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ORIGINAL PAPER

Adolescents with Autism Spectrum Disorder Show a Circumspect Reasoning Bias Rather than 'Jumping-to-Conclusions'

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Abstract People with autism spectrum disorders (ASD) often take longer to make decisions. The Autism-Psychosis Model proposes that people with autism and psychosis show the opposite pattern of results on cognitive tasks. As those with psychosis show a jump-to-conclusions reasoning bias, those with ASD should show a circumspect reasoning bias. Jumping-to-conclusions was assessed in a sample of 20 adolescents with ASD and 23 age-matched controls using the jumping-to-conclusions beads task. Both groups demonstrated equivalent levels of confidence in decision-making, however the ASD group required more beads than controls before making their decision. Furthermore, there was a positive correlation between the beads required and degree of autism symptoms. Consistent with the Autism-Psychosis Model, a more circumspect reasoning bias was evident in ASD.

Keywords Autism · Jumping-to-conclusions · Reasoning bias · Decision-making

Introduction

Autism and Asperger Syndrome are both autism spectrum disorders (ASD) diagnosed based on difficulties in social functioning and communication, along with restricted and repetitive behaviours (APA 2000). Further problems commonly reported in ASD include difficulties in making decisions. Teacher and parent observations report indecisiveness and delayed decision-making in people with ASD (Johnson et al. 2006; Winter 2003). Research has shown intellectually-able people with ASD experience greater difficulty with decision-making when compared with matched controls (Goldstein et al. 2001). Luke et al. (2012) looked more closely at these difficulties and found that people with ASD found decision-making exhausting, and tended to avoid making decisions because they disliked doing so. A study by De Martino et al. (2008) examined decision-making under conditions of uncertainty in ASD and found reduced emotional responses as measured by skin conductance response. The authors interpreted the findings to show reduced integration of emotion in decision-making in those with ASD, alongside a greater reliance on a rational and logical decision-making style.

The enhanced rational and logical decision-making in ASD is consistent with prominent psychological theories, such as the Empathising–Systemising (E–S) theory (Baron-Cohen 2002, 2003, 2009). According to E–S theory, ASD is characterised by a strength in Systemising, which is defined as the drive to analyse or build systems. Systemising represents non-social processing and allows one to predict the behaviour of a system and to control it (Baron-Cohen 2002). ASD is also characterised by deficits in Empathising, which may emerge partly from people with ASD attempting to utilise their strengths in Systemising during social and emotional situations (Golan and Baron-Cohen 2006; Golan et al. 2010). Rutherford and McIntosh (2007) also suggest that those with ASD employ a deliberative and rule-based strategy when perceiving emotions, whereas typical participants employ a rapid intuitive strategy. This is supported by research suggesting longer decision-making times and longer ERP latencies in ASD (Behrmann et al. 2005; Capps et al. 1992; McPartland et al. 2004).

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Dual-process accounts of human cognition suggest two distinct types of reasoning and decision-making; a fast 'intuition' that is independent of working memory and cognitive ability and a slower analytic-logical 'deliberation' that is heavily dependent on working memory and related to individual differences in cognitive ability (see Evans 2008 for review). The greater reliance on analytic and logical processing in ASD may be consistent with a bias towards Systemizing when reasoning and decision-making and underlie the difficulties in making efficient and quick decisions, which may be particularly important in the social world (De Martino et al. 2008). De Martino et al. argue that, consistent with E–S theory, those with ASD tend towards deliberative reasoning and decision-making which is attributable to impairment within their rapid/intuitive mechanisms.

