (Kahneman et al., 1986). Thus, disturbances in bargaining strategies might become apparent when overly fair offers are proposed in the Ultimatum Game as compared to offers proposed in the Dictator Game. In contrast, offering fair amounts in both games could reflect other goals, i.e. inequity aversion or altruism.

The purpose of this study was to examine interactive decision-making behavior in non-patient individuals across the range of schizotypal symptoms. Using multiple Game Theory tasks we were able to test whether schizophrenia phenomena are associated with aberrant social bargaining behavior. We hypothesized that individuals with more schizotypal symptoms would propose a higher share to another person only when their partners can reject unfair offers (parallel to the results of Agay et al., 2008 in patients with schizophrenia). We further expected that when playing the Ultimatum Game in the role of responder to find a relationship between degree of schizotypal symptoms and acceptance rates of unfair offers, as difficulties in understanding bargaining behavior might result in higher acceptance rates in people with more schizotypal symptoms.

In case the above-mentioned main correlations proved to be significant we performed follow-up analyses to test whether specific subscales were associated with game play behavior. For these follow-up analyses, we predicted a positive correlation between ratings on positive and disorganized schizotypy and proposing higher offers in the Ultimatum Game. This was based on the idea that for successful bargaining it is essential to understand the goals and intentions of others and these so-called Theory of Mind capacities have been associated specifically with positive schizotypy and disorganization in the past (Marjoram et al., 2006; Pickup, 2006; Sprong et al., 2007). For responder behavior, we predicted a positive correlation with social–emotional abnormalities as measured by the interpersonal factor of the Schizotypal Personality Questionnaire-Brief version (SPQ-B) and increased acceptance rates in the Ultimatum Game.

2. Methods

2.1. Participants

1691 undergraduate students from the University of Arizona completed the Schizotypal Personality Questionnaire-Brief version (SPQ-B, Raine and Benishay, 1995). Age range: 18–49, mean 18.9 (S.D. 1.8). Their scores covered the complete range on the scale, i.e. from 0 to 22, with a mean score of 8.76 (S.D. 6.42). From these 1691 students, we invited 69 individuals from across the full SPQ-B distribution to participate in a follow-up study. Mean age was 18.2 years (S.D. 0.8) with a range from 18 to 20 years and a male:female ratio of 25:44.

Before the administration of the tasks, subjects again filled out the SPQ-B. Mean SPQ-B score was 8.12 (S.D. 5.43). There was high agreement between the two test scores ($r = 0.85$, $P < 0.0001$), but we observed a slight regression to the mean for the highest scores. The study was conducted in compliance of the Declaration of Helsinki and local ethics committee approval, and all participants provided written informed consent.

2.2. Measures

2.2.1. Schizotypal Personality Questionnaire-Brief version (SPQ-B)

To be able to screen large groups of individuals on schizotypal traits, the Schizotypal Personality Questionnaire-Brief version (Raine and Benishay, 1995) was developed. This is a short 22-item questionnaire with a dichotomous response format (yes or no) based on the Schizotypal Personality Questionnaire (Raine, 1991). Higher scores on the SPQ-B are indicative of more schizotypal symptoms. The primary advantage of the SPQ-B is that it still includes the main three factor structure of the longer schizotypal personality questionnaire, despite being short enough to allow easy screening of large groups. These three main factors are the Cognitive-Perceptual Factor, referring to delusional ideation, unusual perceptual experiences and covering the positive schizotypal symptoms; the Interpersonal Factor, including social anxiety and other negative schizotypal symptoms; and the Disorganized Factor that includes odd or unusual speech and behavior.

2.2.2. Ultimatum Game

In the Ultimatum Game (Guth et al., 1982) a proposer (player 1) proposes the division of a sum of money to a responder (player 2), with the money (in this case $10) provided by the experimenter. The responder can decide to accept this offer or not, in either case ending the game. If the responder accepts the offer, the amount of money is split as agreed. However, if the responder rejects it, neither player receives anything.

Before playing, participants were instructed as to the nature and rules of the Ultimatum Game.

