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No differences between autistic and non-autistic adults in social influence on risky decision-making

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Disclosure of Interest

The authors report no conflict of interest.

Abstract

Everyday risky decisions are susceptible to influence from a variety of sources, including the social context in which decisions take place. In the general population, people update their risk preferences based on knowledge of choices made by previous participants. In this study, we examined the influence of social information on the risky decision-making of autistic adults, a group in which differences in social processing have been observed. Autistic and non-autistic adults completed a risky decision-making task in the presence of both social and non-social information, either choosing for themselves or someone else on each trial. Notably, the social information comprised tokens that represented preferences of previous participants and was thus devoid of overt social cues such as faces or gestures. The non-social condition comprised a previously validated method where tokens represented “preferences” generated by weighted roulette wheels. Participants significantly shifted their choices when the influence (social or non-social) suggested a less risky choice. There were no group differences in risky decision-making when deciding for oneself compared to others. Interestingly, no differences in the effects of social and non-social influence were found between autistic and non-autistic adults. Considering previous evidence of social influence differences when using overtly social cues, we suggest that the removal of social cues in our paradigm led to comparable performance between the autistic and non-autistic groups. The current study paves the way for future studies investigating a confounding effect of social cues, which will lead to important insight for theories of social influence in autism.

Lay Summary

This study shows that autistic and non-autistic individuals do not differ in their behaviour when making risky decisions. When given social information (how many people chose each option) and non-social information (how many roulette wheels “chose” each option), both groups showed the same pattern of behaviour. This is important for showing that, like non-autistic individuals, autistic people are susceptible to influence when social and non-social information are presented using proportions.

Keywords: autism, decision-making, risky choice, social influence, non-social influence

Introduction

Risky decisions are frequently encountered in everyday life. Within these decisions, a choice must be made between options with different levels of risk and reward; for example, a variety of investment opportunities might have different likelihoods of failure, but different levels of monetary gain if they prove successful. These real-world decisions are susceptible to influence from a variety of sources, including the social context in which the decision takes place. One such form of social influence is the presentation of social information during the decision-making process. Members of the general population have been found to use the knowledge of others' choices to update their own preferences in a risky decision-making task (Michael et al., 2019). Indeed, social information influences behaviour in a variety of contexts such as risk evaluation, cooperation, attractiveness ratings and music preferences (Berns, Capra, Moore, & Noussair, 2010; Campbell-Meiklejohn, Bach, Roepstorff, Dolan, & Frith, 2010; Knoll, Leung, Foulkes, & Blakemore, 2017; Parks, Sanna, & Berel, 2001; Zaki, Schirmer, & Mitchell, 2011).

The study of social influence in autistic individuals has presented mixed findings. Large, Pellicano, Mojisich, and Krug (2019) investigated the developmental trajectory of social influence integration in autistic and non-autistic adolescents; their results showed that autistic adolescents did not exhibit the same social influence bias on perceptual decisions as found to develop in non-autistic individuals during their early teens. Further, in a charitable donation decision-making task, Izuma, Matsumoto, Camerer, and Adolphs (2011) demonstrated that whereas non-autistic adults modulated their donations depending on the presence and absence of an observer, autistic individuals did not. A number of studies, however, have found no difference between autistic individuals and non-autistic individuals. For example, Lazzaro et al. (2019) reported that autistic adults were just as susceptible to social influence as non-autistic adults during a memory test, and Wadhera and Kakkar (2020) found susceptibility to social influence in safety judgements for both autistic and non-autistic adults.

A task feature that may be driving these differences is the format in which social influence is presented. Existing tests of social influence in Autism Spectrum Disorder (ASD) have represented social information in a variety of different ways (e.g., the presence of another individual during the decision-making process or being advised to choose one of two options by another individual).

