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The Communication of Metacognition for Social Strategy in Psychosis: An Exploratory Study

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Sharing privately held information, for example, one's confidence in the likelihood of future events, can greatly help others make better decisions as well as promoting one's reputation and social influence. Differences in metacognition on the one hand, and difficulties in social functioning and social cognition on the other, have been reported in people diagnosed with schizophrenia and bipolar disorder. However, despite clear relevance few studies have investigated the link between these abilities and psychosis. In this exploratory study, we compared individuals diagnosed with schizophrenia, bipolar disorder, and a group of unselected general population controls, in an online competitive advice-giving task. Participants gave advice to a client by making a probabilistic perceptual judgment. They could strategically adapt the advice confidence to gain influence over the client. Crucially, participants competed with a rival adviser to attract the client's endorsement. We observe that participants diagnosed with schizophrenia displayed an overall overconfidence in their advice compared with other, bipolar, and unselected control groups, but did not differ in metacognitive efficiency from controls. Symptom-based analysis revealed that the social-influence effect was associated with the presence of delusions but not hallucinations or mood symptoms. These results suggest that the social communication of uncertainty should be further investigated in psychosis.

Key words: social cognition/metacognition/mental health/bipolar disorder/schizophrenia/psychosis

Introduction

We constantly rely on our friends and family's opinions in making everyday decisions. When facing uncertain outcomes, others' information can help us make better-informed decisions.[1,2] Sharing information is the basis of human cultural evolution[3] and plays a major role in maintaining and enhancing social bonds and promoting one's own social influence and status.[4] Indeed, the manner in which we communicate our privately held information is shaped by our perceived social settings, such as our current level of influence on the receiver, perceived social rank, and impression management.[5–7] Some psychiatric disorders, particularly psychotic disorders such as schizophrenia, are characterized by altered social perception[8] raising the question to what extent the cognitive mechanisms underlying social information sharing may be altered in psychosis.

Metacognition has been identified as essential to exactly such social abilities.[2,9] Metacognition is the process of evaluation of one's own cognitive processes, for example, evaluating the vividness of a memory, or the probability of making a correct perceptual judgment.[10] In perceptual decisions, where one indicates whether a signal was present or not, metacognition is a process that usually binds together the saliency of a signal and the uncertainty regarding this signal to form the probability of having made a correct decision. When uncertainty increases, for example, when the contrast is low, the probability of being correct decreases, and so do confidence levels.[11] Confidence regarding perceptual judgments can be shared with others, informing them in a compact manner about our perceptual experience and our estimated probability of making the correct judgment, and can be used as a basis of collective decision making.[12] Sharing information adds a social layer to the metacognitive process, as the shared information can be used to signal socially relevant traits of the sender, such as competence, group affiliation, and social rank. It can also be used to manage one's relationship with others, for example, to maintain or gain influence.[5,9,13]

Differences in metacognition and self-reflection have been found in people diagnosed with schizophrenia,[14–18] along with difficulties in social functioning and social cognition.[8,19,20] People diagnosed with schizophrenia were shown to display inflated overconfidence in incorrect decisions in a variety of tasks, including perceptual judgments.[21,22] This is thought to be associated with lower decision threshold, ie, making decisions before enough evidence is collected, resulting in non-calibrated confidence profile.[16,17] This makes confidence reports non-informative, and may have consequences where metacognition reports are communicated to others to inform their decisions.[1,2,5] Notably, psychosis frequently includes the experience of being influenced by outside, often illusory social agents,[8] and people affected by delusional beliefs can find it hard to withhold communicating their confidence in the belief even when it may lead to social sanction.[23] This suggests that an alteration to the metacognitive processes for social influence may be involved in these experiences in psychosis. However, there is currently little experimental evidence evaluating social information sharing in psychosis.

In previous work, Hertz et al[5] examined the use of confidence in advice giving as a tool to gain and maintain social influence. In their advice-giving paradigm, participants competed with rival advisers for influence over a client. When the participant was ignored by the client, in order to gain more influence in future interactions, participants increased their advice confidence. When their influence over the client was high, they reduced their advice confidence in order to maintain their high influence. In addition, participants' advice-confidence was affected by their performance level and accuracy, as participants were more willing to increase their confidence to gain influence when their previous advice was more accurate.[5,24] These results are in line with a normative account of influence seeking and maintaining strategy,[13] and with theories highlighting the role of social influence in human social behavior.[25–27] Importantly, these results suggest that perceptual confidence can be used strategically to obtain social goals, and is a social cue that is used by others to appraise one's performance.