Participants played two sets of games, one in the role of responder and one as proposer (order of games was counterbalanced). Each set consisted of multiple, single-shot rounds with different partners. Partners could be a human or a computer. This was done to investigate whether differences in bargaining behavior were specific for social interactions, instead of a general difference in bargaining style. Participants did not meet their partners but participants saw a picture of the partner that they played with for that round. In the task instructions it was emphasized that the participant's partners in the games played the game independently of each other, with no collusion. Participants were told that they would be paid according to their choices in the games, i.e. 10% of the total amount of money that was earned in both sets of Ultimatum Games. Participants played 29 rounds, 20 times with another person (10 males, 10 females) and 9 times with the computer, each time dividing $10.

When playing as a responder 9 out of the 29 rounds involved a fair split, i.e. a 50% split of the $10 (three times each against a computer, a male, and a female partner) and 20 rounds involved unfair divisions; these involved six times $3 out of $10 (twice from a computer, male and female partner), six times $2 out of $10 (twice from a computer, male and female partner). The remaining eight unfair offers were $1 out of $10 (twice for computer partner, three times a male and three times a female partner). This set of offers was used as we were mostly interested in unfair offers, because previous research (Sanfey et al., 2003; Van 't Wout et al., 2006; Koenigs and Tranel, 2007) has shown larger rejection rates for these offers. The different types of offers (fair and unfair splits, human and computer partners) were displayed in a random order.

When playing as a proposer, were free to offer whatever amount they wanted to each partner. Participants played again 29 rounds: nine against a computer, ten against a male and ten against a female partner. Participants first saw a picture of their partner, after which they could make their proposal of how they wanted to split the $10. Rejection rates were programmed according to realistic data in which fair offers ($5) or offers more than $5 were always accepted, but acceptance rates decreased as proposed offers became more unfair (in 80% of cases $3 and $4 out of $10 were accepted and 40% of $1 and $2 out of $10 were accepted).

2.2.3. Dictator Game

The Dictator Game (Kahneman et al., 1986) is similar to the Ultimatum Game in that the first player proposes a division of a sum of money (again $10) to a responder. However, in the Dictator Game the responder must accept the proposed offer, thus ending the game and leaving both players with the money as suggested by the proposer. As there is no decision by the responder, we only examined proposer behavior in this game. Participants played nine rounds in total and made offers to six human partners (three males, three females) and three computers. Similar to the procedure in the Ultimatum Game, participants saw a picture of the partner they played with on each round. Again, before playing, participants were instructed as to the nature and rules of the Dictator Game. Participants were told that they would be paid according to their choices in the games.

2.3. Procedure and statistical analyses

The order of the three sets of games played by each participant (Dictator Game Proposer, Ultimatum Game Proposer and Ultimatum Game Responder) was randomized across participants. The data were analyzed using correlation analyses between schizotypy scores and behavior on the different games (percentage of the sum that was offered when playing as proposers, percentage of rejections of unfair offers when playing as a responder). Given the nature of our data (non-normal distribution and binary responses: accept or reject) we used non-parametric Spearman correlations. In addition, we performed non-parametric correlations between task performance and the specific subscales (interpersonal, disorganized and cognitive-perceptual) of the SPQ-B. All tests are two-tailed.

3. Results

3.1. Ultimatum Game proposer behavior

Overall, participants offered an average of $3.80 of the $10 pot (S. D. 8.1) to their partners, which is within the range typically seen for offers in this game (35%–40% of total money amount; Camerer, 2003). There was a significant difference in the amount of money offered to a human as opposed to a computer partner, Wilcoxon Signed Rank test = −3.52, $P = 0.0004$. The average proposal to human partners was $3.90 (S.D. 8.5, range $0–$10), with on average $3.50 (S.D. 10.2, range $0–$8) offered to computer partners. The range of offers shows that occasionally more than half, i.e. $5 of the $10 was offered. These so-called "hyperfair" offers, although not necessary abnormal, are rare in Ultimatum and Dictator game studies, and in the present experiment were exclusively made by participants with higher schizotypal scores.

