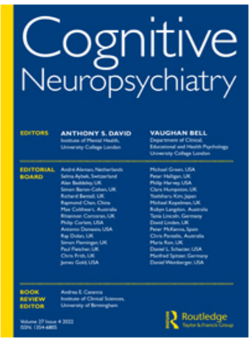

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Seeing minds – a signal detection study of agency attribution along the autism-psychosis continuum

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ABSTRACT

Introduction: Diametrically aberrant mentalising biases, namely hypermentalising in psychosis and hypomentalising in autism, are postulated by some theoretical models. To test this hypothesis, we measured psychotic-like experiences, autistic traits and mentalising biases in a visual chasing paradigm.

Methods: Participants from the general population ($N = 300$) and psychotic patients (N=26) judged the absence or presence of a chase during five-second long displays of seemingly randomly moving dots. Hypermentalising is seeing a chase where there is none, whereas hypomentalising is missing to see a chase.

Results: Psychotic-like experiences were associated with hypermentalising. Autistic traits were not associated with hypomentalising, but with a reduced ability to discriminate chasing from non-chasing trials. Given the high correlation ($\tau = .41$) between autistic traits and psychotic-like experiences, we controlled for concomitant symptom severity on agency detection. We found that all but those with many autistic and psychotic traits showed hypomentalising, suggesting an additive effect of traits on mentalising. In the second study, we found no hypermentalising in patients with psychosis, who performed also similarly to a matched control group.

Conclusions: The results suggest that hypermentalising is a cognitive bias restricted to subclinical psychotic-like experiences. There was no support for a diametrically opposite mentalising bias along the autism-psychosis continuum.

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Intentionality; mentalising; autism; schizophrenia; theory of mind

Introduction

An important aspect of social cognition is the attribution of mental states. One can distinguish between first-order intentionality, the ability to attribute desires different from one's own, and second-order intentionality, the ability to attribute beliefs and knowledge

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different from one's own (Cheney & Seyfarth, 1990). The latter is often assessed in Theory of Mind (ToM). Persons with an autism spectrum diagnosis (ASD) and persons with a schizophrenia spectrum diagnosis (SSD) show an impairment in ToM tasks as well as other areas of social cognition like emotion recognition (Fernandes et al., 2018; Oliver et al., 2021). Yet, it is less clear whether first-order intentionality is affected.

The diametric brain theory proposes that ASD and SSD represent opposite extremes of neural development and social cognition (Crespi et al., 2010; Crespi & Badcock, 2008). Hence, different mechanisms may cause similar social-cognitive deviations in SSD and ASD (Pinkham et al., 2020). We focus on one bias proposed to be opposite along the autism-psychosis continuum; namely, the mentalising bias. Our focus is on first-order intentionality (for second-order see e.g.; Abu-Akel et al., 2015; Castelli et al., 2002).

Displays of simple movements can serve as a paradigm to study first-order intentionality as they can elicit the perception of animacy. For example, chasing, an intentional interaction, is perceived when one object follows another moving object. Such an attribution of a mental state is one dimension of mentalising. It is possible to do too much, inferring intention where it is unlikely to exist (Blakemore et al., 2003; Frith, 2004), or too little, not inferring intention when it is likely to be present (Martinez et al., 2019). These deviations from best inference can straightforwardly be categorised as hyper- and hypomentalising. The hyper- and hypomentalising we discuss is the excessive or deficient attribution of intentions or goals or desires, not to self but to other agents, where an agent is an entity capable of having goals, intentions and desires. It is not relevant to our purposes whether that attribution is automatic or controlled (Luyten & Fonagy, 2015).

A biased attribution of intention, too much or hypermentalising, is proposed in persons with psychotic-like experiences and psychosis (e.g., persons with SSD), whereas too little attribution or hypomentalising is proposed in persons with autistic traits and ASD (Fletcher & Frith, 2009; Kimhi, 2014; Pickup, 2006; Van de Cruys et al., 2014). These theories predict opposite errors in social cognition tasks due to, for example, aberrant attributions of agency and intentionality. A classical task for studying mentalising biases is the paradigm by Heider and Simmel (1944), using animations of geometric shapes to study the perception of interacting agents (see e.g., Heider & Simmel, 1944; for review, see Scholl & Tremoulet, 2000). Studies using this paradigm show that children with ASD and patients with SSD use the appropriate mentalising terms less often than controls (Abell et al., 2000; Bal et al., 2013; Klin, 2000; Langdon et al., 2017; Russell et al., 2006; Salter et al., 2008).