In the current study, we set out to explore the relation between psychosis and strategic use of metacognitive judgments of perceptual accuracy, ie, confidence level, for social influence. Previous studies suggested that impairment in decision threshold and impulsivity may result in non-calibrated confidence reports in schizophrenia.[17,22] Another line of literature highlighted the detrimental effect of non-calibrated confidence reports on social decision making.[12,28] The literature on bipolar disorder has been mixed, however, with studies finding strong evidence[29] for metacognitive impairment, some finding no evidence,[30] and some finding evidence[31] for difficulties that are present but less severe than with schizophrenia. Given the mixed findings with no strong basis for specific directional hypotheses, we conducted an exploratory study to investigate whether people diagnosed with schizophrenia, bipolar, and health controls would differ in how they adapt their advice confidence to the social context, and to what extent such adaptation could be explained by the presence of psychotic or mood symptoms. We used the advice-giving paradigm described above, in which participants play the role of adviser, competing with another adviser for influence over a client (ie, receiver) behavior. We examined 3 cohorts of participants, a control population recruited online, a group of participants diagnosed with schizophrenia, and a third group of participants diagnosed with bipolar disorder. We used between-group analysis to examine differences between clinical population and control population. In addition, we pooled both clinical groups to run a symptoms-based analysis in which psychosis related symptoms and mood-related symptoms were used to predict the social use of advice confidence.

Methods

Sample

We recruited 3 cohorts of participants. The first cohort of participants included 26 individuals diagnosed with schizophrenia (9 males, ages 45.8 ± 12.2). The second cohort included 23 participants diagnosed with bipolar disorder (12 males, 65% bipolar I, ages 45.0 ± 10.7, mean ± SD).All participants had already taken part in the DNA polymorphisms in mental illness (DPIM) study at University College London (UCL).[32] Briefly, participants with an ICD-10 diagnosis of bipolar disorder or schizophrenia were recruited from UK NHS mental health services or from their primary care physicians. Participants with an ICD10 diagnosis of schizophrenia were interviewed by trained research assistants using the Schedule for Affective Disorders and Schizophrenia-Lifetime Version (SADS-L)[33,34] to confirm the diagnosis according to Research Diagnostic Criteria (RDC).[35] Research interviews were supplemented with information from clinical records. Case participants were also rated with the 90-item Operational Criteria Checklist (OPCRIT).[36] DPIM participants were re-contacted via the post to invite them to take part in the current study. Mean time between recruitment onto the register and participation in this study was 3.98 years (SD = 2.84). The invitation letter included information about the study, the technical requirements of the study and a consent form.

Participants who explicitly consented to perform the experimental task were sent a link to the online task. This process introduced additional selection criteria, such as access to a computer and internet connection, active use of an e-mail address and technical literacy. As required by the ethical approval of the study, one of the authors (JB) communicated with participants and liaised with them about what was the most convenient way for them to be tested. Forty-three of the participants carried the task on their own computers on their own, 4 were invited to finish the experiment in the lab in UCL, and 2 were assisted at home by an experimenter. Of these participants, 17 diagnosed with bipolar disorder and 13 with schizophrenia completed the ISS mood questionnaire[37] following the behavioral task. The DPIM study had ethical approval granted by the UK National Health Service Metropolitan Multi-Centre Research Ethics Committee (MREC, now called South Central – Hampshire A; MREC/03/11/090; Chief Investigator Dr. Andrew McQuillin). This study formed an extension to the DPIM study and an amendment to the ethical approval for this study was received before this study commenced. Following the requirement of our ethics approval, these participants did not receive monetary compensation for participating in the task beyond payment for travel where this was relevant.

In addition, we recruited 54 healthy participants to carry the task online via Amazon Mechanical Turk (ages 32.2 ± 9.9 mean ± SD, 30 Males). We used these unselected control group as a similar population displayed consistent performance in this task in 2 previous studies, in a similar manner to lab-based participants.[5,24] Importantly, as most of the experiments in the clinical populations were carried online, we sought to use a similar online platform experience for our control group. These participants completed the Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE) Schizotypy questionnaire[38] (Scores mean ± SD: Unusual Experiences: 1.87 ± 2, Cognitive Disorganization: 2.83 ± 2.66, Introvertive Anhedonia: 3.22 ± 2.1, Impulsive Nonconformity: 1.96 ± 1.89). All online participants provided informed consent and received a fixed monetary compensation (3.5 USD) that was unrelated to task performance. The study was approved by the research ethics committee at UCL. Following a previous study[5] involving 58 participants online, we estimated our effect size to be around 0.5. As our experiment follows a within-participants design, we decided to recruit 50 participants for the control group.

All participants were screened to make sure that they had the ability to track the color of the majority of the balls across the trials. All our participants were able to track the majority color on most of the trials (>60%), and none was removed from analysis.