94 Importantly, some of these presentations involve the use of a visual social stimulus whereas others do
95 not. It is notable that the two aforementioned studies reporting a difference in social influence
96 between autistic and non-autistic groups involved overt social cues as their form of social influence
97 (Izuma et al., 2011; Large et al., 2019), whereas the latter two studies finding no difference between
98 autistic and non-autistic groups did not present social information as overt social cues (Lazzaro et al.,
99 2019; Wadhera & Kakkar, 2020). The former paradigms contain a potentially important confound.
100 Previous research has debated different attention to and processing of social stimuli, such as faces, in
101 the autistic population. Evidence has suggested specific differences in attending to social stimuli
102 compared to non-social stimuli in ASD (e.g., Dawson et al., 2004; Klin, Jones, Schultz, Volkmar, &
103 Cohen, 2002; Swettenham et al., 1998). In addition, Bird, Catmur, Silani, Frith, and Frith (2006)
104 found that attention does not modulate neural responses to social stimuli in autistic adults. In terms of
105 social processing, studies of face stimuli suggest differences in emotion recognition (e.g., Ashwin,
106 Chapman, Colle, & Baron-Cohen, 2006; Lindner & Rosen, 2006). Thus, for social influence
107 paradigms using overt social cues such as pictures or videos of faces, a lack of social influence in
108 ASD may be due to reduced attention to, or processing of, social information. Given that using overt
109 social cues to represent social information may mask intact social influence in autistic individuals, the
110 current study used a paradigm adapted from Michael et al. (2019) and Cook et al. (2019) in which
111 social and non-social information were presented conceptually using tokens.

112 Another difference between tasks which may account for conflicting findings in the ASD
113 social influence literature is the strength of the social influence presented. Due to the use of a variety
114 of social influence formats (e.g., Izuma et al., 2011; Large et al., 2019; Lazzaro et al., 2019; Wadhera
115 & Kakkar, 2020), it is unclear whether the strength of social information is comparable across studies.
116 This variation may be responsible for the disparity in the literature; specifically, studies reporting
117 successful social influence in the autistic population may have exerted a greater strength of influence
118 compared to studies in which an effect of social influence is not found. To investigate whether social
119 influence depends on the strength of the social information presented for autistic adults, the current
120 paradigm presented different levels of influence information. We used the procedure developed by
121 Michael et al. (2019) whereby the number of tokens above each option in the risky decision-making

task was manipulated to represent different proportions of recommendations made, with a 90:10 split of tokens denoting ‘strong’ influence, and a 70:30 split denoting ‘weak’ influence.

Social cognition differences in autistic adults may be due to challenges with switching between the self and others, known as the self-other distinction (Bird & Viding, 2014). Reduced control between self-other representations has been supported by evidence of hyper-imitation in autistic adults (Bird, Leighton, Press, & Heyes, 2007; Hamilton, 2013; Schunke et al., 2016; Sowden, Koehne, Catmur, Dziobek, & Bird, 2016; Spengler, Bird, & Brass, 2010), whereby a blurring of the boundary between self and other seems responsible for increased imitation of the actions of others (but see Williams, Whiten, & Singh, 2004). In the general population, people sometimes make different risky decisions when the outcome of the decision affects oneself compared to another person. The current literature surrounding self-other differences in risky decision making has produced mixed findings; a number of studies have reported riskier decision-making for others compared to oneself (e.g., Agranov, Bisin, & Schotter, 2013; Chakravarty, Harrison, Haruvy, & Rutström, 2011), whilst some studies have demonstrated increased risk aversion when deciding for others (Bolton & Ockenfels, 2010; Olschewski, Dietsch, & Ludvig, 2019; Wang et al., 2018). Notably, Michael et al. (2019), the paper from which we adapted our paradigm, reported no differences. A meta-analysis conducted by Polman and Wu (2020) collated 128 effects from 71 studies, reporting a small but significant shift towards riskier decision-making when deciding for others compared to oneself. Such self-other differences in decision-making processes are likely to be reliant upon an adequate distinction between self and other representations. Therefore, self-other distinction differences in ASD may lead to comparable behaviour when deciding for the self and others in a risky decision-making task. As such, in the current paradigm we indexed risky decision-making for both oneself and others.