Variations on the animation task, designed to isolate potentially different processes, have given varied results. Russell et al. (2006) found that persons with SSD mentalised random and goal-directed animations whereas the control group did not. In contrast, Martinez et al. (2019) found that both persons with ASD and SSD attributed less intentionality in the goal-directed condition than the control group. Children with ASD were less likely to comment on the second-order intentionality of animated shapes (Castelli et al., 2002), but did not differ from control participants in their interpretation of first-order intentionality. Using the same paradigm with 63 healthy participants, Fyfe et al. (2008) found support for a positive association between hypermentalising and delusion-proneness. The authors found no hypermentalising in two other mentalising tasks, suggesting that the effect size is small in healthy participants for those tasks. However, one of those mentalising tasks has also been tested on patients with SSD, where patients with delusions attributed first-order intentionality where control participants did not (Blakemore et al., 2003).

Attribution of mental states can also be studied by asking for people's interpretation of imagined scenarios, as in Waytz et al.'s (2010) Individual Differences in Anthropomorphism Questionnaire (IDAQ). All its 15 questions concern first-order intentionality. If the questionnaire taps into the same process as animated shapes chasing each other, then theories of hypermentalising in psychosis and hypomentalising in ASD predict directional relationships between the tendency to anthropomorphise, as indexed by questionnaire responses, and autistic traits and psychotic-like experiences.

The current study employs a chasing paradigm (Gao et al., 2009) where participants judge the presence or absence of chasing. Participants observe randomly moving circles, where two circles sometimes appear to engage in chasing. This makes it a signal detection problem where accuracy is the ability to distinguish between trials with chasing (hits) and trials without chasing (correct rejections), also referred to as discriminability or sensitivity. A directional bias can then either be seeing a chase when there is none (false alarms) or not seeing a chase when there is one (misses). Hypermentalising corresponds to making errors that are predominantly false alarms, while hypomentalising is evident when misses are more common.

We expect that the chasing paradigm is most relevant to first-order intentionality, the attribution of desires, rather than second-order intentionality, the attribution of beliefs (Cheney & Seyfarth, 1990). This corresponds to Castelli et al.'s (2002) distinction between animations that portray goal-directed behaviour versus those that engage Theory of Mind. Douglas et al. (2016) reported that attributing the ability to have mental states to animated shapes is associated with endorsement of conspiracy theories. Riekki et al. (2013) found that a bias to see faces is associated with belief in the paranormal. There are plausible links between conspiracist ideation and psychosis (Galbraith, 2021), and to the extent that ASD and SSD are opposites, if ASD indeed biases only judgements of second-order intentionality, the same should apply to schizophrenia merely with the opposite sign.

Studies that have used the chasing paradigm found similar accuracy in adolescents with and without ASD (Vanmarcke et al., 2017). One study in patients with SSD found reduced accuracy (Roux et al., 2015), whereas a recent study found no difference in accuracy between patients and the control group (Langdon et al., 2020). Regarding bias, neither Roux et al. (2015) nor Langdon et al. (2020) found a difference between patient and control groups. Yet, the more difficult the trials became, the more the participants erred on the miss side; that is, participants were hypomentalising and conservative with detecting chasing. These three studies found a large effect of trial difficulty, which may overshadow the smaller mentalising bias; we therefore used the same chasing subtlety in all trials.

The studies described above did not address whether co-occurrence of autistic and psychotic traits would normalise the mentalising bias (Fletcher & Frith, 2009; Frith, 2005; Kimhi, 2014; Pickup, 2006; Van de Cruys et al., 2014), as found using a perspective-taking task in a general population sample (Abu-Akel et al., 2015). Thus, in study 1 we measured autistic traits and psychotic-like experiences in a sample from the general population. In study 2 we tested patients who had previously had a psychotic episode.

In study 1, we expected psychotic-like experiences to correlate with detecting chasing when there is none (hypermentalising; hypothesis 1a), and autistic traits to correlate with failing to detect chasing (hypomentalising; hypothesis 1b). Having both many autistic traits and psychotic-like experiences cancels out any mentalising bias (hypothesis 2). We expected no effect of psychotic-like experiences or autistic traits on the ability to discriminate between chasing and non-chasing trials (hypotheses 3a and 3b). Finally, we expected anthropomorphising and a bias to see chasing to correlate positively (hypothesis 4).

Study 1: hypo- and hypermentalising along the autism-psychosis continuum

Method

Participants

Participants were recruited through internet fora, for example, Aspie Quiz site[1], and internal boards at two Norwegian Universities. To ensure anonymous participation and compliance with the National data security regulations (NSD), there were no monetary incentives.