One way to investigate reasoning involved in decision-making is the jumping-to-conclusions reasoning bias task. The jumping-to-conclusions task is a probabilistic reasoning task in which participants see a series of beads drawn from one of two jars, and they have to make a decision about which jar they think the beads are being drawn from. The jars differ in the proportion of black and white beads within each jar, with one containing 60 white and 40 black beads and the other having a proportion of 40 white and 60 black beads. The crucial variable is how many beads the participant requests before making a decision. To date there are no published reports investigating a jumping-to-conclusions reasoning bias in ASD. Much of the previous research about jumping-to-conclusions biases has been conducted in people with schizophrenia, and in particular, those with delusions. A jumping-to-conclusions reasoning bias involving hasty decisions based on minimal information (i.e. one or two beads) has been widely reported in patients experiencing psychosis, and specifically delusional symptoms (e.g., Freeman 2007; Freeman et al. 2008; Garety et al. 2005, 2007). The jumping-to-conclusions reasoning bias is also evident in patients without schizophenia who report symptoms of acute persecutory delusions (Corcoran et al. 2008), and sub-clinical schizotypy groups (e.g., Moritz et al. 2012). Males and females have been found to perform comparably on tasks assessing the jumping-to-conclusions decision-making bias and sex differences are not expected in general or clinical populations (Brosnan et al. 2013; Freeman et al. 2008; Moritz and Woodward 2005).

The Autism-Psychosis Model (Crespi and Badcock 2008) proposes that autism and psychosis reside at opposite ends of the cognitive continuum composed of the relationship between social and non-social components, which are similar to the Empathising and Systemising components of the E–S theory. According to the Autism-Psychosis Model, people with ASD should show the opposite jumping-to-conclusions pattern to that seen in psychosis, namely a more circumspect bias in jumping-to-conclusions tasks. Recent research has demonstrated that people from the general population who self-report high Empathizing scores alongside low Systemizing scores, which is the opposite cognitive pattern to that seen in ASD, report higher levels of psychosis experiences and make hasty decisions based on limited information as shown by requiring fewer beads in the jumping-to-conclusions beads task (Brosnan et al. 2010, 2013). The present study utilised the jumping-to-conclusions beads task in a group of adolescents with and without ASD. The Autism-Psychosis Model predicts those with ASD should demonstrate a more circumspect reasoning bias as shown by requiring more beads to be drawn before making a decision in the jumping-to-conclusions beads task. To better understand the nature of this reasoning bias, correlations between the number of beads drawn and confidence levels were carried out with an index of Systemising.

Methods

Participants

Participants were 20 adolescents (1 female) with ASD and 23 controls (8 females), with ages ranging from 13 to 17 years. ASD participants were recruited from an ASD unit attached to a mainstream school. A clinical diagnosis of Asperger Syndrome according to international criteria (APA 2000) was required as an entry requirement for all students to enrol in the unit. Diagnoses were made by an interdisciplinary team of clinical professionals, including a paediatrician, clinical psychologist and speech and language therapist using the ADOS (Lord et al. 1989). Control participants were recruited from the mainstream school. Participants were all Caucasian and drawn from a suburban lower-middle class school catchment area. There were no recorded co-morbidities (such as AD/HD) for any of the participants. There were no reported psychiatric conditions from parental reports for any participants in the control group. All participants had their IQ indexed using the WASI (Wechsler 1999). Means and standard deviations for age and indices of verbal and non-verbal mental ability are reported in Table 1.

Design

Participants completed a series of assessments in a one-on-one situation with one of the researchers in a quiet area of school during a school day. The following assessments were read to participants, item by item, and their responses noted.

Table 1 Demographic information (mean and standard deviation) for the ASD and control group

	ASD	Control	t score(*df*), *p*
N (males:females)	N = 20 (19:1)	N = 23 (15:8)	
Age	14.60 (1.19)	14.35 (0.93)	t(41) = 0.78, ns
NVMA/PIQ	102.15 (12.46)	103.96 (13.01)	t(41) = 0.46, ns
VMA/VIQ	96.45 (10.89)	104.35 (11.56)	t(41) = 2.30, 0.027
SRS-short	14.05 (6.49)	5.61 (4.37)	t(32.54) = 4.93, 0.001
AQ-pattern/number	7.30 (3.66)	3.52 (3.30)	t(41) = 3.56, 0.001
Beads requested	9.95 (3.33)	6.83 (1.67)	
Confidence	79.85 (16.90)	70.78 (16.04)	