The current study compares autistic and non-autistic individuals on a risky decision-making task adapted from Michael et al. (2019). The paradigm uses a decision-from-experience method where outcomes of two choices are learned through sampling (Hertwig, Barron, Weber, & Erev, 2004; Michael et al., 2019). Compared to risky decision-making task designs in which the riskier choice is explicitly stated (decision-from-description; Tversky & Kahneman, 1981), the current

approach increases real-world applicability as risk is commonly encountered through experience in real-world decision-making. In addition to the social influence condition previously used in this paradigm, we incorporated a non-social influence condition, something which is often absent in studies of social influence. Both forms of influence were presented via tokens above each option in the decision-making task due to the potential confounding effect of overt social cues on the performance of autistic participants. Participants also completed an additional test of social cognition (Sowden, Schuster, Fraser, Keating, & Cook, in press) which enabled us to evidence a distinction between social and non-social influence. That is, we reasoned that a relationship between performance on this socio-cognitive task and social, but not non-social, influence would increase our confidence in the social-specificity of influence in the social condition. Finally, the decision-making paradigm adapted from Michael et al. (2019) enabled the assessment of potential difference in risky choice for self and others.

We hypothesised that social information would influence the decision-making process for the non-autistic group to a greater extent than the non-social information, but these influences would have a smaller/no impact on the autistic group. We further hypothesised that the strong influence level would have a greater impact than the weak influence level on participants risky decision-making behaviour. Finally, we proposed that the non-autistic group would choose more risky options for others as opposed to themselves, but that the autistic group would exhibit comparable findings for themselves and others. The hypotheses, sampling plan, methods, and pre-registered analyses are available online at: <https://osf.io/eg9w6/>.

Methods

Participants

A total of 20 autistic and 20 non-autistic participants were recruited from the Birmingham Psychology Autism Research Team database and Prolific. The study was approved by the STEM Ethics Committee at the University of Birmingham (ERN_16-0281AP9B) and was carried out in accordance with the principles of the revised Helsinki Declaration.

An *a priori* power analysis was calculated with G*power (Erdfelder, Faul, & Buchner, 1996) using data from Michael et al. (2019) which showed that individuals alter their risk preference based

on social information; with a Cohen's d effect size of 0.73 and .05 alpha level, it was determined that a minimum of 14 participants were required to achieve a power level of 0.80. However, due to insight from Button et al. (2013) who suggest that effect-size estimates are commonly inflated ("the winner's curse"), we deemed it necessary to increase the number of participants used in the current study in order to obtain adequate power. Thus, we increased our recruited sample size ($N = 20$ per group).

Procedure

Participants completed group-matching measures followed by the risky decision-making task, both of which were administered online via Qualtrics and Pavlovia respectively. The social cognition task had previously been administered to participants; the current study re-recruited a subset of participants used in the earlier study (Keating, Fraser, Sowden, & Cook, under review).

Group-matching measures.

Participants provided information on age and gender to ensure group matching, in addition to completing the Toronto Alexithymia Scale (TAS; Bagby, Taylor, & Parker, 1994) and the Matrix Reasoning Item bank (MaRs-IB; Chierchia et al., 2019), a measure of non-verbal reasoning (NVR) lasting 8 minutes. The Autism Quotient (AQ; Baron-Cohen, Hoekstra, Knickmeyer, & Wheelwright, 2006) was also completed to ensure that the autistic group were higher on autistic traits.

Risky decision-making task.

Participants were provided with comprehensive instructions, including example trials, the details of which are reported in the Supplementary Materials [S1]. The task was adapted from Michael et al. (2019), with the social and non-social influence manipulation adapted from Cook et al. (2019).

Figure 1 displays the structure of each trial in the task. During each trial of the risky decision-making task, participants first had the opportunity to sample 2 loot boxes each relating to a different risky gamble. The outcome of sampling each loot box was drawn from its assigned distribution of varying means and variances. The distributions associated with the less risky gambles had a mean between £2.00 and £4.00, randomly assigned on each trial, and a uniform pay-out range of $\pm$ £0.50 from that mean. The distribution associated with the riskier gamble had a mean pay-out that was £0.50 higher than the mean of the less risky distribution, but a larger range set at $\pm$ £2.50 from that

mean. Thus, a gamble with a higher mean and a higher variance was considered a riskier gamble than one with a relatively lower mean but a smaller variance. During this sampling phase, participants had 10 opportunities to sample the boxes, distributed across the boxes as they wished, to learn about the possible outcomes of each.