The inclusion criteria were (1) informed consent, (2) being at least 18 years old, (3) responding to more than 80% of the items, (4) viewing the experiment on a screen equal to or larger than 726×554 pixels, and (5) scoring above 2.5 on three psychosis control questions (Moritz et al., 2013). Of the 932 participants that opened the survey, 529 (56.7%) responded to less than 80% of the items and were excluded. Another 103 participants were excluded for failing to meet inclusions criteria 2, 4 or 5. The analysed sample included 300 adults (103 males, 179 females, 11 participants identifying as "other", seven missing). The age of the participants ranged from 18 to 70, with a mean age of 32 years ($SD = 12.4$). Two hundred and eight participants took the survey in English, and 92 in Norwegian.

Ethics

The study design, procedure and data collection were approved by the institutional review board at UiT - The Arctic University of Norway. Participation was anonymous. The survey, implemented in Qualtrics, required participants to consent to the study and assured them that no identifiable data would be collected about them.

Open Science

The questionnaire, visual search videos, data, and analysis code are publicly available at https://osf.io/qaeyu/.

Measures and Procedure

Demographic measures were age and gender. We asked for days per week and hours per day playing videogames.

The autism-spectrum quotient – short form (AQ-28). The participants completed the abridged version of the Autism Spectrum Quotient (AQ-28; Hoekstra et al., 2011). The items were rated on a four-point scale (1 = *definitely agree* to 4 = *definitely disagree*). Traits are assessed along the five dimensions of social skills, routine, imagination, switching and numbers/patterns. The scoring procedures followed the four-response scoring format of Hoekstra et al. (2011), based on the recommendation by Kuenssberg et al. (2014). Sum scores range from 28 to 112, where the maximum score represents a full endorsement of all autistic traits. In the current sample internal consistency, McDonalds ω, was .912.

The positive subscale of the Community Assessment of Psychic Experiences (CAPEpos) scale. Participants completed the positive symptoms subscale of the Community Assessment of Psychic Experiences scale (CAPEpos; Stefanis et al., 2002). The self-report questionnaire consists of 20 items measuring the presence of positive symptoms, such as paranormal beliefs and bizarre perceptual experiences. The distress items were not included in the current study. Three control questions reflecting common misconceptions about psychosis were added to catch trolls (Moritz et al., 2013). The items were rated on a 4-point scale (1 = *never* to 4 = *always*) for frequency. Sum scores ranged from 20 to 80 points. The positive subscale has been divided into three dimensions: bizarre experiences, delusional ideation and perceptual anomalies (Mark & Toulopoulou, 2016). Konings et al. (2006) demonstrated good reliability and validity of the questionnaire. In the current sample internal consistency, McDonalds ω, was .927.

The individual differences in anthropomorphising questionnaire. Participants completed the 15-item version of the Individual Differences in Anthropomorphising Questionnaire (IDAQ; Waytz et al., 2010), and rated on an 11-point scale (0 = *not at all* to 10 = *very much*) the extent to which they believed nonhuman entities possessed human characteristics, such as free will or emotions. Scores range from 0 to 150 points, with higher scores indicating greater tendency to anthropomorphise. The IDAQ demonstrates good internal consistency (Letheren et al., 2017) and moderately high reliability (Waytz et al., 2010). McDonalds ω was .874 for the current sample.

Visual search task. The participants were presented with a total of 50 videos, each 5 seconds long. Based on the wolf and sheep task by Gao et al. (2009), we created chasing videos in LabVIEW version 6.1. Sixteen red distractor discs and one yellow disc moved in random directions, as if moving of their own accords. In half of the 50 videos, one of the 16 red discs would chase the yellow disc (see Figure 1). The story was that this particular red disc was a wolf that was trying to catch the sheep (yellow disc). This is similar to the goal-directed condition in the animation task (Abell et al., 2000; Fyfe et al., 2008; Russell et al., 2006). Each red disc was marked with a different letter. The participants were instructed to watch the videos once, and after each video they were asked, "was the yellow sheep being hunted?". In trials where the participants answered "yes", they were asked to identify the wolf by clicking on the corresponding letter.