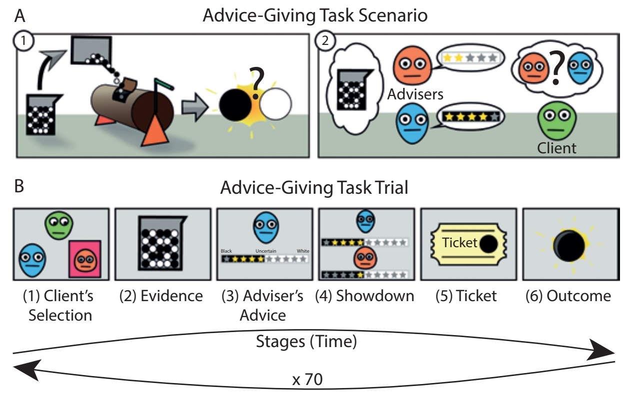

Fig. 1. Experimental design. We used a 3-person advice-giving game, in which 2 advisers compete for influence over a client's behavior. (A) In the game over multiple trials a client wants to bet on a winning color in a lottery but does not know on which color (black or white) to bet. The client therefore has to rely on the advice of his 2 advisers who have private information about the chances of winning for black and white. Participants always played the role of one adviser, and the rival adviser and client were programmed virtual agents. (B) At the beginning of each trial the client publicly chooses which adviser to follow (stage 1). The advisers then get to see the rack of black and white balls about to be put in the raffle, representing the probabilistic information about the chance of winning color (stage 2). They then advise the client using a confidence scale (stage 3). The advice of both advisers is then revealed to all participants (stage 4), after which the client's bet is made (stage 5) and the winning color is revealed (stage 6). For the next trial, the client can decide to stick with the same adviser or to switch. For an interactive demo see: http://urihertz.net/AdviserDemo2/.

Task

All participants played an advising game.[5] In this advice-giving task, over multiple trials 2 advisers competed for influence over a client's attention (figure 1A). All participants played the role of adviser in the game, and the behavior of rival adviser and the client was governed by an algorithm (supplementary methods). On each trial, the client would select an adviser to bet (on behalf of the client) on the winning color of a ball selected from a rack of 2 colored balls in differing proportions put into a raffle. The client chose between 2 advisers based on their previous confidence and accuracy.

From the point of view of our participants, the trial started with the client's choice of adviser displayed to the advisers (figure 1B, panel 1). The participant and the rival adviser then proceeded to observe the private evidence (figure 1B, panel 2). The advisers saw (duration: 1000 ms) a rack of black and white balls about to be put in the raffle. The ratio between the black and white balls indicated the probability of the winning color. Naturally, if there were more black balls in the rack, the probability that a black ball would be drawn from the raffle was higher. Next (figure 1B, panel 3), the advisers gave their advice about the more likely color of the winning ball (black/white) and their estimate of the likelihood of it winning using a 5-stars confidence scale. Subsequently (figure 1B, panel 4), both declarations were shown to both advisers and the client. The client followed the chosen adviser's bet (figure 1B, panel 5), and finally, the color of the winning ball was revealed to everyone (figure 1B, panel 6) and the next trial ensued. All participants played the advice-giving game for 70 trials. Key behavioral variables are the advisers' choice of lottery and their confidence in their suggestions in each trial.

Non-Social Performance Measures

First we measured group differences in metacognitive abilities, ie, how well they could interpret evidence uncertainty and report their decision and confidence accordingly, regardless of the social aspects of the task. We calculated the participants' advice accuracy, their average confidence ratings, and the time it took them to give the advice (reaction time), and the speed-accuracy trade of measure of efficiency, ie, the accuracy divided by reaction time.[39] We also used signal detection theory measures of perceptual (ie, d') and metacognitive sensitivity (ie, meta-d').[40] This was done specifically to evaluate participants' metacognitive calibration, ie, how informative their confidence levels were on their performance.[18,22] The latter measure estimates the likelihood of being correct when using high confidence ratings and making mistakes when using low confidence reports. Finally, M-ratio was calculated as the ratio between meta-d' and d'.[41] We used one-way ANOVA to evaluate group effects in our metacognitive and performance measures, and post-hoc *t*-tests to evaluate the direction of the effects. All analyses were carried using Matlab R2018b Statistics Toolbox (MathWorks Inc.) and the type 2 signal detection theory analysis toolbox by Maniscalco and Lau.[40]

Social Influence Strategy Measures

To assess the participants' strategic social behavior in advising, we examined the trial-by-trial deviance of advice confidence from the probabilistic evidence.[5] If an adviser is strictly committed to communicating the evidence they are given, then confidence should exactly match the ratio of black to white balls in the rack (figure 1b). For such adviser, confidence level of 5 stars for black to win is reported when close to 100% of the balls in the rack are black. Conversely, a low-confidence advice of one star for black would be reserved to weak evidence, in which the ratio between black and white balls is very close to 50-50. Advice confidence would deviate if the confidence is higher (positive deviance) or lower (negative deviance) than the probability indicated by the evidence. Advice deviance was used as the dependent variable in a mixed effect linear model, with participant identity as a random effect and influence (ignored/chosen) and accuracy in previous trial (wrong/correct) as within-subjects fixed effects and group (control, schizophrenia and bipolar) as between-subject independent variable.