Following the sampling phase, participants proceeded to the decision phase in which they were asked to choose one of the two loot boxes. Prior to the decision, they were exposed to social or non-social influence in the form of tokens above each loot box, the proportions of which were manipulated across the trials. Participants were told that the social influence represented the proportion of previous participants who chose each loot box and that the non-social influence represented the outcome from a system of rigged roulette wheels. The extent of the social influence was manipulated by changing the proportion of the 20 tokens associated with each loot box. This was divided into strong (10% and 90%), weak (30% and 70%), and neutral (50%) influence. Percentages refer to the tokens above the riskier gamble; thus, there were trials in which the influence favoured the less risky decision (10% and 30%), the riskier decision (70% and 90%), and neither decision (50%).

Participants completed 4 blocks in a random order, each comprised of 25 trials. The 4 blocks were defined by pairwise combinations of influence type (social/non-social) and recipient (self/other). At the beginning of the two self-blocks, participants were told that they would receive a bonus determined by their average performance. Conversely, at the beginning of the two other-blocks, they were told that their bonus would be determined by the average performance of another participant on their other-trials, and that their performance in this block would determine the bonus for another participant. A fixed bonus of £5 was paid to participants regardless of performance on the task.

[INSERT FIGURE 1 HERE]

Within each block, a catch trial was completed in which there was a loot box that clearly dominated the other. Specifically, the samples for the dominant loot box were drawn from a uniform distribution between 5 and 6, and the samples for the non-dominant gamble were drawn from a uniform distribution between 0 and 1. In the decision phase, the dominant gamble was clearly favoured by the influence information (90% of tokens). Performance on these catch trials was used as

an attention check; as pre-registered, data were removed from blocks in which the participant failed the associated catch trial.

Social cognition task.

In this social cognition task (developed by Sowden et al. (in press); reported in full in Keating et al. (under review)), participants viewed 108 trials comprising point-light displays of three facial expressions (angry, happy and sad). For analyses reported in Keating et al. (under review) stimuli were manipulated in their speed (50%, 100%, 150%) and spatial extent (50%, 100%, 150%). Participants rated how angry, happy and sad each stimulus appeared.

Score Calculations

Group-matching measures.

Scores for the TAS were calculated as a sum of participants' responses, whereby some questions were reverse scored, with a maximum possible score of 100. Scores for the MaRs-IB (NVR) were calculated as the percentage of correct responses within 8 minutes. The AQ was scored as the sum of participants' responses, whereby some questions were reverse scored, with a maximum score of 50 reflecting the highest level of autistic traits.

Risky decision-making task.

Influence scores for both social and non-social forms of influence were calculated, representing the extent to which the information influenced the participant's choice. The proportion of risky choices made at the 50% social and non-social influence levels were taken as baseline risky decision-making for the social and non-social conditions respectively. Social and non-social influence scores were calculated for the remaining influence levels. Where influence levels favoured the riskier choice (70% and 90%), baseline decision-making was subtracted from the proportion of risky choices in these levels. Where influence levels favoured the less risky choice (10% and 30%), the proportion of risky choices in these levels were subtracted from baseline. Thus, positive and negative scores reflected a shift towards and away from the influence information respectively. Overall scores for social and non-social influence were also calculated as the average influence score across all conditions. *Risky decision-making proportion indices* for the two recipient conditions (self/other) were calculated as the proportion of risky choices made in the 50 trials of each condition.

Social cognition task.

For each stimulus video, accuracy scores were calculated as the rating for the correct emotion minus the mean of the two incorrect emotion ratings. We calculated an overall social cognition score for each participant by taking a mean of the accuracy scores for all stimulus videos.

Analyses

All analyses were conducted using JASP version 0.12. Data, analysis files and pre-registration are available online at <https://osf.io/eg9w6/>.

Bayesian analysis.