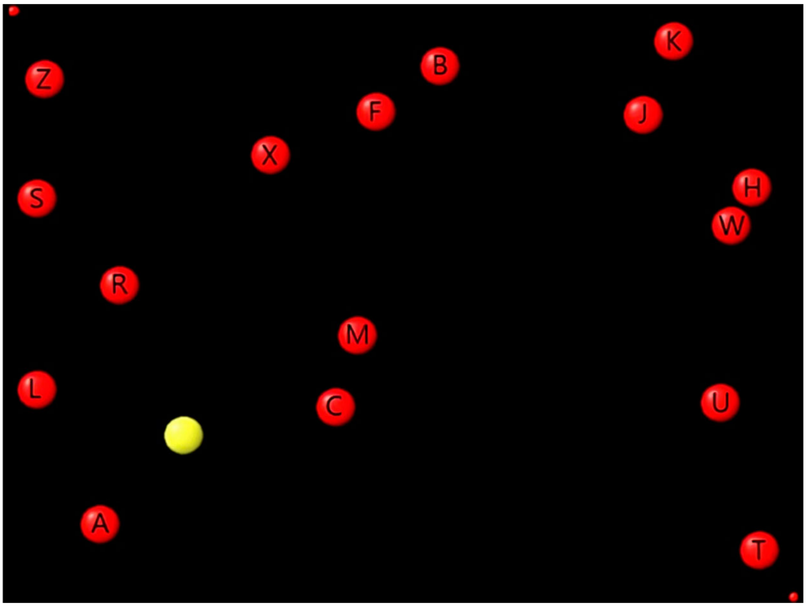

Figure 1. A screenshot from a video from the wolf and sheep task.

There were two practice trials with decreased difficulty level, achieved by reducing the number of distractors. Feedback was given after those practice trials (Vanmarcke et al., 2017). The practice trials were not included in any analysis.

Stimuli. The discs, measuring at 34 pixels wide and 33 pixels long, moved across a black, 726 × 554 pixels background. The discs appeared in random locations at the beginning of each video and moved in random directions, with each disc moving 12 steps of 5 pixels length in one direction before choosing a new direction randomly from ±90° of the previous direction. This speed was constant for all discs. Each step was calculated every 20 ms, so that a change in direction could be made if the discs encountered the edge of the frame before completing the 12 steps. The discs instantly chose a new direction when reaching the edge of the frame, by choosing a random direction from the 180° range leading away from the edge.

In trials without chasing, the sheep moved the same way as the other discs. In chasing-present trials, the sheep (yellow disc) would choose a direction from the ±90° range that was leading away from the wolf (Figure 2A). The wolf's direction would be chosen from the ±90° range leading towards the sheep (Figure 2B). This wide range of directions was chosen to make the wolf's pursuit less obvious (Gao et al., 2009).

The survey consisted in total of 66 questionnaire items and 50 trials of the visual search task. To avoid fatigue, questionnaire items and visual search task trials were intermixed.

Statistical analysis

We used signal detection theory (Macmillan & Creelman, 1991) to calculate discriminability (sensitivity) d' and the response bias, reporting both criterion c and the log of the

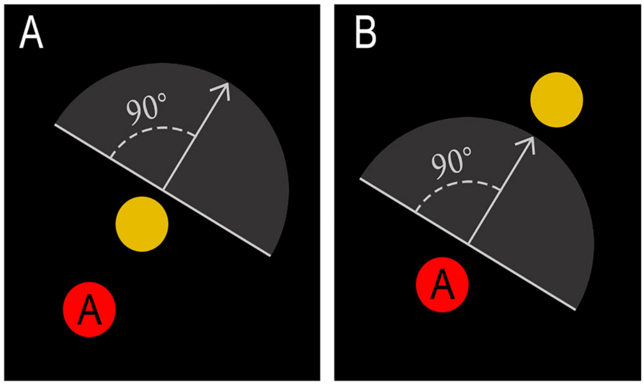

Figure 2. An illustration of the chase angle and escape angle in chasing present trials. The grey areas show the angular zones from which new directions are chosen. The grey area, the lines and the arrows were not part of the actual display. (A) The sheep (yellow disc) chooses a direction from the ±90° range (total grey area) leading away from the wolf (red disc). (B) The wolf chooses a direction from the ±90° range (total grey area) leading towards the sheep.

likelihood ratio (Langdon et al. reported criterion c, Roux et al. reported ln(β)). Larger d' means a better ability to detect when chasing (a wolf) was present or absent. Criterion c reflects the participants' propensity to perceive the wolf as present or absent. A negative c score represents a bias to see a wolf more often than is appropriate, referred to as hypermentalising; a positive score represents a bias not to see the wolf, referred to as hypomentalising. For ln(β) neutral responding corresponds to 0, values <0 / > 0 indicate hyper- and hypomentalising, respectively.

We calculated an average AQ-28 score, and an average CAPEpos score to compensate for items not answered. The hypotheses were examined by using Bayesian correlations, using Kendall's tau-b (hypotheses 1 and 3) and regression (hypothesis 2). The Bayes factor (BF) was interpreted according to Wetzels and Wagenmakers (2012) descriptions. The threshold for evidence in favour of a hypothesis was BF $\geq$ 3.0. JASP version 0.14.1 (JASP Team, 2016) and R version 3.5.0 (R Core Team, 2017) were used.

Results

Descriptives can be found in Table 1. There was no effect of video game playing (see supplementary material). Participants' bias was significantly different from no bias, criterion c: $t(299) = 8.418$, $p < .001$, $d = .486$, $\log BF_{10} = 28.785$; $\ln(\beta) = t(299) = 9.808$, $p < .001$, $d = .566$, $\log BF10 = 38.615$.