Social Responsiveness Scale-Short (SRS-S)

Although all participants with ASD had received a diagnosis based on international criteria (APA 2000) in order to attend the ASD unit of the school, the specific diagnostic criteria for this group was not available for this research. The SRS-S is not diagnostic, but was used here to confirm a group difference in autistic characteristics between the groups. The 11 item SRS-S was developed to be a short screen for ASD characteristics based upon the full SRS (Constantino and Gruber 2005; Kanne et al. 2009). Constantino et al. (2007) report extremely high specificity (0.96) and sensitivity (0.75) for clinical and research diagnoses of ASDs (area under receiver operating characteristics curve = 0.95) from a range of informants using the SRS. Kane et al. report 11 original SRS items (based on SRS items 6, 15, 16, 18, 24, 29, 35, 37, 39, 42, and 58) all had high loadings on a single unrotated principal components analysis factor. Items from each of the three autism symptom domains, social impairment (e.g., making friends and relating to peers, eye contact, social interest, others' perceptions), language impairment (e.g., conversational skills, understanding aspects of nonverbal communication), and stereotyped/repetitive behaviours (e.g., restricted areas of interest, cognitive style, difficulty with change, and sensory difficulties), were included. The short version of the SRS used in this study has been shown to be well validated against the full SRS (Kanne et al. 2009), and has previously been utilised as a screening measure for ASD characteristics in research studies (Christ et al. 2010; Reiersen et al. 2008). Responses were given on a 4 point scale from 0 to 3 (0 = false, not at all true; 1 = slightly true; 2 = mainly true; 3 = very true) and scores could range from 0 to 33. First we analysed the whole group, then reanalysed the data using an SRS-S cut off of 10. We excluded those in the ASD group with a score of less than 10 and those in the control group with a score of 10 or more (see Results section). Reiersen et al. report a Cronbach's alpha of 0.81 for this short version of the SRS and Christ et al. reported this version of the SRS correlates highly (0.75) with the full version of the Autism Quotient (AQ: Baron-Cohen et al. 2001).

Autism-Spectrum Quotient (AQ)—Numbers/Patterns Factor

We wanted a brief index of Systemizing for this sample, to allow us to investigate if this factor related to the jumping-to-conclusions reasoning bias. The AQ has been factor analysed to highlight two distinct factors—social (Empathizing) and non-social (Systemizing) components. We used the non-social factor which contains five items labelled as 'Numbers/Patterns' (Hoekstra et al. 2011). Participants completed the Numbers/Patterns subscale in the same manner as the SRS-short. Hoekstra et al. employed a 4 point response scale from 0 to 3[1] and scores could therefore range from 0 to 15. Cronbach's alpha for those with ASD for this subscale was 0.73.

AQ scores can be predicted from combining Empathizing and Systemizing scores (Wheelwright et al. 2006). To confirm the Numbers/Patterns AQ factor related to Systemizing we asked 128 (65 females, 53 males; average age 22 years: SD = 6.6) undergraduate students to complete both the Numbers/Patterns subscale and a Systemizing Quotient questionnaire (SQ: Wakabayashi et al. 2006). As expected there was a sex difference in the Numbers/Patterns subscale and SQ, with males scoring higher than females (6.91(3.39) vs. 5.52(3.21); t(116) = 2.27, $p = 0.013$; 21.42(8.60) vs. 10.88(5.34); t(115) = 8.10, $p < 0.001$; respectively). The two scales also significantly positively correlated with each other (r = 0.29, $p = 0.001$; partial correlation controlling for gender). Cronbach's alpha for the Numbers/Patterns subscale was 0.78. We therefore concluded that the Numbers/Patterns subscale of the AQ related to Systemizing, and use the term Systemizing henceforth to refer to this subscale.