The frequentist analyses below were supplemented by additional Bayesian analyses to quantify the evidence in support of the null hypothesis that there is no relationship between the two variables. Bayes Factors (BF_{01}), which provide a ratio of the likelihood for the observed data under the null hypothesis compared to the alternative hypothesis (Dienes, 2016), were calculated. Values of greater than 10, 3-10 and 1-3 were taken as strong, moderate and anecdotal evidence for the null hypothesis respectively (Lee & Wagenmakers, 2014).

Group demographics.

Independent samples t-tests were employed to assess possible group differences in age, NVR, TAS and AQ. A chi-squared test assessed group differences in gender.

Self/other risky decision-making.

To compare the autistic and non-autistic groups on risky decision-making for self and other, a pre-registered 2x2 mixed-model ANOVA was conducted on the risky decision-making proportion indices with group (autistic/non-autistic) as a between-participants factor and recipient of the bonus (self/other) as a within-participants factor.

Influence scores.

To compare the autistic and non-autistic groups on social and non-social influence across different levels, a 2x2x2 mixed-model ANOVA was conducted on the influence scores. Group (autistic/non-autistic) was a between-participants factor, and influence type (social/non-social), direction of influence (less risky/riskier) and strength of influence (strong/weak) were within-participants factors. Whilst separate 2x2x2 ANOVAs for social and non-social data were pre-

registered, we have reported a combined ANOVA to show comparisons between the two forms of influence; the separate ANOVAs are reported in the Supplementary Materials [S2]. To test whether the effect of the influence significantly differs from zero, one-sample t-tests were employed to test each level of influence for all participants. In addition, the pre-registered approach of conducting one-sampled t-tests for autistic and non-autistic groups separately is reported in the Supplementary Materials [S3].

Sequential analysis.

To assess the impact of additional participants, sequential analyses were conducted for independent samples t-tests between autistic and non-autistic groups for both social influence and non-social influence scores. These analyses demonstrate the impact of each subsequent participant on the resultant BF_{01} factors, thus are able to depict a levelling off of change in the BF_{01} factors as more participants are added (Marsman & Wagenmakers, 2016).

Exploratory analysis of social cognition scores.

The social cognition scores served three purposes. First, they enabled us to verify that the autistic and non-autistic groups differed in terms of socio-cognitive function; an independent t-test was run on social cognition scores between groups. Second, they enabled us to assess whether autistic traits were associated with socio-cognitive function; and third, they enabled us to test whether social, but not non-social, influence was associated with socio-cognitive function - we reasoned that such a result would increase our confidence in the social-specificity of influence in the social condition. To make the latter two inferences, we carried out a regression model predicting social cognition scores with AQ (autistic traits), social and non-social influence scores.

Results

Group Demographics

Due to the removal of data from participants who failed catch trials, complete datasets from 17 autistic and 15 non-autistic participants remained. Descriptive statistics for each of these groups, in addition to group comparison statistics, are presented in Table 1. Participant ethnicity is reported in the Supplementary Materials [S4].

[INSERT TABLE 1 HERE]

Self/Other Risky Decision-Making

There were no reliable differences in self-other risky choice, as can be seen in Figure 2. A 2x2 ANOVA conducted on the risky decision-making proportion indices revealed no main effect of recipient ($F(1,30) = 0.99, p = .33$; $BF_{01} = 2.83$) nor group ($F(1,30) = 0.22, p = .64$; $BF_{01} = 2.12$), and no interaction effect between group and recipient ($F(1,30) = 1.42, p = .24$; $BF_{01} = 1.76$).

[INSERT FIGURE 2 HERE]

Influence Scores

The influence scores did not differ across groups, influence type (social vs non-social), nor strength of that influence. Figure 3 shows, however, that the influence towards less risky options was substantially more potent than towards risky options. A 2x2x2x2 ANOVA conducted on the influence scores confirmed no main effect of group ($F(1, 30) = 0.47, p = .50$; $BF_{01} = 3.84$), influence type ($F(1, 30) = 0.02, p = .90$; $BF_{01} = 7.15$) nor strength ($F(1, 30) = 1.78, p = .19$; $BF_{01} = 6.04$). A main effect of direction was found ($F(1, 30) = 7.10, p = .012$, $BF_{01} < 0.01$). No interaction effects between group and influence type ($F(1, 30) < 0.01, p = .99$; $BF_{01} = 4.70$), group and strength ($F(1, 30) = 0.07, p = .79$; $BF_{01} = 5.35$), nor group and direction ($F(1, 30) = 0.03, p = .86$; $BF_{01} = 5.5$) were found. Separate ANOVAs for both social and non-social influence scores are reported in the Supplementary Materials [S2].