Table 1. Descriptive statistics for study 1.

	Mean	SD	Range
AQ-28	2.75	0.55	1.29–3.86
CAPEpos	1.99	0.53	1.00–3.45
IDAQ	36.5	22.72	0–112
Criterion c	0.195	0.4	−1.46–1.23
Ln(β)	0.364	0.642	−0.98–2.13
Discriminability d'	1.421	0.557	−0.15–2.93

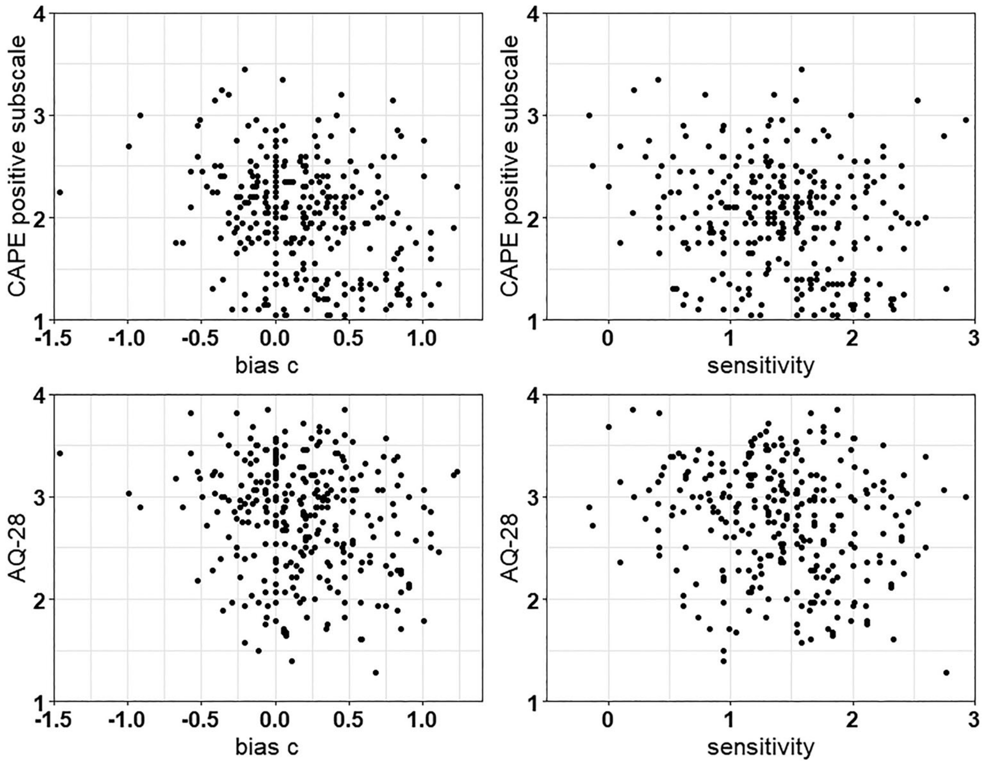

Figure 3. Scatterplots for hypothesis 1 and 3 (note that the statistical analysis is based on rank correlations). Left-hand side: criterion c (a bias measure independent of sensitivity *d′*; right-hand side: discriminability and sensitivity *d′*, respectively).

Hypothesis 1a was confirmed, as psychotic-like experiences were associated with hypermentalising, criterion c: $\tau(299) = -.145$, $BF_{10} = 82$ (Figure 3); ln(β): $\tau(299) = -.148$, $BF_{10} = 108.609$. Hypothesis 1b was not confirmed, as autistic traits were not associated with hypomentalising (nor hypermentalising), criterion c: $\tau(299) = -.093$, $BF_{10} = 1.34$; ln(β): $\tau(299) = -.104$, $BF_{10} = 2.826$.

Hypothesis 2 was not confirmed. The Bayesian regression neither refuted nor supported the model including AQ-28 scores over the model only including CAPEpos scores, $BF_{01} = 2.3172$. A follow-up Bayesian ANOVA using dichotomised groups of participants scoring below or above the average CAPEpos or AQ-28 score indicated an additive effect (Figure 4). Participants scoring high on both psychotic-like experiences and autistic traits had the least bias, c: $M = 0.074$, $SD = 0.411$, 95% credible interval [−0.001; 0.148], whereas scoring low on either AQ-28, CAPEpos, or both, yielded hypomentalising (average c ranged from 0.205 to 0.283, 95% credible intervals did not include 0). The results are similar for lnβ; least bias among those scoring high on autistic and psychotic-like experiences, $M = 0.184$, $SD = 0.567$, 95% credible interval [.082; .286], and the highest bias (hypomentalising) among those scoring low on autistic traits and psychotic-like experiences, $M = 0.529$, $SD = 0.709$, 95% credible interval [0.39; 0.669]. Next, we calculated a difference score between the standardised AQ-28 and CAPEpos scores (Abu-Akel et al., 2018) and correlated it with discriminability and bias. All