With respect to the schizotypal continuum, there was a significant positive correlation between schizotypal scores and the amount of money offered to partners, Spearman $r = 0.36$, $P = 0.003$ for human partners; Spearman $r = 0.25$, $P = 0.04$ for computer partners. To test whether people higher on the schizotypy continuum are also proposing more fair ($5) shares, we correlated the total number of $5 offers with amount of schizotypal symptoms which was positively correlated, Spearman $r = 0.39$, $P = 0.0009$. To provide support that the above results are not due to proposing hyperfair offers only (amount of hyperfair offers correlated significantly with amount of schizotypal symptoms, Spearman $r = 0.29$, $P = 0.03$), we re-analyzed the data and removed all hyperfair offers. The remaining correlation was significant for human partners, Spearman $r = 0.27$, $P = 0.03$, but not for computer partners, Spearman $r = 0.19$, $P = 0.11$.

Follow-up correlations between specific SPQ-B subscales and the amount of money proposed to partners showed that higher scores on the cognitive-perceptual subscale correlated with the amount of money proposed, Spearman $r = 0.34$, $P = 0.005$ for human partners; Spearman $r = 0.28$, $P = 0.02$ for computer partners. Scores on the disorganized subscale of the SPQ-B also correlated positively with offer amount in the game, but only for human partners, Spearman $r = 0.299$, $P = 0.015$. See Table 1 for correlations between SPQ-B ratings and money proposed to human partners. However given that there were significant correlations between SPQ-B subscales (all $P \leq 0.001$), we performed partial correlations to test whether subscales were correlated with task performance independent of the other subscales. This resulted in reduced correlations between scores on the cognitive-perceptual subscale and money proposed to human partners, $r = 0.24$, $P = 0.055$ and computer partners, $r = 0.22$, $P = 0.08$. The correlations between scores on the disorganized subscale and money proposed to human or computer partners in no longer significant (all $P \geq 0.3$).

3.2. Ultimatum Game responder behavior

In this analysis we report data from 65 instead of 69 participants. Two participants were excluded from the analysis as they rejected every offer that was presented, including fair offers, and two people did not complete the task due to technical difficulties. Fair offers ($5) were almost always accepted (99% of cases), and, as is normally observed, acceptance rates decreased as offers decreased (for $3:79.7%, $2:36.7%, and $1:19.9%). In general, unfair offers from humans were rejected more often (59.4%) than those from computers (51.5%), Wilcoxon Signed Rank test = −2.90, $P = 0.004$.

Schizotypy scores correlated positively with higher acceptance rates of the most unfair offers ($9:$1) from human partners, Spearman $r = 0.27$, $P = 0.03$. This suggests that individuals higher on the schizophrenia continuum reject these unfair offers to a lesser extent. Follow-up correlations with particular subscales resulted in significant positive correlations between acceptance rates of these very unfair offers and the interpersonal subscale as well as the disorganized subscale, Spearman $r = 0.33$, $P = 0.008$ and Spearman $r = 0.27$, $P = 0.03$ respectively. See Table 1 for correlations between SPQ-B ratings and acceptance rate $1 offers made by human partners.

Table 1
Correlations (Spearman r and P-values) between SPQ-B ratings and performance on each task and scores for human partners only.

	Ultimatum Game proposer behavior	Ultimatum Game acceptance $1	Dictator Game proposer behavior
Cognitive-perceptual	$r = 0.34$, $P = 0.005$	$r = 0.09$, $P = 0.46$	$r = 0.13$, $P = 0.31$
Interpersonal	$r = 0.21$, $P = 0.098$	$r = 0.33$, $P = 0.008$	$r = 0.01$, $P = 0.92$
Disorganization	$r = 0.29$, $P = 0.015$	$r = 0.27$, $P = 0.03$	$r = -0.02$, $P = 0.90$
Total SPQ-B	$r = 0.36$, $P = 0.003$	$r = 0.27$, $P = 0.03$	$r = 0.05$, $P = 0.68$

However when using partial correlations these correlations are non-significant ($P \geq 0.14$).