The results of one-sample t-tests testing the deviation from zero of the effect of each level of influence are presented in Table 2. Wilcoxon statistics are reported where appropriate and BF_{01} values where applicable. The results reveal significant deviation from zero for conditions in which the direction is less risky. Separate one-sample t-tests for each group are reported in the Supplementary Materials [S3].

[INSERT FIGURE 3 HERE]

[INSERT TABLE 2 HERE]

Sequential Analysis

Figure 4 displays graphs for the sequential analyses of the independent samples t-tests between autistic and non-autistic groups for both social influence (left) and non-social influence scores (right). The change in BF_{01} factors is displayed as subsequent participants are added to the

analysis. We observe that, in both instances, the BF_{01} factor stabilizes just under 3 at around the 20th total participant.

[INSERT FIGURE 4 HERE]

Exploratory Analysis of Social Cognition Scores

An independent samples t-test demonstrated a significant difference in social cognition scores between the autistic and non-autistic groups ($t(30) = 3.07, p = .005$; Mann-Whitney = 192, $p = .014$, $BF_{01} = 0.108$). A regression model predicting social cognition scores with AQ, social and non-social influence scores accounted for 38.6% of the variance observed ($F = 7.49, p < .001$). AQ was a significant predictor (standardised $\beta = -0.56, t = -3.86, p < .001$), as well as social influence score (standardised $\beta = -0.51, t = -2.86, p = .008$). Non-social influence score was not a significant predictor (standardised $\beta < 0.01, t = 0.05, p = .96$). The significant predictors AQ and social influence scores were both significantly correlated with social cognition scores ($p < .05$; $BF_{01} < 1$); thus, these relationships did not depend on the presence of the other predictors in the model.

Discussion

The current study investigated the influence of social and non-social information on risky decision-making in autistic and non-autistic adults. The social and non-social information were represented conceptually, removing the potentially confounding effect of overt social cues. Firstly, no differences in self and other risky decision-making were found between autistic and non-autistic groups. In terms of influence on risky decision-making, we found no difference in the effect of influence based on group (autistic/non-autistic) or type of influence (social/non-social). Further, whilst no effect of the strength of the influence information was found, the direction of the influence did play a role in decision making: people were more likely to select the less risky option when the influence directed them in that direction.

Our results revealed that risky decision-making behaviour did not differ when deciding for oneself compared to others for either autistic or non-autistic adults. This is consistent with the findings of Michael et al. (2019), the paper from which our paradigm was adapted. Whilst this adds to the inconsistency within the self-other risky decision-making literature (e.g., Agranov et al., 2013; Bolton & Ockenfels, 2010; Chakravarty et al., 2011; Wang et al., 2018), the lack of main effect of

group within this analysis with anecdotal evidence supporting the null hypothesis ($BF_{01} = 2.12$) is useful for demonstrating comparable risky decision-making behaviour between autistic and non-autistic individuals.

The results of the influence analyses demonstrate no differences in decision-making between autistic and non-autistic individuals in the presence of social or non-social influence. Indeed, the observed BF_{01} factor of 3.84 for the main effect of group provides moderate evidence in favour of the null hypothesis that there was no difference between groups. A larger BF_{01} factor of 4.70 for the interaction effect between group and influence type demonstrates moderate evidence for similar trends of the effect of influence types within the two groups. We speculate that the lack of group differences is related to our conceptual representation of social and non-social information. Existing literature positing a difference in social influence has often relied on overt social cues to represent social influence (e.g., Izuma et al., 2011; Large et al., 2019). These cues may act as a confounding variable when attempting to observe the effect of social influence, due to differences in social attention and processing in ASD (e.g., Ashwin et al., 2006; Bird et al., 2006; Dawson et al., 2004; Klin et al., 2002; Lindner & Rosen, 2006; Swettenham et al., 1998). Thus, it is highly plausible that the removal of overtly social cues in our paradigm has led to comparable performance between the autistic and non-autistic groups. These findings add to existing literature demonstrating no differences in social influence when information is presented conceptually (Lazzaro et al., 2019; Wadhera & Kakkar, 2020). This growing body of evidence is important for understanding whether social influence *per se* is typical in ASD but can *appear* atypical if the social information is presented via overtly social cues. These results pave the way for further research investigating the potential confounding effect of overt social cues in ASD on aspects of social cognition beyond social influence, such as imitation.