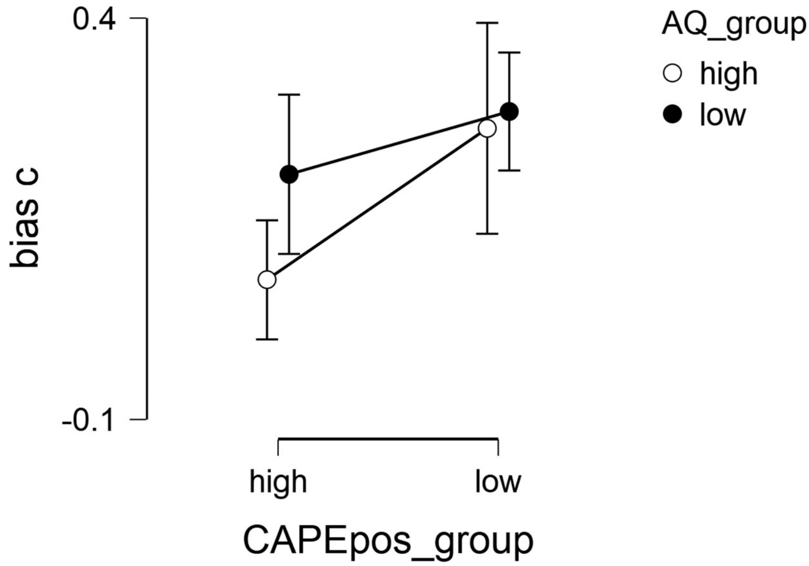

Figure 4. Dichotomising CAPEpos and AQ-28 scores into low and high groups is not supporting that having both traits cancels out a mentalising bias, rather the opposite. Error bars denote 95% credible interval.

correlations had $\tau(299) < .08$ and $BF_{10} < 0.47$; that is again support for disconfirming hypothesis 2.

Hypotheses 3a and 3b on discriminability were disconfirmed. There was lower discriminability the more psychotic-like experiences, d': $\tau(299) = -.105$, $BF_{10} = 3.03$, and autistic traits the participant reported, d': $\tau(299) = -.117$, $BF_{10} = 6.89$.

Hypothesis 4 was not confirmed, as anthropomorphising was neither associated with discriminability, d': $\tau(299) = -.084$, $BF_{10} = 0.81$, nor with mentalising, criterion c: $\tau(299) = -.039$, $BF_{10} = 0.13$; $\ln(\beta)$: $\tau(299) = -.062$, $BF_{10} = 0.281$. The Bayes Factor supports an absence of a relationship between IDAQ and criterion c. Anthropomorphising was associated with psychotic-like experiences, $\tau(299) = .233$, $BF_{10} = 497{,}200$, and autistic traits, $\tau(299) = .125$, $BF_{10} = 13.26$. Finally, autistic traits were strongly associated with psychotic-like experiences, $\tau(299) = .437$, $\log BF_{10} > 1000$.

The supplementary material reports the suscales analyses and a re-analysis using the 24 most informative videos. The latter was done as study 2 used these 24 videos. Briefly, using the most informative videos did not affect the bias, but discriminability's associations with autistic traits and psychotic-like experiences became non-significant.

Study 2: hypermentalising in persons with a psychotic episode?

Study 1 found support for the hypothesis that hypermentalising is related to psychotic-like experiences in the general population. Yet, two previous studies on patients with SSD found no evidence of hypermentalising (Langdon et al., 2020; Roux et al., 2015). The two studies do not report whether symptom severity is related to mentalising. Aim 1 was to investigate whether —within the patient group— more positive symptoms would relate to more hypermentalising (Frith, 2004). From Roux et al.' results one would predict that discriminability but not bias would correlate negatively with positive symptoms. Aim 2 was therefore to investigate whether patients would differ from a matched control group when task difficulty was kept constant, as previous studies found large effects for chasing subtlety (Langdon et al., 2020; Roux et al., 2015; Vanmarcke et al., 2017).

Methods

Participants

Twenty-six patients (nine female) with a diagnosed psychotic episode were recruited from the MCT plus trial (Schneider et al., 2016) at the University Hospital Hamburg Eppendorf as part of the three-year follow-up. All had a schizophrenia diagnosis according to the DSM-V (American Psychiatric Association, 2020). Mean age was 46 years, ranging from 25 to 64. Nineteen patients had completed high school (12–13 years of schooling) and nine patients had completed secondary school.

