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Thinking, fast and slow on the autism spectrum

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Abstract

The Dual Process Theory of Autism proposes that autistic individuals demonstrate greater deliberative (slower) processing alongside reduced (faster) intuitive processing. This study manipulated the reasoning time available to investigate the extent to which deliberative and intuitive processing are sensitive to time context in autism. A total of 74 young autistic people and 132 control participants completed the Cognitive Reflection Test to measure intuition and deliberation, with responses being either speeded (fast condition) or delayed (slow condition). The autistic group produced more deliberative and less intuitive responses than controls overall. Both groups showed more intuitive responses in the fast condition and more deliberative responses in the slow condition, demonstrating the reasoning style in autism is sensitive to context.

Lay abstract

What is already known about the topic

Daniel Kahneman wrote a highly influential book titled 'thinking, fast and slow'. He proposes that people usually think in a rapid, automatic, intuitive style. When people realise their intuitive thinking may be wrong, a slower, effortful, deliberative style of thinking takes over. It has recently been proposed that thinking in autistic individuals can be characterised as usually thinking in the deliberative style (rather than the intuitive style that non-autistic people usually think in).

What this paper adds

As intuitive thinking is fast and deliberative thinking is slow, this research manipulated the time available to complete a series of reasoning questions. These questions have been developed to have intuitive answers (which are incorrect) and deliberative answers (which are correct). For the first time, a fast time manipulation (you must answer quickly) and slow (you must think about your answer before responding) was undertaken with autistic individuals. Autistic participants did produce more deliberative answers than the non-autistic participants. However, both groups produced comparably more intuitive answers and less deliberative answers in the fast condition. This shows that while autistic people tend not to use their intuition, autistic people can be encouraged to use their intuition.

Implications for practice, research or policy

Using rapid intuition can be useful in fast-changing contexts, such as some social situations. Future research can explore how to support autistic individuals to use their intuition when the need arises. In addition, the propensity for deliberation resulting in unbiased, correct responses reflects a strengths-based account of autism. This requires more mental effort and is less susceptible to bias and errors. This is called 'Dual Process Theory'.

Keywords

cognition (attention, learning, memory), deliberation, intuition, psychological theories of autism, reasoning, thinking

Introduction

When considering human reasoning and decision-making, Dual Process Theory has been a dominant model within cognitive psychology for over 50 years (Evans & Frankish, 2009). The dual processes are termed Type 1 and Type 2, and can be referred to as intuitive and deliberative

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processing (respectively). Intuitive processing involves rapid, effortless, parallel, non-conscious, implicit processing that is independent of working memory and cognitive ability. Deliberative processing, however, involves slower, effortful, sequential, conscious, explicit processing and is heavily dependent on working memory and related to individual differences in cognitive ability (see Evans, 2011, 2019; Evans & Stanovich, 2013; Kahneman, 2011; Stanovich & West, 2000, 2008 for reviews; see Bago & De Neys, 2017; Keren & Schul, 2009 for critique; see Kruglanski & Gigerenzer, 2011 for an alternative view; see Melnikoff & Bargh, 2018; Pennycook et al., 2018 for debate).

Within Dual Process Theory, rapid autonomous processes ('intuitive') are assumed to yield default responses unless intervened upon by distinctive higher order reasoning processes ('deliberative'). Intuitive processing preceding deliberative processing is known as the default-interventionist position, which proposes that reasoning and decision-making reflective of deliberative processing occur after intuitive processing has been undertaken and is rejected as a viable solution (see Evans, 2019; Evans & Stanovich, 2013; Kahneman, 2011). Travers et al. (2016), for example, used a methodology of monitoring computer mouse movements over multiple-choice answers to highlight that participants initially moved the mouse to (incorrect) intuitive response options before moving on to and clicking (correct) deliberative response options. Across a series of reasoning problems, Thompson et al. (2011) instructed participants to provide an initial, intuitive response to the problem along with an assessment of the 'feeling of rightness' for that answer. Participants were then allowed as much time as needed to reconsider their initial answer and provide a final answer. Thompson et al. found that a low 'feeling of rightness' was associated with longer rethinking times and an increased probability of answer change. These findings are consistent with the dual interventionist position of an intuitive response being provided initially, unless over-ridden by a deliberative response due to an awareness that the intuitive response may be erroneous.