[1] Originally Systemizing was scored 1 for an agree response and 2 for a strongly agree response and zero otherwise. Hoekstra et al. used a 0, 1, 2, 3 rating response scale. In the present study for the ASD and control participants, these two scoring frameworks were highly correlated (r(43) = 0.96, $p<0.001$) and we retained the scoring of Hoeekstra et al..

The Jumping-to-Conclusions Beads Task

The jumping-to-conclusions decision-making bias was assessed using a computer-based version of the 'beads task'. The participants were initially shown two large jars on the screen containing many beads. One of the jars had a ratio of 60 % black beads and 40 % white beads, and the other had the opposite ratio with 40 % black beads and 60 % white beads. The jars were then covered up and participants requested one bead at a time to be drawn, and this bead was shown on the screen. After each bead request participants then had to make a decision about which jar they thought the beads were being drawn from, or else they asked for another bead to be drawn (Freeman 2007; Freeman et al. 2008; Garety et al. 2005, 2007). This was done to a maximum of twenty beads in total. The key dependent variable measured was the number of beads requested before making a decision (Langdon et al. 2010; McKay et al. 2006, 2007). To minimise memory requirements, the beads already drawn were displayed on the screen for participants to see and to note the order the beads were drawn (Lincoln et al. 2010). After making the decision, participants were asked how confident they were about their decision on a scale from 0 (no confidence) to 100 (complete confidence). See Brosnan et al. (2013) for more details about the task procedures.

Ethics

The research was approved by the Departmental Ethics Committee which implements the ethical guidelines of the British Psychological Society. These guidelines were adhered to at all times and written informed consent was obtained from all participants and their parents/carers.

Results

T- Test comparisons showed there were no differences between groups for age or performance IQ, see Table 1. However, significant group differences were seen for gender ratio ($\chi^2 = 5.73$, $df = 1$, $p = 0.017$) and verbal IQ (see Table 1). The range of beads requested was 5–16 for the ASD group and 3–9 for the control group. The means are reported in Table 1 and represented in Fig. 1, note the 95 % confidence interval error bars do not overlap between the ASD and control group. As there was a significant difference in the index of VIQ, this variable was controlled for as a covariate in a univariate ANOVA with Group (ASD vs. control) as the independent variable and the number of beads requested as the dependent variable. Results showed the number of beads requested by the ASD group was significantly greater than the control group ($F(1,40) = 15.65$, $p < 0.001$).

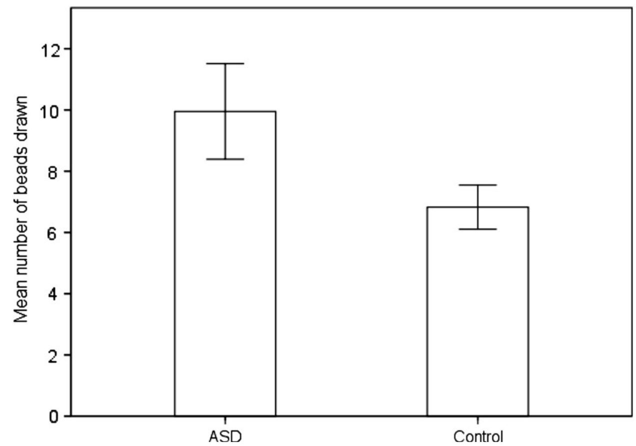

Fig. 1 Mean number of beads drawn for ASD and control groups (*error bars* represent 95 % confidence intervals)

A univariate ANOVA with Group (ASD vs. control) as the independent variable and confidence level as the dependent variable did not reach significance ($F(1,40) = 4.06$, ns). The number of beads drawn and the confidence level positively correlated with each other for both the ASD group ($r(20) = 0.76$, $p < 0.001$) and the control group ($r(23) = 0.82$, $p < 0.001$). Interrelationships between experimental and demographic variables were also explored. Since significant group differences were identified for some of the variables, partial correlations were conducted controlling for Group (ASD or control). Both the number of beads drawn and confidence level positively correlated with Systemizing (both $r(40) = 0.53$, $p < 0.001$). Neither of these measures correlated with the SRS-S, verbal IQ, or Performance IQ (all $p > 0.05$). Figure 2 highlights the relationship between the number of beads drawn (2a) and confidence (2b) with Systemizing.