Ethics

The study was approved by the ethical committee of the German Society for Psychology (DGPs) (Germany).

Material and procedure

We used the same visual search task as in study 1. To minimise the burden and shorten the duration for participants, we selected the 24 most discriminative videos from study 1.

Participants were first administered the Positive and Negative symptom scale (PANSS) (Kay et al., 1987); a clinical interview to assess their symptom severity. The PANSS was scored according to the five-factor model by van der Gaag et al. (2006), using average scores to compensate for two patients having some missing values. Each symptom is scored from 1 (absent) to 7 (extreme). After the interview and other tasks (not analysed here), the experimenter would open the web browser and instruct the participant to watch the videos and rate them. There were two practice trials with feedback. This task took on average 10 min.

Statistical analysis

The videos were analysed as in study 1. We matched the 26 patients by age and gender with 26 participants from study 1 using the MatchIt package in R (Ho et al., 2011). We used two-sided testing, reporting Bayes Factor and Kendall's τ as well as frequentist t and p-values and Cohen's d as effect size.

Results

The average total PANSS score was $M = 42.8$, ranging from 29 to 61. The average scores for the five subscales were: positive symptoms: $M = 1.21$, $SD = 0.66$, negative symptoms: $M = 1.2$, $SD = 0.47$, disorganisation: $M = 1.23$, $SD = 0.27$, excitement: $M = 1.23$, $SD = 0.28$, emotional distress: $M = 1.79$, $SD = 0.7$.

Patients had on average a hypomentalising bias, c: $M = 0.102$, ranging from -1.373 to .912 and $\ln(\beta)$: $M = 0.365$, ranging from -0.313 to 3.618. A one-sample t-test revealed no

Table 2. Bivariate correlation for symptom severity and signal detection theory parameters.

Subscales, df = 24	Criterion *c*, BF	Ln(β), BF	Discriminability *d′*
Positive symptoms	$\tau = .281$, $BF_{10} = 1.744$	$\tau = .269$, $BF_{10} = 1.485$	$\tau = .306$, $BF_{10} = 2.517$
Negative symptoms	$\tau = .424$, $BF_{10} = 20.637$	$\tau = .218$, $BF_{10} = .807$	$\tau = .247$, $BF_{10} = 1.121$
Disorganisation	$\tau = -.034$, $BF_{10} = .259$	$\tau = -.157$, $BF_{10} = .461$	$\tau = -.041$, $BF_{10} = 0.263$
Emotional distress	$\tau = .234$, $BF_{10} = .967$	$\tau = .164$, $BF_{10} = .488$	$\tau = .305$, $BF_{10} = 2.454$
Excitement	$\tau = .372$, $BF_{10} = 7.514$	$\tau = .31$, $BF_{10} = 2.684$	$\tau = .337$, $BF_{10} = 4.109$

conclusive support for a significant difference from no bias, c: $t(25) = 1.105$, $p = .28$, $d = .217$, $BF_{10} = 0.359$, ln(β): $t(25) = 1.892$, $p = .07$, $d = .371$, $BF_{10} = 0.969$. Average discriminability d' in patients was: $M = 0.684$, ranging from -0.842 to 2.349. Table 2 reports the correlations with symptom severity. The more negative symptoms the more hypomentalising (criterion c but not ln(β)).

Next, we matched the 26 patients with 26 participants from study 1 by age and gender. There was no difference between the two groups in discriminability; d': $t(50) = .703$, $p = .485$, $d = .195$, $BF_{10} = 0.341$, and mentalising; c: $t(50) = 1.377$, $p = .175$, $d = .382$, $BF_{10} = 0.605$. These Bayes factors allow no conclusive evidence in favour of the null hypothesis. There was more hypomentalising among patients when applying ln(β): $t(50) = 2.847$, $p = .006$, $d = .79$, $BF_{10} = 6.853$ (i.e., $M_{\mathrm{SCZ}} = .191$, $SD_{\mathrm{SCZ}} = .416$ and $M_{\mathrm{control}} = -.138$, $SD_{\mathrm{control}} = .418$).

Discussion of study 1 and 2

In two studies, we investigated the mentalising bias along the autism-psychosis continuum by using a chasing paradigm (Gao et al., 2009) which measures first-order intentionality. Participants were conservative in attributing first-order intentionality, yet those with more psychotic-like experiences attributed more intentionality (hypermentalising); here seen as detecting agency when there was none. This is in line with Fyfe et al. (2008) who also found more hypermentalising the more delusions a participant had.

There was no hypomentalising in participants with many autistic traits. Moreover, participants with many autistic and psychotic traits did not equal those with few traits, contradicting a finding from a perspective-taking task (Abu-Akel et al., 2015) and the more general opposite-bias view (Crespi et al., 2016; Gillespie et al., 2017).