3.3. Dictator Game behavior

On average, participants offered $2.80 (S.D. $0.14) of their $10 to their partners in the Dictator Game. To human partners, participants gave on average $3.30 (S.D. $0.15, range $0–$8), whereas the average offer to computer partners was $1.80 (S.D. $0.15, range $0–$5). Compared to the Ultimatum Game trials, proposals were significantly lower to both human partners, Wilcoxon Signed Rank test $= -3.12$, $P = 0.002$ and computer partners, Wilcoxon Signed Rank test $= -6.39$, $P < 0.0001$. But similar to the results in the Ultimatum Game, the amount of money offered to a human partner was significantly higher than the amount offered to a computer partner, Wilcoxon Signed Rank test $= -6.64$, $P < 0.0001$. On five occasions participants offered more than 50% to a human partner, again all by people who scored relatively higher on the SPQ-B.

However, there was no significant correlation between total schizotypy score and the amount of money offered to human partners, Spearman $r = 0.05$, $P = 0.68$, and computer partners, Spearman $r = -0.05$, $P = 0.69$. There were also no significant correlations between any of the SPQ-B subscales and performance on the Dictator Game. See Table 1 for correlations between SPQ-B ratings and money proposed to human partners.

4. Discussion

In this study we examined interactive decision-making behavior using classic economic game theory tasks in individuals with varying levels of schizotypal symptoms. As expected, our results show that the people with more schizotypal symptoms proposed more money to their partners in the Ultimatum Game. In addition, higher levels of schizotypal symptoms were related to more often proposing both a fair distribution and hyperfair offers. These data echo previous findings reported by Agay et al. (2008), who found that patients with a clinical diagnosis of schizophrenia were less strategic and more often proposed hyperfair offers to their partners compared to non-schizophrenia controls in a multi-round Ultimatum Game.

Furthermore, we examined non-social interactions and, contrary to our predictions, found that proposing higher offers in the Ultimatum Game was not specific for human interactions, as participants higher on schizotypy offered greater amounts to all partner types (human and computers). Although this correlation did not remain significant after we removed hyperfair offers. We further investigated whether specific schizotypal symptoms were related to proposer behavior and observed that proposing higher offers in the Ultimatum Game specifically correlated with having more cognitive-perceptual and disorganized schizotypal symptoms, but not with interpersonal schizotypal symptoms. The correlation between more cognitive-perceptual symptoms and proposing higher offers to a human partner remained significant independent of the correlations with the other subscales. This suggests that proposing higher offers is related to positive schizotypal symptoms, and disorganized symptoms to some extent. Given that an adequate Theory of Mind (understanding the goals and intentions of others) is crucial for successful bargaining, our data appear consistent with previous studies reporting a relationship between mentalizing and Theory of Mind capacities and positive symptoms and disorganization in both clinical patients as well as high-risk individuals (Marjoram et al., 2006; Pickup, 2006; Sprong et al., 2007).

However from the Ultimatum Game data alone it is difficult to conclude that participants with more schizotypal symptoms have aberrant bargaining strategies. For instance, one reason for proposing higher offers is that individuals scoring higher on schizotypy care more about fairness than people with less schizotypal symptoms. This inequity aversion will be reflected in the proposing of higher offers (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000). In order to further test whether schizotypal symptoms were indeed associated with aberrant bargaining we examined performance on the Dictator Game, a task similar to the Ultimatum Game with the difference being that partners were not able to reject any offers. Therefore, if participants propose generous or fair offers in both the Ultimatum as well as the Dictator Game, we can conclude that fairness is a strong motivator behind proposer decision-making in these games (Kahneman et al., 1986; Forsythe et al., 1994; Scheres and Sanfey, 2006). If on the other hand, participants offer less in the Dictator Game as compared to the Ultimatum Game, we could assume that these higher Ultimatum Game offers are strategic in nature, and are made because of anticipation that unfair offers will be rejected (Camerer, 2003).

Our results showed no significant correlation between schizotypy and the amount of money offered in the Dictator Game. Additionally, given that the amount of money proposed to partners in the Dictator Game was considerably lower as compared to the amount proposed in the Ultimatum Game, the increased offers proposed in the Ultimatum Game are likely due to being afraid that unfair offers could be rejected, as opposed to an inequity aversion account. Our data therefore support Agay et al's (2008) conclusion that schizophrenia phenomena can be associated with poorer bargaining strategies even in a one-shot interaction. Being able to understand what range of offers others would be willing to consider is crucial for good bargaining. Typically, slightly unfair offers, that is, offers around 35%–40% of the total, are accepted and considered reasonable by others (Camerer, 2003). Individuals with a greater degree of schizotypal symptoms appear less sensitive to this norm and as a result display abnormalities in bargaining.