Dual Process Theory has been applied to autism to provide a strengths-based account of differences in cognition. Autism spectrum disorder (ASD) is characterised by differences in social communication and interaction as well as patterns of restricted and repetitive behaviours, interests and activities, and is diagnosed in around four times as many males as females (American Psychiatric Association [APA], 2013; World Health Organization [WHO], 2018). The Dual Process Theory of Autism (Ashwin & Brosnan, 2019; Brosnan & Ashwin, 2022; Brosnan et al., 2016, 2017; Lewton et al., 2019) proposes that autistic individuals and those high in autistic traits engage in deliberative processing to a greater degree and intuitive processing to a lesser degree than neurotypical peers. From this view, deliberation and reduced intuition in decision-making by autistic individuals can be characterised as a disruption to the default-interventionist position. Evidence for this comes from reasoning tasks, such as the Cognitive Refection Test (CRT) or syllogistic reasoning. On these tasks, autistic individuals consistently provide more correct deliberative responses compared to neurotypical comparisons, who provide more intuitive responses (Frederick, 2005). For example, for the CRT item 'A bat and ball together cost £1.10. If the bat costs £1 more than the ball, how much does the ball cost?', an intuitive response is considered to be 10p (given by most neurotypical groups, Frederick, 2005), whereas the correct deliberative response is 5p (given by most autism groups, Brosnan et al., 2016, 2017).

Similarly, specific advantage is shown on incongruous syllogistic reasoning tasks but not congruous syllogistic reasoning tasks. Syllogistic reasoning tasks typically require participants to identify if a conclusion logically follows from two premises. When the syllogisms are congruous with the real world (All birds have feathers. Robins are birds. Therefore: Robins have feathers), reasoning success is predicted by cognitive ability (such as non-verbal intelligence quotient (IQ)). However, when the syllogisms are incongruous with the real world (e.g. All mammals walk. Whales are mammals. Therefore: Whales walk), reasoning success is predicted by higher autistic traits (Lewton et al., 2019; see also Handley et al., 2011). Autistic traits are argued to be normally distributed across the general population in a dimensional manner, and autistic individuals possess higher levels of autistic traits than those without a diagnosis of autism (Baron-Cohen et al., 2001; Kanne et al., 2012; Ruzich et al., 2015). Within the general population, males typically report higher levels of autistic traits than females, with no sex differences within the autistic population (Baron-Cohen et al., 2001; Kanne et al., 2012; Ruzich et al., 2015).

The proposal from the Dual Process Theory of Autism that autism is characterised by greater deliberative processing and diminished intuitive process is consistent with self-reports of autistic individuals having difficulty making decisions quickly (Luke et al., 2012) as well as experimental studies demonstrating autistic individuals reason in a more logically consistent manner (De Martino et al., 2008; Farmer et al., 2017; Fujino et al., 2019; Shah et al., 2016) and have a 'circumspect reasoning bias' (Brosnan et al., 2014; see also Lu et al., 2019; Vella et al., 2018 for similar findings and Jänsch and Hare (2014) for an opposite finding). Enhanced performance on these tasks is attributable to autistic participants and those with higher levels of autistic traits engaging in (slow) deliberative processing, rather than reflecting normative biases associated with (fast) intuitive processing (see Kahneman, 2011). There are potential overlaps between autistic individuals biasing towards deliberative processing and away from

Table 1. Demographic variables for autism and control groups.

Group	Autism	Control	Statistical test
Sex (male/female)	51/20	77/55	$\chi^2(1) = 3.61$, $p = 0.057$
Age (mean, SD)	17.69 (1.01)	17.37 (1.26)	$t(201) = 1.92$, $p = 0.056$
SATQ (mean, SD)	38.61 (10.32)	23.72 (7.89)	$t(121.40^a) = 10.76$, $p < 0.001$

SATQ: Sub Autistic Trait Questionnaire.
[a]Equal variances not assumed.

intuitive processing with a tendency for 'systemising' in autism (Baron-Cohen et al., 2003), which is a drive to analyse and construct 'if-then' rules and can underpin relative autistic strengths (Baron-Cohen, 2020; see also Crespi, 2021).

Many questions remain concerning the underlying mechanisms related to the reasoning differences in autism. One possibility is that the mechanisms for intuitive processing are impaired in autism, resulting in deliberation being the default and dominant form of reasoning. If the intuitive mechanisms are impaired, this would lead to pervasive deficits in any processing requiring rapid and unconscious processing across different domains and functioning, such that even if an autistic individual tried to utilise intuitive processing, they would have difficulties in doing so. An alternative possibility is that the mechanisms for intuitive processing are intact, but that autistic individuals do not typically or spontaneously utilise this specific style of reasoning, or that the information processing style in autism does not involve or require intuitive processing (Ashwin & Brosnan, 2019; Brosnan & Ashwin, 2022).