Advice Confidence Analysis

To examine the effects of accuracy and influence on advice deviance, our measure of strategic advice confidence, we used mixed-effects regression models. Participants' trial-by-trial advice deviance served as the dependent variable, and the trial-by-trial influence over the client (ignored/chosen), advice accuracy (incorrect/correct), and group (control, schizophrenia, bipolar) were used as dependent variables of interest. Our models are multilevel models,[42] and include group-level coefficients, referred to in the text as fixed effects,[43] and individual-level coefficients of the individual intercepts referred to in the text as random effects.[43] This resulted in estimation of slope, standard error, and confidence interval for the effects at hand, which could be statistically tested using *t*-test. This approach of trial-by-trial estimation across multiple participants is useful when the conditions (such as number of ignored vs chosen trials) are not balanced within participants, but are balanced across participants, as is the case here. All models were fitted using Matlab R2018b Statistics Toolbox (MathWorks Inc.).

Results

Non-Social Measures of Task Performance

We first compared the overall accuracy of advice, ie, the percentage of times the participants picked the winning color (figure 2A). While overall performance was different across groups, it is clear that all groups were able to perform the task as their accuracy levels were comparable, and far higher than chance. We used one-way ANOVA to examine group differences, and found a significant group effect ($F(2,102) = 4.73$, $P = .011$). We found that individuals diagnosed with bipolar disorder gave the most accurate advice (mean ± SD [percent correct], control: 0.71 ± 0.052, schizophrenia: 0.71 ± 0.043, bipolar: 0.75 ± 0.05, 2-tailed *t*-test: control vs bipolar: $t(75) = 2.62$, $P = .01$, control vs schizophrenia: $t(78) = 0.51$, $P = .6$, bipolar vs schizophrenia: $t(47) = 2.98$, $P = .0045$).

Examining response time, we found a significant group effect in a 1-way ANOVA ($F(2,102) = 25.84$, $P < .00001$), as control participants spent less time on each advice (figure 2B, mean ± SD [seconds], control: 1.3 ± 0.43, schizophrenia: 3 ± 1.8, bipolar: 1.7 ± 0.55, 2-tailed *t*-test: control vs bipolar: $t(75) = 3.3$, $P = .0015$, control vs schizophrenia: $t(78) = 6.55$, $P < .00001$, bipolar vs schizophrenia: $t(47) = 3.32$, $P = .0017$). Decision efficiency, defined as the accuracy divided by the time spent on each advice, was also significantly different across the groups ($F(2,102) = 31.5$, $P < .00001$). It was highest in the control group (figure 2C, mean ± SD [decision efficiency], control: 0.58 ± 0.15, schizophrenia: 0.31 ± 0.14, bipolar:

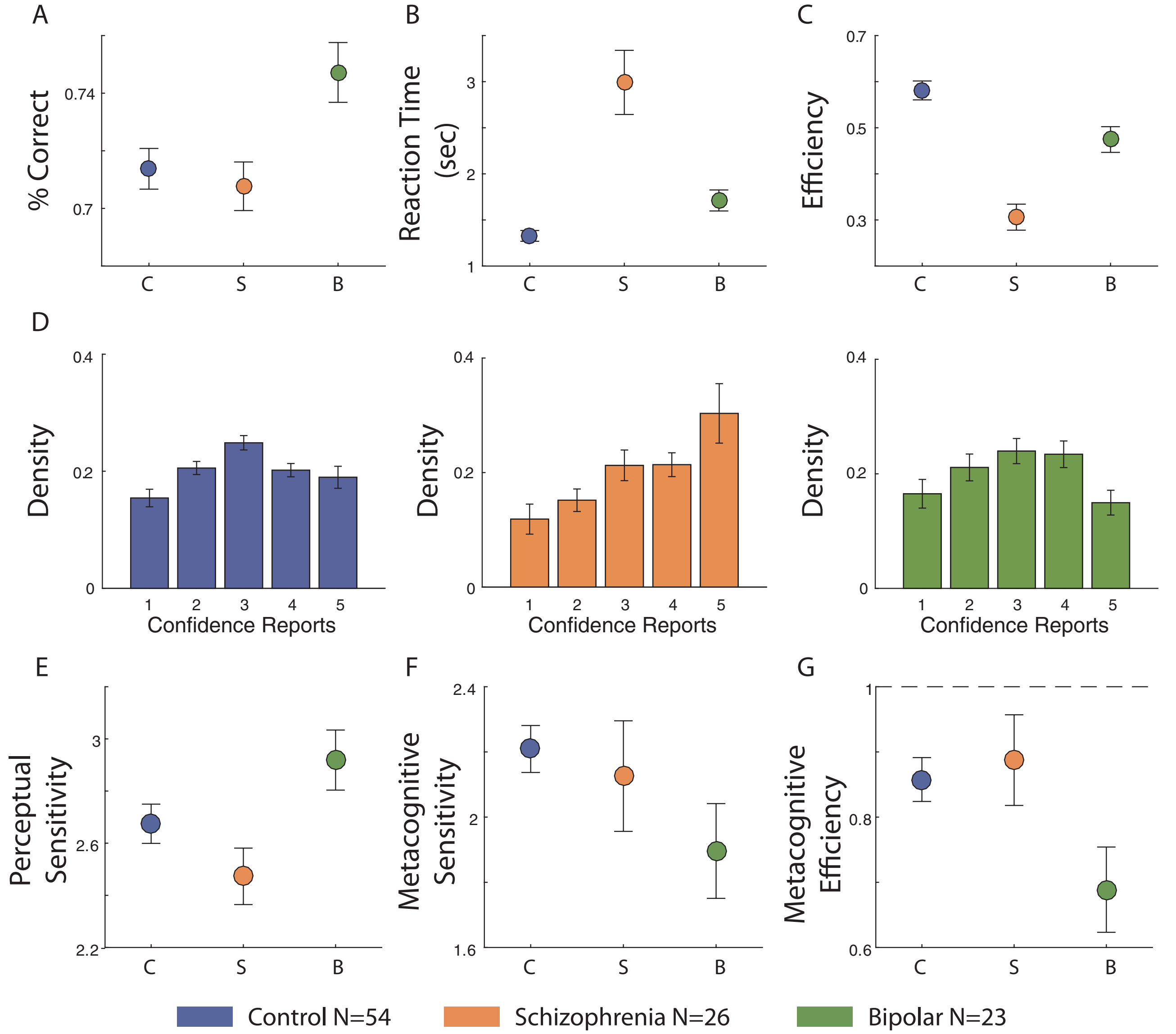

Fig. 2. Non-social measures of task performance. (A) Overall perceptual accuracy (ie, frequency of choosing the winning color) comparing Control participants (blue - C) to individuals diagnosed with schizophrenia (orange - S) and individuals diagnosed with bipolar (green - B) disorder. (B) Reaction times. (C) Decision efficiency (ie, accuracy divided by reaction time) (D) Frequency histogram of confidence in the 3 groups. Individuals diagnosed with schizophrenia (middle panel) were more likely to use the highest confidence level in their advice. (E) Perceptual sensitivity (d′). (F) Metacognitive sensitivity (Meta-d′). (G) Metacognitive efficiency (meta-d′/d′). Error bars indicate SEM.

0.47 ± 0.13, 2-tailed t-test: control vs bipolar: $t(75) = 2.93$, $P = .0045$, control vs schizophrenia: $t(78) = 7.75$, $P < .00001$, bipolar vs schizophrenia: $t(47) = 4.22$, $P = .0001$). Individuals diagnosed with either bipolar disorder or schizophrenia spent more time contemplating each advice, which made their decisions less efficient.

Next, we examined the use of confidence scale by our participants. Using 1-way ANOVA we found a significant group effect on confidence ratings ($F(2,102) = 5.53$, $P = .0053$), as individuals diagnosed with schizophrenia tended to use the high confidence ratings more often than individuals diagnosed with bipolar disorder and the control participants (histograms in figure 2D) (mean ± SD [confidence], control: 3.1 ± 0.46, schizophrenia: 3.4 ± 0.7, bipolar: 3 ± 0.39, 2-tailed t-test: control vs bipolar: $t(75) = 0.68$, $P = .49$, control vs schizophrenia: $t(78) = 2.76$, $P = .007$, bipolar vs schizophrenia: $t(47) = 2.65$, $P = .01$).

To formally examine the differences in metacognitive abilities between the different groups we employed signal detection theory measures of metacognition[22,40]: perceptual sensitivity (d′), metacognitive sensitivity (meta-d′) and metacognitive efficiency (the ratio between meta-d′ and d′). Perceptual sensitivity assessed the ability of an agent to notice small difference in the evidence (black-white marble ratio). Metacognitive sensitivity indicated how well confidence reports matched the evidence strength. Finally, while metacognitive efficiency offered a finer measure of metacognitive sensitivity by controlling for individual differences in perceptual sensitivity (see Methods).