We predicted no association between personality traits and discriminability. Discriminability was on average very good, indicating few errors in detecting chasing.

Still, the chasing task requires visual attention with its many dots moving seemingly randomly. There was one salient stimulus (yellow circle) and a set of "distractors". Visuospatial perception and attention have been found to be better in ASD than SSD (Kuo & Eack, 2020). However, autistic traits, like psychotic-like experiences, were negatively associated with discriminability in the chasing paradigm, contradicting any advantage autistic traits may give in this task. This finding also contradicts that of Abu-Akel et al. (2018), who found that when visual distractors should be ignored, performance was positively correlated with autistic traits and negatively correlated with psychotic traits. When the distractors were informative, the opposite pattern occurred. Such a double-dissociation and opposite bias were not found in our sample from the general population.

Bias to perceive first-order intentionality in the IDAQ scenarios was positively related to both autistic traits and psychotic-like experiences. This contradicts studies that have linked ASD to either no difference in (Castelli et al., 2002) or decreased attribution of first-order intentionality to animated shapes displaying goal-directed movements (Martinez et al., 2019). To our knowledge, our study is the first to measure anthropomorphising and psychotic-like experiences and confirms the predicted relationship (Fyfe et al., 2008) of more anthropomorphising the more positive symptoms a participant reports. The participants' IDAQ scores were not associated with a bias nor discriminability in the chasing paradigm. The absence of a relationship between anthropomorphising and bias might indicate a difference between measuring behaviour explicitly (verbal, questionnaires) versus implicitly (responses). A similar absence of a relationship between a questionnaire-based and a task-based measure has been found for the Jumping to Conclusion bias (Peters et al., 2014).

In line with Roux et al. (2015) and Langdon et al. (2020), we did not find hypermentalising in study 2 where we tested patients with a psychotic episode. Patients were instead more prone to hypomentalising. Although this finding contradicts theories of too much attribution of intention in SSD (Fletcher & Frith, 2009; Frith, 2004; Van de Cruys et al., 2014), it is in line with previous studies showing patients making fewer causal mental state attributions than the control group in both the goal-directed and the ToM conditions of the Heider & Simmel task (Langdon et al., 2017; Martinez et al., 2019). Since there are different dimensions of mentalising (Luyten & Fonagy, 2015), it is not surprising that tasks measuring agency detection and ToM do not correlate (Langdon et al., 2020; Schimansky et al., 2010) and that an association with traits also varies by the task used (Fyfe et al., 2008). Further, the hypothesised hypo- and hypermentalising view in ASD and SSD rests on no co-occurrence of negative symptoms and depression. The more negative symptoms, the more hypomentalising is expected (Frith, 2004). Alternatively, hypomentalising might be due to more cautious and conservative responding, as the patients underwent cognitive remediation or metacognitive training (Moritz et al., 2014; Moritz & Woodward, 2007; Vitzthum et al., 2014). Thus, future experiments should control for depressive and negative symptoms both in a healthy sample and in persons with ASD and SSD, and assess patients with SSD before they underwent therapy.

Limitations and strengths

Participants could play the videos more than once. We do not assume that this affects agency detection, but rather that motivated participants might have re-watched the videos to indicate the letter of the circle (the wolf). Yet, restricted watching, as done in study 2, is recommended in future studies. We did not measure negative symptoms in study 1 as we assumed that this affects persons with many autistic and psychotic traits equally, and hence might weaken but not erase the opposite bias. Yet, future studies should investigate the contribution of negative symptoms on mentalising in healthy participants.

This study has several strengths. Examining relationships rather than group differences reflects the fact that autistic and psychotic traits are distributed continuously in the population (Hoekstra et al., 2011; Stefanis et al., 2002) and also co-occur within a person (Kincaid et al., 2017; Martinez et al., 2021). Investigating both autistic and psychotic traits within the same detection paradigm offers more validity to any speculations regarding the hypo- and hypermentalising dimension. Sampling from a general population rather than a clinical one also means that general impairment and medication would not bias any results. Compared to other tasks, a mentalising bias in the agency task is less likely driven by motivational issues or miscomprehension.

Conclusion

Our findings do not support a diametrically opposite mentalising bias (first-order intentionality) along the autism-psychosis continuum. They do support that negative symptoms are associated with hypomentalising, and psychotic-like experiences with hypermentalising. However, autistic traits did neither relate to hypomentalising nor did the co-oocurence of autistic and psychotic-like experiences cancel the mentalising bias.

Note

1. https://rdos.net/eng/Aspie-quiz.php

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that support the findings of this study are openly available in Open Science Framework repository at https://osf.io/qaeyu/

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