Taken together, the literature indicates that, while neurotypical individuals demonstrate a bias for fast intuitive processing unless over-ridden by deliberative processing, autistic individuals demonstrate a bias for slower deliberative processing over rapid intuitive processing. The central role of processing time (fast versus slow) on intuitive and deliberative processing is highlighted by studies demonstrating enhanced intuitive responses when participants are forced to respond rapidly, and enhanced deliberative responses when participants are forced to respond after a time delay (Evans & Curtis-Holmes, 2005). This malleability of reasoning in response to timing manipulations has been demonstrated in the neurotypical population, and this study explored whether time restrictions encouraged intuitive processing and time delays encouraged deliberative processing for autistic individuals. We hypothesised that if intuitive processing was impaired in autism (hypo-intuition idea), the degree of intuitive responses given by the autistic group would not change based on restrictions in processing time during the reasoning task, or might change less than the control group. If, however, intuitive processing was intact but was dominated by an over-reliance on deliberative processing in autism (hyper-deliberation idea), then the number of intuitive responses would change based on imposing restrictions of processing time in the reasoning task, designed to preference intuitive processing.

Method

Participants

A total of 206 participants were recruited for the study, who were all attendees at various summer schools held for students thinking of attending university. A total of 74 autistic participants were recruited from a summer school for students with a diagnosis of autism. To attend the summer school, students had to present a copy of their autism diagnosis which was screened by trained autism clinicians. The diagnoses were all identified as undertaken by professionals adhering to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM; APA, 2013) or the *International Classification of Diseases* (ICD; WHO, 2018) criteria. All participants also completed the Sub Autistic Trait Questionnaire (SATQ; Kanne et al., 2012) as a measure of autistic traits. The autistic group comprised of 51 males, 20 females and three 'non-binary/trans' genders with a mean age of 17.69 years (standard deviation (SD) = 1.01). A total of 132 participants were recruited from attendees at a general summer school, and who self-reported no neurodevelopmental conditions and were the control group. The control group comprised of 77 males and 55 females and had a mean age of 17.37 years (SD = 1.26). The male:female ratio and age did not significantly differ between the two groups (see Table 1).

Measures

To confirm the autism group were higher in autistic traits than the control group, participants completed the SATQ (Kanne et al., 2012). This is a 24-item self-report questionnaire with four possible responses. Participants were told 'For each item, please use the scale below to rate the extent to which it describes you on most days, there are no right or wrong answers. Please answer all of the items the best that you can'. They respond on a 4-point Likert-type scale with 0 = false, not at all true, 1 = slightly true, 2 = mainly true and 3 = very true. The SATQ items were drawn together through exploratory then confirmatory factor analyses of items from four widely used dimensional measures of autistic traits (the Social Communication Questionnaire (SCQ), Berument et al., 1999; the Broader Autism Phenotype Questionnaire (BAPQ), Hurley et al., 2007; the Social Reciprocity Scale (SRS), Constantino et al., 2000; and the Autism-Spectrum Quotient (AQ), Baron-Cohen et al., 2001) using both autism and non-autism samples. The Cronbach's alpha coefficient is 0.73, and the test–retest reliability is 0.79. Kanne et al. report a

general mean of 23.1 and an autism mean of 40.8 and correlations for both groups of the SATQ with the AQ and BAPQ of 0.7–0.8. The SATQ mean for the autism group was 40.8 (SD = 13.6) and the control group was 23.1 (SD = 7.1).

Reasoning was assessed using the Cognitive Reflection Test (CRT; Frederick, 2005). The CRT consists of three questions which were preceded by a practice question to ensure the timing instructions had been understood. Reponses could be Intuitive, or Deliberative, and the CRT has been used in previous autism research (Brosnan et al., 2016, 2017). Scores for Intuitive and Deliberative can range from 0 to 3 and are yoked in the sense that if an intuitive answer is provided for a question, a deliberative answer cannot be provided. The CRT is not purely ipsative, however, as it also possible to make random errors.