Confirming the accuracy effects, we found a significant group effect on d' ($F(2,102) = 3.97$, $P = .022$), as the individuals diagnosed with bipolar disorder displayed the highest perceptual sensitivity (figure 2E, mean ± SD [perceptual sensitivity], control: 2.7 ± 0.55, schizophrenia: 2.5 ± 0.55, bipolar: 2.9 ± 0.55, 2-tailed t-test: control vs bipolar: $t(75) = 1.77$, $P = 0.08$, control vs schizophrenia: $t(78) = 1.52$, $P = 0.13$, bipolar vs schizophrenia: $t(47) = 2.82$, $P = .007$). Metacognitive sensitivity (meta-d′) did not vary significantly across the groups ($F(2,102) = 1.79$, $P = .17$), figure 2F), while being lowest in individuals diagnosed with bipolar disorder (figure 2F, mean ± SD [metacognitive sensitivity], control: 2.2 ± 0.53, schizophrenia: 2.1 ± 0.86, bipolar: 1.9 ± 0.7, 2-tailed t-test: control vs bipolar: $t(75) = 2.15$, $P = 0.03$, control vs schizophrenia: $t(78) = 0.53$, $P = .59$, bipolar vs schizophrenia: $t(47)= 1.01$, $P = .31$). Finally, controlling for perceptual performance, we found a significant group effect on metacognitive efficiency ($F(2,102) = 2.43$, $P = .036$), as individuals diagnosed with bipolar disorder had the lowest metacognitive efficiency (figure 2G, mean ± SD [adjusted metacognitive efficiency], control: 0.86 ± 0.25, schizophrenia: 0.89 ± 0.35, bipolar: 0.69 ± 0.31, 2-tailed t-test: control vs bipolar: $t(75) = 2.52$, $P = .013$, control vs schizophrenia: $t(78) = 0.43$, $P = .66$, bipolar vs schizophrenia: $t(47) = 2.06$, $P = .04$).

To conclude, individuals diagnosed with schizophrenia tended to use higher confidence ratings compared to individuals diagnosed with bipolar and control participants. However, their metacognitive sensitivity and efficiency matched those of control participants, ie, their confidence reports were informative regarding their accuracy. Individuals diagnosed with bipolar disorder were more accurate in their estimation overall, and matched control participants in their average confidence but displayed reduced metacognitive sensitivity and efficiency—their confidence reports were less informative (vs control) about the accuracy of perceptual decisions.

Social Measures of Task Performance: Advice Confidence as a Persuasive Signal

We were primarily interested in understanding the way participants were using advice confidence as a social persuasive signal to manage their influence over the client. Previous results using the advice-giving task[5] showed that trial-by-trial advice deviance was affected by the participants' level of influence over the client, ie, was the participant chosen or ignored by the client by their performance level and their advice accuracy. With this hypothesis in mind, we used a mixed-effect linear regression, with advice deviance as a dependant variable and influence (chosen/ignored) and previous advice accuracy (wrong/correct) as within-subjects independent variables. We also included group (control, schizophrenia, and bipolar) as between-subject dependent variable and individual intercept coefficients as a random variable (results in table 1).

Confirming our principle hypothesis, we found a significant main effect of influence (table 1): across all groups, participants gave more confident advice when they were ignored by the client compared to when they were the chosen advisers. This finding is in line with our previous results.[5,24] There was no significant interaction between influence and group, either in the schizophrenia or the bipolar disorder groups, indicating that the effect did not differ by diagnosis. We found a small overall increase in advice confidence in individuals diagnosed with schizophrenia (table 1), in line with our results indicating the use of higher confidence ratings overall (figure 2). We did not find any significant main effect for advice accuracy: however, accuracy significantly affected the advice confidence for individuals diagnosed with schizophrenia and individuals diagnosed with bipolar disorder (table 1). Compared to control, schizophrenia and bipolar diagnosis groups gave more confident advice after having given accurate advice in the previous trial.

Table 1. The Effect of Diagnosis, Advice Accuracy, and Influence on Advice Confidence

Variable Name	Estimate ± SE	t(df)	P	95% CI
Intercept	0.15 ± 0.08	1.9 (7201)	.056	−0.004, 0.3
Influence (Ignored)	0.14 ± 0.03	3.9 (7201)	.0001*	0.07, 0.2
Accuracy (Correct)	−0.006 ± 0.03	−0.17 (7201)	.86	−0.07, 0.06
Group (SCZ)	0.27 ± 0.14	1.96 (7201)	.049*	0.0006, 0.54
Group (BP)	−0.17 ± 0.14	−1.22 (7201)	.22	−0.45, 0.11
Influence (Ignored) × Group (SCZ)	−0.05 ± 0.066	−0.81 (7201)	.41	−0.18, 0.07
Influence (Ignored) × Group (BIPOLAR)	−0.046 ± 0.066	−0.69 (7201)	.48	−0.17, 0.08
Accuracy (Correct) × Group (SCZ)	0.17 ± 0.062	2.71 (7201)	.007*	0.046, 0.29
Accuracy (Correct) × Group (BP)	0.16 ± 0.066	2.36 (7201)	.02*	0.027, 0.28

Note: SCZ, individuals diagnosed with schizophrenia; BP, individuals diagnosed with bipolar disorder.
*P < 0.05.