The observed similarity in proposer behavior on the Ultimatum Game between non-clinical undergraduate students that score higher on schizotypy and patients with schizophrenia as reported by Agay et al. (2008) is of clinical importance. Not only do our results strengthen the previous findings in patients since the observed behavioral pattern in the Ultimatum Game cannot be due to confounding factors such as severe symptomatology, medication use or hospitalization in schizophrenia. The strikingly similar aberrations in interactive decision-making that we observed in healthy undergraduates also reflect at least in part a vulnerability to schizophrenia. Hence, abnormal strategic interactive decision-making appears to be associated with vulnerability for schizophrenia and not with being ill. Furthermore, our findings support the idea of a continuity between symptoms characteristic of schizophrenia and schizophrenia-related phenomena in the normal population, which is important for the development for adequate preventive intervention methods.

With respect to the responder role in the Ultimatum Game, that is, when participants were in the position to either reject or accept proposed offers, we observed that individuals with more schizotypal symptoms accepted highly unfair offers made by human partners more often. This is a surprising finding because one could hypothesize that people who propose higher offers themselves might also expect higher offers, and thus reject these very unfair offers more often to signal how one wants to be treated (Camerer, 2003; Fehr and Camerer, 2007). The decreased rejection rate of very unfair offers in participants with more schizotypal symptoms could be interpreted as supporting the idea that individuals with higher schizotypy scores signal their social boundaries to a lesser extent. Alternatively, the increased acceptance rates could reflect reduced emotional responses, i.e. blunted reactions, from higher schizotypal scoring participants when confronted with such offers. This interpretation is further supported by the finding that specifically severity of interpersonal schizotypy, part of the negative schizotypal symptom dimension and which includes social withdrawal, social anxiety and blunted affect, was related to the increase in acceptance rates. However these explanations of the data are more speculative and should be

interpreted as such, especially given that after controlling for disorganization and cognitive-perceptual symptoms the correlation between interpersonal schizotypy did not remain significant.

All participants played multiple games and, although the order of the games was fully randomized to reduce systematic effects of order on a particular task, the administration of multiple games might have influenced the validity of the games and behavior accordingly.

For instance people typically offer on average somewhere between 35% and 40% of the total money amount (Camerer, 2003) and this was also true for our participants. Therefore when playing as responders our participants received a relative large amount of unfair offers (6 times 20% and 8 times 10% of total). This might have surprised participants who were first asked to propose offers and as a result they might have rejected more unfair offers when they played as responders. Moreover, participants did not meet their partners, but saw a picture of their partners instead which might have made the games less realistic. Nevertheless studies (Van 't Wout et al., 2005; 2006; Harle and Sanfey, 2007) in which subjects did not meet their partners reported similar behavior compared to those where participants first met their partners. Future research might want to use a design in which participants meet their partners while keeping play behavior of partners under control as was done by Sanfey et al. (2003). Lastly, we tested only undergraduate students and this reduces the degree of generalizability of our findings and did not confirm severity of schizotypal symptoms.

Future research might want to focus on factors that are known to influence social interactive decision-making and test these in patients with schizophrenia or people high on the schizophrenia continuum. For instance, we recently have showed that the effortless processing of social cues influences behavior in social interactions (Van 't Wout and Sanfey, 2008) and we are currently testing whether patients with schizophrenia based their decisions to a lesser degree on such social cues. In addition, other measures of mentalizing or Theory of Mind, executive functioning, planning and (social) reward processing in relation to aberrations in (social) bargaining.

The main advantage of our experimental set-up was to address one of the limitations mentioned by Agay et al. (2008) as they could not control the unfairness of the offers proposed and which made the low rejection rates of patients difficult to interpret. Our observation of unusual bargaining behavior comparable to recent findings of Agay et al. (2008) in clinical patients with schizophrenia suggests that aberrant interactive decision-making behavior could point to vulnerability for serious mental illness. To our best knowledge, this is the first study that examines consequential interactive decision-making behavior in psychosis-prone individuals.

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