Experimental manipulation

Participants were randomly assigned by the computer into the fast or slow condition for the CRT reasoning. Participants were presented with the CRT question and a countdown timer from 20 s. Participants were told they had 5 s to read the question, and then the countdown timer would start. In the fast condition, participants were told they had to answer as fast as possible before the countdown timer reached zero. In the slow condition, participants were told they had to think about the answer, and could only respond after the countdown timer had reached zero (after Evans & Curtis-Holmes, 2005). Although timing data were not accurate enough for analysis of response times (see section 'Procedure'), a pilot study was initially undertaken as an experimental check to confirm that responses were significantly faster in the fast condition compared to the slow condition (i.e. 20 s). A total of 29 participants, which included 11 participants from the autism group and 18 participants from the control group, underwent the fast condition with response latencies recorded. The mean response time for all three CRT questions for the autism group was 4.89 s (SD = 4.09) and was 4.65 s (SD = 2.86) for the control group. The difference between the groups was not statistically significant ($t(27) = 0.85$, $p = 0.854$), both groups averaging just under 5 s to answer each CRT question in the fast condition. The times were combined for the groups to compare the time in the fast condition to the deliberation time in the slow condition (20 s). Results using a one-sample *t*-test showed that the mean time taken for the combined pilot sample in the fast condition (mean (M) = 4.74; SD = 3.31) was significantly less than the mean deliberation time of 20 s for the CRT questions in the slow condition ($t(28) = 24.82$, $p < 0.001$).

Procedure

All assessments were completed on desktop computers accessing Qualtrics software. The summer schools all used the same computers and room and ran the same measures and task, with the same experimenter running the testing sessions. Ethical approval was obtained from the Psychology Research Ethics Committee.

Analysis

A repeated measures analysis of covariance (ANCOVA) was conducted with the total responses to the CRT (total intuitive and total deliberative) as the repeated measure dependent variable (DV). A repeated measures analysis was employed as the intuitive responses to the CRT are yoked to the deliberative responses (such that if an intuitive response is given, a deliberative response cannot be given), although they are not ipsative as errors can also be made. For example, there are three questions and the CRT may provide a score of 3-0 for a participant providing all intuitive responses and no deliberative responses or 1-1 for a participant who provided one intuitive and one deliberative response (as well as one error). The number of intuitive and deliberative responses negatively correlated with each other $r = -0.84$ in the slow condition and $r = -0.66$ in the fast condition. Therefore, one repeated measures ANCOVA was run with CRT score (intuitive total and deliberative total) as the repeated DV measure. Group (autism/control) and Condition (fast/slow) were the between group IV factors. Although not significantly different between groups in this study, age and gender were covariates as previous research has identified differences related to these variables (such as numbers diagnosed with autism and autistic traits, see section 'Introduction'). The analyses were conducted using SPSS version 26, and the statistical assumption for the analyses was met.

Community involvement

There was no community involvement in the reported study.

Results

For autistic traits, the SATQ scores are reported in Table 1 and highlight the autism group had significantly higher levels than the control group. This was consistent with the published means for both groups (Kanne et al., 2012), and there was a significant difference between the groups with a large effect size (Cohen's $d = 1.64$). Table 2 highlights the means for the autism and control groups totals on the CRT. The fast condition had 38 (26 males, 68%) participants on the autism spectrum and 67 (36 males, 54%) control participants, and the slow condition had 36 (25 males, 74%) participants on the autism spectrum and 65 (41 males, 63%) control participants. The male:female ratio did not significantly differ between the groups for the fast

Table 2. Mean values (and standard deviations) for the autism and control groups on the Cognitive Reflection Test (which has intuitive, deliberative and error responses).

Condition	Fast		Slow	
Group	Autism	Control	Autism	Control
Intuitive	1.34 (0.94)	1.88 (0.91)	0.86 (1.15)	1.54 (1.06)
Deliberative	1.03 (1.10)	0.52 (0.70)	1.75 (1.27)	0.98 (1.10)
Errors	0.63 (0.79)	0.60 (0.76)	0.39 (0.73)	0.48 (0.64)

condition ($\chi^2(1)=2.71$, $p=0.10$) or the slow condition $\chi^2(1)=1.10$, $p=0.30$). The SATQ scores did not differ for the autistic participants in the fast and slow conditions (37.68 (9.39) vs 39.58 (11.27), respectively, $t(72)=0.7$, $p=0.43$) nor the control participants in the fast and slow conditions (23.81 (8.59) vs 23.65 (7.16), respectively, $t(130)=0.12$, $p=0.91$).

Wilks' Lambda indicated that the ANCOVA model was significant for Group ($F(1, 200)=17.68$, $p<0.001$, $\eta_p^2=0.081$); the autism group made significantly fewer intuitive and more deliberative responses than the control group. Condition was also significant ($F(1, 200)=12.76$, $p<0.001$, $\eta_p^2=0.060$), with significantly more intuitive/fewer deliberative responses made in the fast condition compared to the slow condition. This result highlighted the time manipulation was effective. However, the interaction between Group and Condition was not significant ($F(1, 200)=0.57$, $p=0.303$), and there were no significant effects of the covariates of age ($F(1, 200)=2.17$, $p=0.068$, nor gender ($F(1, 200)=1.65$, $p=0.204$). Figure 1(a) illustrates how the autism group provided fewer intuitive responses than the control group, and both groups were comparably affected by the fast/slow manipulation. Figure 1(b) illustrates the same pattern for deliberative responses. There were no group differences in the total number of random errors made by the autism and control groups (M = 0.51 (SD = 0.76) and M = 0.54 (SD = 0.70), respectively; $t(204)=0.23$, $p=0.390$).