To illustrate the direction and magnitude of these effects, we separated the trials according to group, influence (ignored/chosen), and advice accuracy (wrong/correct) and calculated each participant's average advice deviance in each condition (figure 3). Control participants were mostly driven by influence level—they gave more confident advice when they were ignored by the client. Participants in the schizophrenia and bipolar groups were also affected by their own previous advice accuracy, increasing their advice confidence after having been correct. These findings indicate that control participants were more strategic in their use of advice confidence: unencumbered by their previous failure or success, control participants increased their confidence when ignored in order to gain influence and attenuated it when selected consistent with normative prescriptions for maintaining social influence.[5,13] Individuals diagnosed with schizophrenia and those with bipolar disorder were also concerned by monitoring their own performance.

Exploratory Analysis: Association With Psychotic Symptoms

We used the scores associated with hallucination, delusions, and mood items of the 90-item Operational Criteria Checklist (OPCRIT)[36] across participants and fitted a mixed-effect linear regression to advice confidence, with task-related effects (Accuracy and Influence), and symptom-related effects (hallucination, delusion and mood scores) as fixed effects. We found that delusion scores interacted with influence, ie, participants with high delusion scores increased their confidence more when they were ignored by the client (table 2). However, we wish to emphasize the exploratory nature of this analysis and caution the reader—with a *P* value of 0.036 and small sample size, perhaps this finding is best interpreted as preliminary evidence.

Discussion

In this study, we compared the performance of 3 groups of participants in a competitive advice-giving task: individuals diagnosed with schizophrenia, individuals diagnosed with bipolar disorder, and unselected controls, and, in addition, we examined performance transdiagnotically in relation measures of psychotic and mood symptoms. In this task, participants observed probabilistic perceptual evidence about the likelihood of 2 different outcomes in a lottery and (1) gave advice about which outcome was more likely, and (2) communicated their confidence in (1). Crucially, participants competed with rival advisers over a client's attention which was awarded based on a function of advice accuracy, confidence, and outcome. We found that while the highest overall confidence in advice was found in participants diagnosed with schizophrenia, they did not differ from controls in their metacognitive efficiency. In addition, participants diagnosed with schizophrenia and those diagnosed with bipolar disorder were more affected by their accuracy history when giving advice compared with control participants. An overall effect of social influence was observed, by which participants increased their advice confidence when they were ignored by the client and reduced their advice confidence when selected by the client, in line with social-influence-seeking strategy.[5,13] Symptom-based analysis revealed that the social-influence effect was associated with the presence of delusions but not hallucinations or mood symptoms.

It is important to note that we are reporting an exploratory study and further research will be needed to confirm the results reported here. However, the association

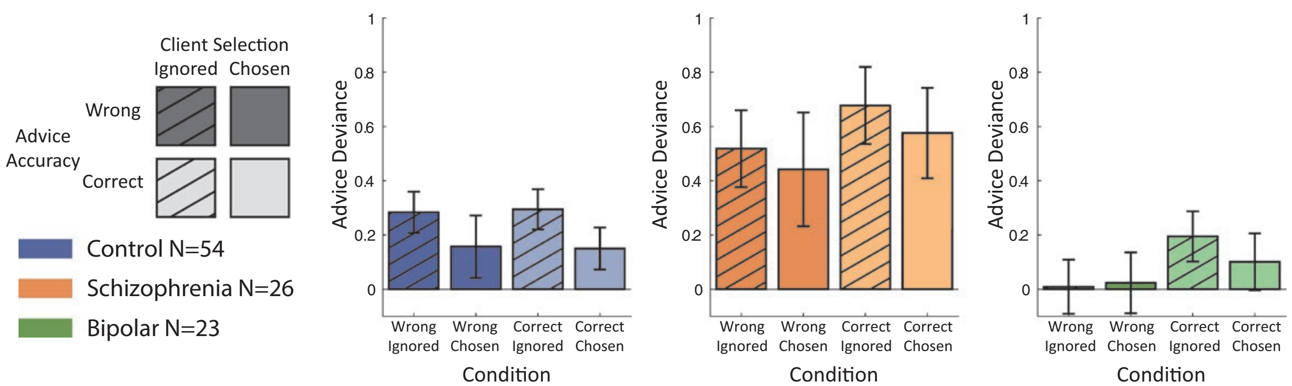

Fig. 3. The Strategic effects of influence level and competence on advice confidence when participants are treated as social agents. Here is a graphical demonstration of the effect revealed by our mixed-effect linear regression in table 1. Advice deviance from perceptual evidence (ie, how over- or under-confident the advice was) is depicted here in a 2 × 2 design consisting of accuracy in the previous trial (dark shade for incorrect previous advice and light shade for accurate previous advice), and social influence level in the current trial (lined bars for ignored by the client and empty bars for chosen by the client). Both individuals diagnosed with bipolar disorder and schizophrenia were more affected by their own advice accuracy compared with control participants. Only healthy controls demonstrated a strategic use of confidence for increasing their social influence. The bars indicate the groups' mean scores, and the error bars indicate SEM.