The lack of group differences is unlikely to be due to limited power within this sample. Firstly, the current sample exhibited group differences in the social cognition task, along with a significant relationship between autistic traits and performance on a socio-cognitive task. This result demonstrates that, within this sample, there were observable group differences in ASD-related characteristics (specifically facial emotion recognition). Despite the limited sample size, the BF_{01}

factors in the influence ANOVA provide moderate or strong evidence in support of the null hypothesis. In addition, the sequential analysis of independent samples t-tests between autistic and non-autistic groups for both social influence and non-social influence scores shows a levelling of the BF_{01} factors (see Figure 3). This suggests that adding additional participants is unlikely to change the BF_{01} factors observed, and thus acts as evidence for the power of the study (Marsman & Wagenmakers, 2016). Finally, the pre-registered power analysis required 14 participants per group, a number which remained fulfilled after the removal of participants with incomplete data.

The influence analysis also failed to reveal a significant main effect of influence type, suggesting no difference between the effects of social and non-social influence. Indeed, moderate evidence was found in support of the null hypothesis ($BF_{01} = 7.15$). One interpretation is that the two distinct forms of influence had the same effect on risky decision-making. Alternatively, individuals may simply have failed to recognise the social and non-social information as distinct from one another. There are a number of reasons why we believe the social and non-social information were indeed recognised as distinct. Firstly, the paradigm used to describe social and non-social influence was adapted from Cook et al. (2019), in which separate relationships for two forms of influence were indeed observed. Clear instructions were provided to participants at the start of the task similar to those used by Cook et al. (2019) which described the difference between the forms of influence in depth (see Supplementary Materials [S1]). Perhaps more importantly, within the current dataset, there were different relationships for the two forms of influence with a socio-cognitive task. Performance on the social cognition task was significantly predicted by overall social influence score but not by overall non-social influence score. We therefore argue that social and non-social influence were recognised as distinct from one another, but their effects on the participants in both the autistic and non-autistic group were of comparable magnitude.

The influence analysis did reveal a significant main effect of direction, whereby significant influence was exerted by both social and non-social influence when advising participants to choose the less risky option. Thus, this paradigm may prove useful for the development of strategies for persuading individuals to choose less risky options in real-world settings such as insurance, healthcare, and gambling interventions. Further, no main effect of influence strength was found; a

significant influence effect was found when information was both ‘weak’ and ‘strong’ in advising the less risky option, and no difference between strength was seen when the information advised participants to choose the riskier option. This suggests that, within our paradigm, influence information was perceived as binary, whereby a majority of any strength was treated the same. This is consistent with the conformity literature where it has been suggested that, when influence is represented as a percentage, having over 50% support is sufficient to influence behaviour (Gardikiotis, Martin, & Hewstone, 2005; Martin, Gardikiotis, & Hewstone, 2002). These results suggest that the direction of sources of influence should be an important consideration in models of the decision-making process.

The current study investigated the effect of social and non-social influence on the risky decision-making behaviour of autistic and non-autistic individuals. We revealed evidence in favour of the null hypothesis that there are no differences between the performance of the two groups, demonstrating that autistic individuals did not treat the social and non-social influence information differently from non-autistic individuals, nor did they differ in their self-other risky-decision making. These comparable findings between autistic and non-autistic adults, combined with the validation of the distinct influence methods and potential for group differences with this sample, have implications for models of social influence in ASD. Specifically, this paradigm demonstrates that, when social influence information is represented conceptually, comparable influence is observed.