Finally, to explore the relationship between autism and autistic traits with intuition and deliberation, two partial correlations were conducted, first controlling for condition (fast/slow) as well as gender and age. The correlation between autistic traits and intuition was negative and significant ($r(201)=-0.23$, $p=0.001$), and the correlation between autistic traits and deliberation was positive and significant ($r(201)=0.31$, $p<0.001$). Second, the partial correlation was rerun with the addition of controlling for group (autism/control). The negative correlation between autistic traits and intuition was rendered non-significant ($r(200)=-0.09$, $p=0.20$) and the positive correlation between autistic traits and deliberation retained significance ($r(200)=0.18$, $p=0.01$).

Discussion

This study sought to identify the impact of manipulating fast and slow processing times upon the intuitive and deliberative reasoning responses on the CRT of autistic individuals compared to neurotypical controls. Consistent with the Dual Process Theory of Autism, autistic participants were more deliberative/less intuitive compared to neurotypical peers. The findings also confirmed the experimental manipulation of processing time was effective, with more intuitive responses provided during the fast condition and more deliberative responses provided during the slow condition. Importantly, this modification in reasoning responses was found for both the autistic and control groups, indicating that the impact of the temporal manipulation upon intuitive and deliberative processing was comparable for autistic and control groups. This is the first study to show that, while intuitive responses are reduced in autism, they are susceptible to manipulation in a comparable way to neurotypical peers. These findings are consistent with interpretations about intuitive processing in autism being relatively intact and available but dominated by an over-reliance upon deliberative processing (hyper-deliberation idea). Deliberative processing was similarly susceptible to manipulation, encouraged by enforced time delay for both groups.

The first main finding of a bias towards greater deliberative processing in the autistic group is consistent with the Dual Process Theory of Autism (Ashwin & Brosnan, 2019; Brosnan & Ashwin, 2022; Brosnan et al., 2016, 2017; Lewton et al., 2019). The capacity to deliberate is a core component of rationality (Stanovich & West, 2008; Stanovich, 2011), and there is potentially a vast array of environments within which an orientation towards deliberative processing would be positive. The higher levels of deliberation in autism can therefore inform a strengths-based approach to developing academic interests and skills in Science, Technology, Engineering, Arts and Mathematics, as well as effective job matching for employees on the autism spectrum (see Black et al., 2020; Lee et al., 2020). Environments that highlight the explicit nature of what to expect within that context, and that provide suitable time to meet any expectations, would facilitate deliberative processing and be beneficial for autistic individuals. As with many workplace/study space adjustments, these adjustments may prove to be universally beneficial. Greater deliberation may also come with risks of 'information overload' actually making some decisions more effortful resulting in mental exhaustion or freezing (see Luke et al., 2012).

The second main finding of reduced intuitive responding is also consistent with the Dual Process Theory of Autism (Ashwin & Brosnan, 2019; Brosnan & Ashwin, 2022; Brosnan et al., 2016, 2017; Lewton et al., 2019), showing that autism is characterised by under-utilisation