Table 2. The Effect of Symptoms (Hallucination, Delusions, Mood), Advice Accuracy and Influence on Advice Confidence

Variable Name	Estimate ± SE	*t*(df)	*P*	95% CI
Intercept	0.12 ± 0.34	0.34 (1742)	.58	−0.46, 0.83
Influence (Ignored)	−0.036 ± 0.09	−0.4 (1742)	.68	−0.21, 0.14
Accuracy (Correct)	0.16 ± 0.05	2.79 (1742)	.0052*	0.047, 0.27
Delusion	−0.61 ± 0.57	−1.08 (1742)	.28	−1.73, 0.5
Mood	−0.1 ± 0.18	−0.58 (1742)	.56	−0.25, 0.47
Hallucination	1.07 ± 0.64	1.65 (1742)	.098	−0.19, 2.33
Influence (Ignored) × Delusion	0.51 ± 0.24	2.09 (1742)	.036*	0.03, 0.99
Influence (Ignored) × Hallucination	−0.26 ± 0.24	−1.08 (1742)	.28	−0.74, 0.21

Note: $^{*}P < 0.05$.

of differences in confidence, and differences in communication of confidence for social influence, with psychotic disorder and delusions has prima facie validity. Delusions are the defining feature of psychosis and, by definition, beliefs that are held with high degrees of confidence that do not conform to social norms and are not swayed by those in the social milieu in which the affected person resides. Previous, non-social accounts of metacognition in schizophrenia indicated overall increased confidence, especially when making mistakes, resulting in decreased efficiency of confidence reports.[18,21,22] Here, we did not observe such decreased efficiency, maybe as this task was relatively easy, but did observe overall overconfidence in participants diagnosed with schizophrenia. Importantly, here metacognitive reports were used to communicate one's private information and had social consequences. Our findings indicated that participants diagnosed with schizophrenia displayed a unique combination of high advice confidence and sensitivity to social context, especially associated with the presence of delusions. This is in line with previous research showing that individuals diagnosed with schizophrenia show increased metacognitive confidence for inaccurate beliefs about others during strategic interactions[44] and for inaccurate perception of self-referential communication.[45] This suggests that alterations to metacognition for social judgments may play a role in the generation or maintenance of psychotic symptoms,[23,46] echoing recent work on the role of beliefs as having primarily a social function,[47] and linking the literature on metacognition in schizophrenia[17] with their possible social outcome. Nevertheless, the extent to which this is characteristic of all people with schizophrenia and/or psychosis has been debated in light of results that suggest that extreme overconfidence for social cognitive judgments was characteristic of only a subset of patients[48] which may be one factor in the low strength of evidence for clear effects reported in this study.

It is worth noting some limitations to this study. Patient diagnoses were established and symptoms were measured using gold standard structured interviews at the time of recruitment onto the research register, but participation happened later and so may have changed since participation. Symptoms measured at the time of participation were solely through validated self-report scales. Longitudinal studies looking at symptom stability over multi-year periods have found that baseline severity is more likely to change than relative severity between symptoms which remains relatively stable.[49,50] However, further studies that measure psychotic symptoms using gold-standard assessments at the time of cognitive task participation would likely provide a better estimate of the associations reported here. Furthermore, this study did not measure cognitive function, which may account for the differences between participant groups reported here. We found that individuals diagnosed with schizophrenia used higher confidence ratings compared to individuals diagnosed with bipolar and control participants but that their metacognitive abilities matched those of control participants, potentially suggesting that differences in general cognitive function did not play a role in overall task performance. However, dedicated measures of general cognitive function are needed to confirm this. Although not a limitation per se, this was an exploratory study and further pre-registered research will be needed to test specific hypotheses regarding the association between clinical features and the sharing confidence judgments for social influence.

In conclusion, we report an exploratory study suggesting that psychosis, particularly delusions, is associated with differences in sharing metacognitive judgments of confidence for social influence. Although exploratory in nature, given the face validity of this association in light of the presentation of psychosis, we suggest further research in this domain may be a useful line of enquiry.

Supplementary Material

Supplementary data are available at *Schizophrenia Bulletin Open* online.

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