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Tables

Table 1

Descriptive statistics (M = mean, SD = standard deviation) for the autistic and non-autistic participant groups and group comparison statistics. Independent samples t-tests confirmed that the autistic and non-autistic participant groups did not differ on age, NVR or TAS, and that AQ was significantly higher in the autistic group. A chi-square test confirmed that the groups did not differ on gender (research in the socio-cognitive domain is not anticipated to differ between genders (Lai et al., 2012), so males and females were pooled). All participants in the ASD group had previously received diagnoses of ASD from independent clinicians. BF₀₁ factors are also reported, showing evidence for the null hypothesis.

Variable	Autistic group	Non-autistic group	Statistical comparison
Age	M = 33.3, SD = 10.4	M = 27.5, SD = 10.0	$t(30) = -1.60, p = .12, BF_{01} = 1.14$
Gender	9 female, 8 male, 0 other	6 female, 8 male, 1 other	$X^2 = 1.48, p = .48, BF_{01} = 1.88$
NVR	M = 59.9, SD = 17.2	M = 66.7, SD = 15.0	$t(30) = -1.18, p = .25, BF_{01} = 1.75$
TAS	M = 57.8, SD = 9.2	M = 57.4, SD = 14.7	$t(30) = -0.10, p = .92, BF_{01} = 2.96$
AQ	M = 34.1, SD = 8.5	M = 21.2, SD = 7.4	$t(30) = -4.51, p < .001, BF_{01} < 0.01$

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619

620 Table 2

621 *Test statistics and significance values for one-sample t-tests assessing the deviation from zero of the*
 622 *effect of each level of influence. BF_{01} factors are also reported, showing evidence for the null*
 623 *hypothesis.*

Influence Type	Direction	Strength	t-value	df	p-value	BF_{01}
Social	Less Risky	Weak	4.24 (Wilcoxon = 433)	31	<.001 (Wilcoxon < .001)	<0.01
		Strong	4.46	31	<.001	<0.01
	Riskier	Weak	1.79	31	.084	1.28
		Strong	1.68	31	.103	1.50
Non-social	Less Risky	Weak	4.13	31	<.001	<0.01
		Strong	5.51 (Wilcoxon = 469)	31	<.001 (Wilcoxon < .001)	<0.01
	Riskier	Weak	1.71	31	.098	1.45
		Strong	1.16	31	.254	2.86

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Figures

627

628 *Figure 1. The structure of a trial within the risky decision-making task. On each round, participants*

629 *first took 10 samples of two loot boxes, receiving feedback each time, before making a single final*

630 *choice. The external influence was introduced on the screen before the final choice.*

631

632 *Figure 2. Plots displaying the self and other risky decision-making scores for the autistic group and*

633 *non-autistic group. Data points for individual participants are displayed for each condition. The*

thick black horizontal lines represent the sample means, the surrounding boxes represent 1 standard error of the mean and the shaded regions represent 1 standard deviation. Higher scores indicate riskier decision-making, arising from a participant selecting the riskier option on a greater number of trials. The dashed line reflects a score of 0.5, arising from a participant selecting the riskier option on exactly half of the trials. No significant differences were found between autistic and non-autistic participant groups for self and other decision-making.

Figure 3. Plots displaying the influence score for all levels of influence across all participants, split by type of influence. Data points for individual participants are displayed for each condition. The thick black horizontal lines represent the sample means, the surrounding boxes represent 1 standard error of the mean and the shaded regions represent 1 standard deviation. The first two columns represent situations in which the influence favoured the less risky option, and the latter two columns represent situations in which the influence favoured the riskier option. Positive and negative scores reflect a shift towards and away from the influence information respectively. The dashed line indicates zero influence effect. It can be seen that influence towards less risky options had greater impact than towards risky options.

650

651 *Figure 4. Outcome from the sequential analyses for independent samples t-tests assessing the*
 652 *difference between the autistic and non-autistic groups for both social influence (left) and non-social*
 653 *influence scores (right). In both instances, the BF_{01} factor stabilizes just under 3 at around the 20th*
 654 *total participant.*