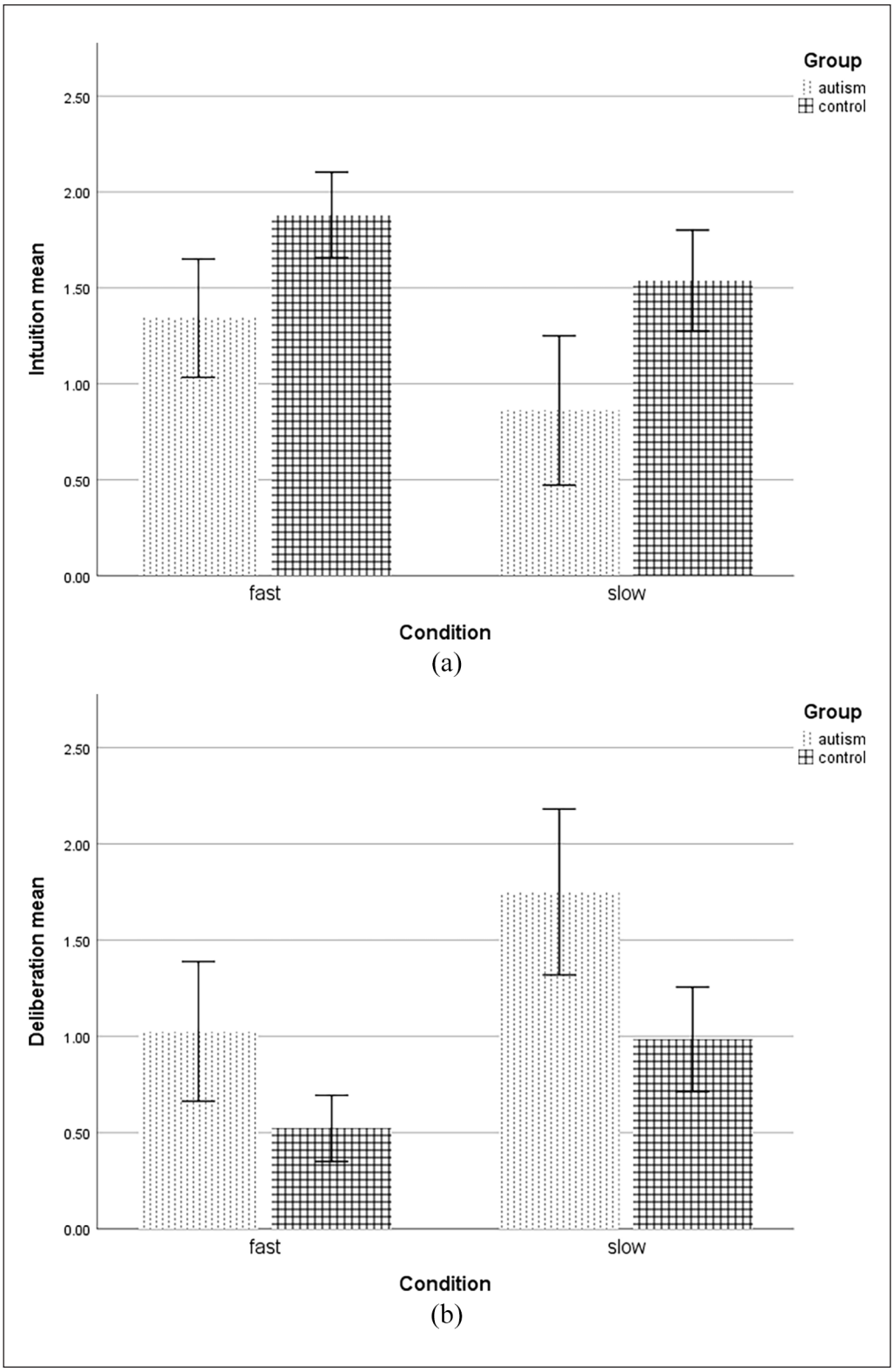

Figure 1. (a) Intuition by condition (fast/slow) and group (autism/ control), with 95% confidence interval error bars. (b) Deliberation by condition (fast/ slow) and group (autism/ control), with 95% confidence interval error bars.

of rapid, effortless, parallel, non-conscious, implicit processing (see Evans, 2011, 2019; Evans & Stanovich, 2013; Kahneman, 2011; Stanovich & West, 2000, 2008). However, this study extends the theory and

previous findings by revealing that intuitive responding in the autistic group was amenable to time-based manipulation in a comparable way to the control group. The fast manipulation condition increased intuitive responses compared to deliberative responses, and the slow condition increased deliberative responses compared to intuitive responses, an effect found for both the autistic and control groups. This study is consistent with previous research for neurotypical groups (Evans & Curtis-Holmes, 2005), and extends findings for the first time about the malleability of intuitive/deliberative processing due to a context of time constraints to autism. Within the Dual Process Theory of Autism, these findings would suggest that the default-interventionist position is typically suppressed in autism during reasoning, rather than being inaccessible.