Although all participants received a clinical diagnosis of ASD in order to be enrolled in the specialist ASD Unit, the only diagnostic information we had about the participants was SRS-S scores. Therefore, we tested whether the difference in number of beads requested would retain significance when a stricter SRS-S cut-off criteria was applied to our two groups. We used a cut off value of 10 (mean + 1 SD of the control group), which allowed the resulting group means to be consistent (relatively) with the group means reported for the full SRS (Constantino and Gruber 2005). This resulted in the exclusion of 5 participants in the ASD group with an SRS-S score of less than 10, and 3 control participants with an SRS-S of 10 or greater. This mean SRS-S scores of the stricter groups was 16.87 (SD = 4.75) for the ASD group and 4.35 (SD = 2.32) for the controls. The resulting means are consistent with scores from previous research using high and low SRS-S groups (Kanne et al. 2009). A univariate ANOVA analysis investigating group differences using

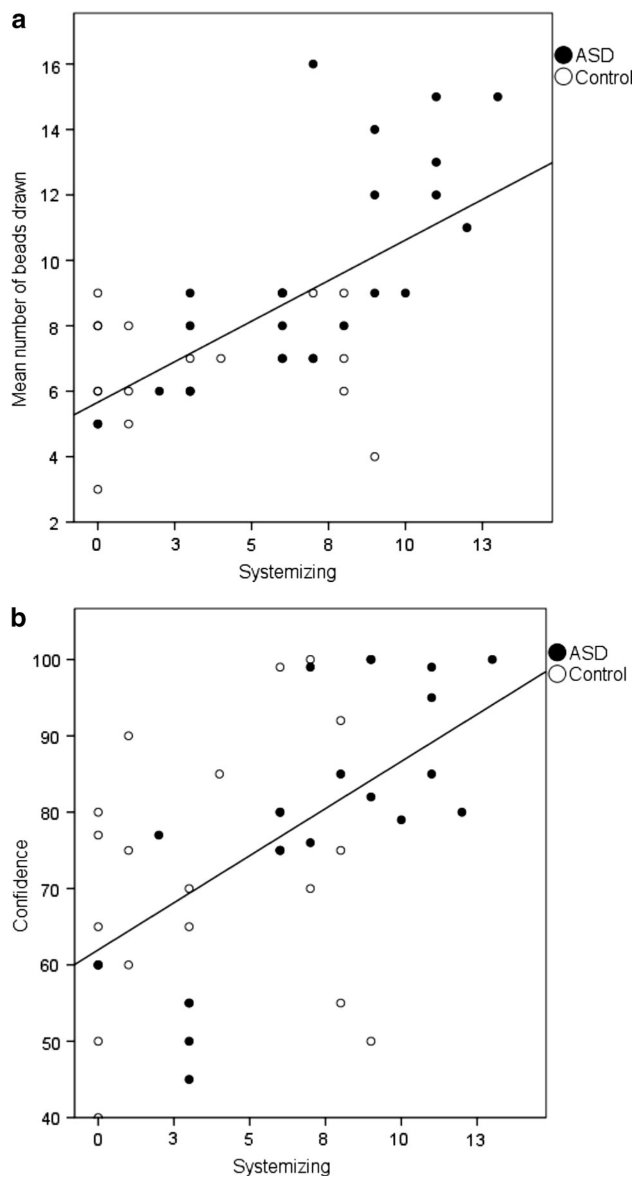

Fig. 2 **a** Relationship between mean number of beads drawn and systemizing for ASD and control groups. **b** Relationship between mean confidence and systemizing for ASD and control groups

these stricter exclusion criteria showed the ASD group still requested significantly more beads than the controls ($F(1,32) = 9.38$, $p = 0.004$).

Although gender was not expected to have any effect on the results, the control group contained more females than the ASD group. Therefore, the ANOVA was rerun using the groups defined by the stricter SRS-S cut off including only the male participants, which results in14 participants in both groups. Once again, the finding of a greater number of beads drawn by the ASD group was confirmed ($F(1,25) = 8.38$, $p = 0.008$).

Discussion

This is the first study to reporting the jumping-to-conclusions beads task in ASD. Results showed the ASD group required more beads to be drawn before making a decision compared to controls. This reveals a more circumspect reasoning bias in ASD, where those with ASD gathered more data before a decision was made. This represents the opposite pattern to the jumping-to-conclusions reasoning bias seen in psychosis, which confirms predictions from the Autism-Psychosis Model. The more circumspect reasoning bias in ASD may be related to enhanced Systemising and may help explain research and anecdotal evidence that people with ASD do not make decisions quickly.

The present findings are consistent with the Autism-Psychosis Model, which proposes that cognitive functioning in ASD is at the opposite end to psychosis within a cognitive spectrum comprised of social and non-social components. A wealth of research has demonstrated those with psychosis tend to jump-to-conclusions (Freeman 2007; Freeman et al. 2008; Garety et al. 2005, 2007; Langdon et al. 2010; McKay et al. 2006, 2007). The present findings show a more circumspect reasoning bias is evident in those with ASD compared to a control group, which is the opposite type of reasoning bias to that typically seen in psychosis. Research examining the experiences of people with ASD has revealed they have particular problems when decisions need to be made quickly, and they find decision-making to be exhausting (Luke et al. 2012). Temple Grandin, a high-functioning person with ASD, reports using logic to make all her decisions because emotions are not normally integrated into her thoughts (Grandin 2000, 2002). This is consistent with neurophysiological and behavioural research reporting that people with ASD fail to utilise emotional processing in decision-making, and rely more on an enhanced analytical thinking style (De Martino et al. 2008). Temple Grandin also reports that her mind is like a Web browser, and she analytically goes through all the details stored in her brain in order to make a decision (Grandin 2000, 2002). This style of reasoning would require the acquisition of sufficient information in order to weight all the possible choices, and would be time-consuming. This is consistent with the present findings that the ASD group needed to gather more information than controls before making their decision about which jar the beads were being drawn from. There are also various anecdotal reports that people with ASD show the opposite pattern of jumping-to-conclusions to that seen with psychosis, rarely making initial guesses about situations because they scrutinize the details in an overly thorough manner (Perry 2008; Turner-Brown et al. 2008).

A positive correlation was found in the present study between the number of beads drawn and greater scores on an index of Systemising, namely the Numbers/Patterns factor of the AQ. This suggests the greater reasoning in ASD is related to the strength in non-social processing, or Systemizing, which is theorised to occur alongside reduced Empathising (Baron-Cohen 2002, 2003, 2009; De Martino et al. 2008; see also Crespi and Badcock 2008). From this perspective, the enhanced logical and rational reasoning style in ASD serves to gather more information than usual in order to make a more informed decision-making. This may be beneficial in non-social situations where a more Systemising approach might help to weigh the evidence in order to make an informed decision, such as those commonly seen in occupations like science and engineering. This reasoning bias, however, might not always be useful in social situations, where quicker intuitive reasoning might help make efficient decisions and judgments. It may be the application of this circumspect reasoning to social-emotional contexts that characterises the deficits associated with ASD. Whilst there is evidence for a bias towards and an association between Systemizing and deliberative processing from dual processing accounts of human cognition, whether this is attributable to impairment within the rapid/intuitive mechanisms in ASD (e.g., De Martino et al. 2008) is a question for future research.