There are potential parallels with other theoretical accounts of autism. Navon (1977) argues that for the general population, context-driven global perception precedes detail-driven local perception and the term 'global precedence' means attending more to global details than local details. Weak Central Coherence Theory (Frith, 1989; Happé & Frith, 2006) proposes that autism is characterised by greater attention to processing local detail than initial context-driven or global processing typical of neurotypical perception (or a lack of global precedence, see Jolliffe & Baron-Cohen, 1997; Mottron & Belleville, 1993; see also the enhanced perceptual functioning model: Mottron & Burack, 2001; Mottron et al., 2006). Vermeulen (2015) characterises autism as 'context blindness', highlighting evidence that context is less attended to during a wide variety of cognitive tasks including reasoning and decision-making. There are parallels therefore between these accounts and dual process theories, if initial (intuitive) context-driven global processing typically precedes subsequent (deliberative) detail-driven local processing – differences in global (intuitive) precedence characterising autism. A monotropic model proposes that differences in autism are driven by interests of the autistic mind. Within the model, attention is a resource which is competed for by task demands, and there is no reason to expect a bias of detail-driven local processing over context-driven global processing, rather a hyper attentional focus on the aspect of the task being attended to (Murray et al., 2005). Thus, within this model, rather than a general global precedence, global processing in autism can be idiosyncratic, based upon the interest of the individual (see Milton, 2012).

While the autistic group consistently produced fewer intuitive/more deliberative responses compared to the control group, there were 'medium' effect sizes for malleability in this reasoning bias in response to time available for the autistic group. The finding that intuitive responding was increased in the autistic group when time was limited in the task shows that greater reliance on intuitive mechanisms is possible in autism, suggesting that certain contexts or cues may be useful for autistic individuals to help facilitate intuitive processing in relevant situations. To some degree at least, it may be the case that just as the neurotypical pattern is to bias towards intuitive processing until task demands require deliberative processing, autistic individuals may have flexibility to overcome a bias towards deliberative processing when task demands require intuitive processing. Identifying the task demands that encourage autistic individuals to engage in intuitive processing is central to the generalisability of these findings. Plaisted et al. (1999) found that while autistic children tended to demonstrate a local precedence on a visual task, they also demonstrated the neurotypical global precedence when explicitly told to attend to the global level. This suggests that context-driven global processing can be undertaken when it is the focus of autistic people's attention, consistent with the monotropism model. Should individuals on the autism spectrum wish to address 'context blindness' (Vermeulen, 2015) by engaging in context-driven global processing, explicitly cueing may be beneficial and this study suggests explicit cueing concerning processing time limitations may serve as an effective cue.

Rapid responding is a task demand for many social situations that autistic individuals can find challenging. For example, an autistic advocate reflected 'One either is quick enough to keep up, or one is weird and socially disabled' (Darius, 2002, p. 25). This is consistent with a review of social cognitive differences in autism, suggesting that many of the difficulties characteristic of autism can be identified as difficulties with implicit processing (Happé et al., 2017). The malleability demonstrated by both groups in intuitive and deliberative processing was in response to explicit cues regarding time constraints in a laboratory setting. However, in real-world reasoning contexts, autistic individuals might not spontaneously utilise their intuitive processing in situations where neurotypical peers do utilise their intuition. Future research can explore how to cue intuitive processing in more real-world contexts. The social context is of particular relevance, and other research has reported reduced spontaneous use of cues in social contexts in autism, such as for gaze processing (Leekam et al., 1997, 1998; Nation & Penny, 2008) and for theory of mind (Senju, 2012, 2013).

Recent research has also suggested that autistic individuals utilise a 'secondary route' that is cognitively taxing in an attempt to 'compensate' in social situations. This compensation involves non-social instead of social cognitive processes being utilised in social situations (Livingston et al., 2019). Compensation can be along the lines of 'make appropriate eye contact, even if it is not useful for communication and/or is aversive' or 'predict likelihood of what someone is thinking/feeling based on logic, the context or experience of how that person has previously behaved' (Livingston et al., 2020). Thus, future research can explore both the extent to which such compensation reflects deliberative processing as well as the extent to

which intuitive processing can be cued to support spontaneous social processing in autism in real-world contexts. If explicit time-restricted contexts can be used to encourage intuitive processing in autistic individuals, the underlying mechanisms of any behavioural similarities to neurotypical peers will need further investigation. As Happé et al. (2017) note, factors that determine learning speed (such as social attention, social reward and social learning ability) may produce associations if intuitive processes are learned over development or produce dissociations if intuitive processes rely on dedicated domain-specific modules.

It may be that differences in intuitive processes are what distinguishes autistic individuals from individuals high in autistic traits (without a diagnosis). This study found that whether or not controlling for autism diagnostic status (autism/control), higher levels of autistic traits significantly related to higher deliberation scores. The negative relationship between higher levels of autistic traits and lower intuition scores, however, was only significant when not controlling for diagnostic status. This suggests the positive relationship between higher levels of autistic traits and a preference for deliberation is relatively independent of diagnostic status, whereas a relatively reduced preference for intuitive processing in those higher in autistic traits may be dependent on diagnostic status. Clearly such a suggestion is speculative, warranting further investigation of intuitive processes in autism. For example, as Pennycook et al. (2016) note for the CRT, as the intuitive and deliberative responses are yoked, lower intuition score may be driven by higher deliberation scores. Pennycook et al. therefore suggest that the CRT may measure intuitive *preference* rather than intuitive *ability* (see also McPhetres, 2018).