Thus, greater Systemizing relating to a greater number of beads requested before making a decision in the present study may be consistent with greater deliberation (as contrasted with intuition, see Evans 2008). Brosnan et al. (2013) also demonstrated a relationship between a reduced jumping-to-conclusions bias was and greater Systemizing in addition to less Empathizing in a general population. Though yet to be empirically demonstrated, there are potential links between intuition and impairments characteristic of ASD (Allman et al. 2005). Stone et al. (1998) argue that the use of theory of mind (ToM) is rapid, automatic, requiring no effortful attention in the typical population. It is interesting to speculate that ToM deficits in ASD may relate in part to a more general deficit in rapid, automatic, pre-attentive processing. Senju et al. (2009) suggest that, whilst the understanding of others' emotions typically requires the spontaneous, automatic encoding of socially relevant information, a comparable understanding can be achieved by those with ASD through the application of explicit verbally-mediated reasoning strategies.

Such a deficit would also be consistent with the perceptual literature that has identified a deficit in perceiving pre-attentive Gestalt forms in ASD (Brosnan et al. 2004; Farran and Brosnan 2011). Typically global processing precedes local processing reflected in global advantage, which has been found to be irregular in ASD. It is possible that a predisposition to sample more information would render a pre-potent global bias irrelevant. Thus global processing could be under taken but is not preferenced as a facet of a general tendency to process more of the environmental stimuli. This would be consistent with Enhanced Perceptual Theory (Mottron et al. 2006; Plaisted et al. 1999) and future research could explore whether the circumspect reasoning bias in ASD is related to global/local perceptual biases in addition to ToM deficits. Future research can explore the extent to which reasoning and decision-making (including social cognition) in ASD can be conceptualised in terms of the dominance of deliberative types of cognitive processes over intuitive types of cognitive processing, as well as whether the opposite pattern is evident in psychosis.

An alternative interpretation of the data is that the greater number of beads drawn by the ASD group might simply reflect perseverative behaviour in ASD. If this was the case, then we would have expected those in the ASD to reach the maximum number of beads to be requested in the task, which was 20. However, no participants in either group reached this maximum number of beads. In addition, a strong relationship was evident for both groups between the number of beads requested and confidence levels in the subsequent decision. There were no differences in confidence levels between groups, showing that the ASD group required greater data in order to reach the same confidence level as the controls. This may indicate that those with ASD do not require a higher level of confidence to make a decision, rather they require more information to reach the level of confidence typically required to make a decision. Another potential explanation to explain the greater number of beads drawn in the present results is that participants with ASD may have had a higher interest in beads. However, none of the participants in our study reported having a particular interest in beads and all were high-functioning, so we do not believe this can explain the findings.

There are some limitations to the present study that should be noted. Timing data for the task was not available and so we cannot determine how fast the ASD group made each specific choice within the task. It could be the case that the ASD group drew more beads than the control group, but made each choice quicker. Further research controlling for timing is necessary to investigate this. The SRS-short and AQ Numbers/Patterns subscale were both brief self-report measures which may be open to bias from participants and whilst they may approximate the full versions of the scales, future research should replicate the findings utilising behavioural and varied indexes of ASD. The present jumping-to-conclusions beads task utilised the same design as that commonly run in the psychosis field, which does not typically include a control condition, which limits the conclusions that can be drawn from the present results. The task is typically run once, and the implications are limited by being based upon a single task. Within the psychosis literature, the number of beads drawn variable has often been dichotomised to identify those who jump to conclusions, with 2 or fewer beads drawn generally defining a jumping-to-conclusions bias. The present research predicted the ASD group would show a greater data gathering and therefore this dichotomy was not expected to be useful in the present study. In fact, no participants in the present study actually made a decision after drawing only 1 or 2 beads. In future, the jumping-to-conclusions beads task may be useful in helping understand non-social reasoning and decision-making biases, and how these relate (or do not relate) to social impairments in ASD.

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