Testing was done in group sessions in this study which was not amenable to timing data, so timing to index about intuitive versus deliberative processing was not suitable. Given that intuitive and deliberative responses are characterised by rapid and slower processing (respectively), it could be hypothesised that there would be associated differences in response time data related to cognitive processing. However, given the array of additional processes involved in the task (including perceptual, motor, etc.), tightly controlled experimental conditions would be required to use response time data to support the contention that intuitive or deliberative processing was being employed. Krajbich et al. (2015) highlight the potential for circularity if deliberative processing is inferred from longer response times and longer response times are taken to infer deliberative processing. Krajbich et al. (2015) argue that response time increases can better be accounted for when participants are presented options that are harder to discriminate between (e.g. strength-of-preference or discriminability between choice options). In response, Pennycook et al. (2016b) argue that rather it is the detection of conflict with an initial intuitive response that causes deliberative processing and consequent increases in response time. In addition, during repeated measures assessments, response times can be affected by the success of previous responses (Spiliopoulos, 2018). Evans and Stanovich (2013) have claimed that speed and accuracy are correlated but not central factors in what determines the distinction between intuitive and deliberative processing. The interferences about dual processing that can be drawn from response times are therefore open to debate (see De Boeck & Jeon, 2019, for an overview). In addition, Bago and De Neys (2017) speculate that people have different types of rapid intuitions, including 'logical intuition', that is rapid intuitions which are logically accurate. Future research can explore whether individuals on the autism spectrum produce logically accurate responses more rapidly and effortlessly than non-autistic individuals. Combined with the present findings of a bias away from intuitive responses and towards deliberative responses in this study (see also Ashwin & Brosnan, 2019; Brosnan & Ashwin, 2022; Brosnan et al., 2016, 2017), future research can explore the possibility of autism being characterised by rapid, effortless 'non-social' processing and slow, deliberative 'social' processing (opposite to the neurotypical pattern).

There are some limitations to this study to be noted. The intuitive and deliberative responses are yoked together (i.e. you could not give both responses); however, they are not ipsative because errors can also be made in the task which are neither intuitive nor deliberative. It is of note that general errors were not significantly different between the groups within the analyses, which is pertinent as the intuitive response to the CRT questions is actually an erroneous response (see Pennycook et al., 2016). However, the finding of this study relates to the specific response that was pre-specified based on previously published research as being intuitive, and not as errors more generally. Other limitations include that the CRT is a brief measure of three items, and we also did not assess previous exposure, although the CRT is consistent with a wide array of other assessments of deliberation and stable across time and multiple exposures (Meyer et al., 2018; Stagnaro et al., 2018; Toplak et al., 2011). Bialek and Pennycook (2018) found that the predictive power of the CRT was not undermined by repeated exposure.

Another limitation is that all the participants were relatively academically able as they were considering going to university, and cognitive ability was not explicitly assessed in this study. A deliberative bias is dissociable from cognitive ability and enhanced performance on the CRT is attributable to a deliberative bias rather than cognitive ability (such as non-verbal IQ; Brosnan et al., 2017; Pennycook & Ross, 2016; Toplak et al., 2011, 2014). Brosnan et al. (2017), for example, found a deliberative reasoning bias in an autistic group when controlling for cognitive ability. However, the CRT is a reasoning task

that requires both literacy and numeracy skills (see Pennycook & Ross, 2016) and alternative assessments may need to be developed to explore the wider autism spectrum, including those with a co-occurring intellectual disability. It may be the case that more implicit methodologies, such as eye-tracking (see Farmer et al., 2021), can contribute to the debate regarding how and when intuitive/deliberative processing is undertaken by individuals on the wider autism spectrum. In addition, a range of other dispositions may be relevant and were not assessed in this study and may limit generalisability. For example, self-reports of 'Faith in Intuition', 'Need for Cognition', 'open minded thinking' and 'superstitious thinking' as well as religious beliefs and political ideology have all been found to be correlates of the CRT (Pennycook et al., 2016; Stagnaro et al., 2018; Toplak et al., 2014).

In conclusion, consistent with the Dual process Theory of Autism, the autism group produced more deliberative responses, and the control group more intuitive responses, on the CRT. This study highlights for the first time that intuitive and deliberative processing in autism is malleable based on time constraints, comparable to the malleability demonstrated by the control group.

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