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E-S and dual process

Is Empathizing intuitive and Systemizing deliberative?

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### Is Empathizing intuitive and Systemizing deliberative?

**Abstract:** This is the first study to explore the relationship between Empathizing-Systemizing (E-S) theory that provides an account of sex differences in human cognition and dual process theories of cognition. 68 undergraduates undertook both performance and self-report assessments of Empathizing, intuition, Systemizing and deliberation. A fast (500ms) and slow (5000ms) version of the Reading the Mind in the Eyes Task (RMET) was included to explore the effects of rapid presentation on emotional stimuli. Consistent with E-S theory, sex differences were found in Empathizing (favouring females) and Systemizing (favouring males). Females were also found to be more intuitive and males more deliberative for performance, but not self-report, assessments of intuition and deliberation. Empathizing significantly positively correlated with intuition and negatively with deliberation. Conversely, Systemizing significantly positively correlated with deliberation and negatively with intuition (trend). This pattern was replicated in a study of 65 participants from the general population. The exception was the RMET which had no significant sex differences or correlates (fast or slow). The implications for considering both dual process theories of cognition and E-S theory are discussed, with a focus upon the implications for Autism Spectrum Disorder and psychosis.

#### Highlights:

- Sex differences were identified in Empathizing and intuition favouring females.
- Sex differences were identified in Systemizing and deliberation favouring males.
- Empathizing was related to intuition and Systemizing was related to deliberation.
- Differences between self-report and performance measures were identified.

**Keywords:** Empathizing, Systemizing, E-S theory, intuition, deliberation, dual process theory.

## 1. Introduction

Empathizing-Systemizing (E-S) theory proposes that individual differences in cognition and emotion processing can be classified along these two dimensions and that human sex differences can largely be explained by variation in mean levels of Empathizing (favouring females) and Systemizing (favouring males; Baron-Cohen, 2002; 2003; 2009). Empathizing relates to social processing and has been defined as the drive to identify and understand the thoughts and feelings of others and to respond to these with appropriate emotions (Baron-Cohen, 2002; 2003; 2009). Empathizing allows for the understanding of human behaviour that often does not conform to highly predictable rules. Empathizing has been conceived of a multidimensional construct comprising of different but related components of cognitive (e.g. perspective taking) and affective (e.g. empathic concern) empathy (Blair, 2005; Davis, 1983). Self-report assessments of Empathizing (the Empathizing Quotient) are argued to assess both cognitive and affective empathy, upon which females typically report higher levels of Empathizing than males (Baron-Cohen & Wheelwright, 2004; Wakabayashi et al., 2006). Behavioural assessments of cognitive empathy (the Reading the Mind in the Eyes Test) also typically demonstrate a female advantage (Baron-Cohen et al., 2001a). Systemizing, on the other hand, relates to non-social processing and has been defined as the drive to analyse or build systems (Baron-Cohen, 2002; 2003; 2009). Systemizing allows one to predict the behaviour of a system and to control it. Self-report assessments of Systemizing (the Systemizing Quotient) and behavioural assessments (the Intuitive Physics Test) typically demonstrate a male advantage (Baron-Cohen et al., 2001b; 2003; Wakabayashi et al., 2006). Empathizing and Systemizing are hypothesised to be normally distributed across the population with males characteristically having relatively greater Systemizing relative to Empathizing abilities and females characteristically having greater Empathizing relative to Systemizing abilities. In terms of mapping onto wider personality constructs, Empathizing has been found to significantly correlate with Agreeableness from the 'Big 5' (Costa and McCrae, 1992), though Systemizing has no correlates (Nettle, 2007). Whilst the general population vary along these two continua, extreme Systemizing relative to Empathizing and extreme

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Empathizing relative to Systemizing have been argued to have clinical implications, characterising Autism Spectrum Disorders (ASD) and psychosis respectively (Baron-Cohen, 2002; Brosnan et al., 2010; see Crespi and Badcock, 2008).

This is pertinent as in ASD, for example, it has been suggested that Systemizing strengths can compensate for Empathizing deficits (Rutherford and MacIntosh, 2007; Walsh et al., 2013). These authors provide evidence consistent with the hypothesis that those with ASD use explicit Systemizing strategies ('corners of mouth turned down, lowered eyebrows = sad') rather than the rapid Empathizing abilities typically used during emotion recognition tasks. The application of either Systemizing or Empathizing abilities to tasks potentially has parallels with dual process theories of human cognition. 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; Evans and Stanovich, 2013; Kahneman, 2011; Stanovich and West, 2000; 2008 for reviews). Rapid autonomous processes ('intuitive') are assumed to yield default responses unless intervened on by distinctive higher order reasoning processes ('deliberative'; Evans and Stanovich, 2013). Empathizing has been argued to be a rapid, automatic process requiring no effortful attention in the typical population whereas Systemizing has been argued to be a slower more deliberative process (e.g. Brosnan et al., 2014; Stone et al., 1998). Rapidly jumping to conclusions, for example, has been associated with higher levels of Empathizing and lower levels of Systemizing (Brosnan et al., 2013).

The potential relationship between Empathizing and intuition is most likely related to the emotion recognition component of empathy. Kahneman (2011: 19), for example, proposes that emotion recognition is an inherently intuitive process. Clark et al. (2008) argue the ability to rapidly and automatically extract emotional information feeds 'downstream' empathy processes and related social-emotional functioning. A number of studies have explored emotion recognition in both

typically developing and ASD populations with limited stimuli exposure time. For example, Tracy et al. (2011) argue that under rapid time constraints, deliberative strategies such as Systemizing would fail (i.e. result in a lower emotion recognition) and would result in greater response times. The authors found that participants (ASD and typically developing) tended to show higher levels of emotion recognition accuracy when they responded more quickly. As such studies assess reaction time, typically a 2-choice decision is made (e.g. whether the target emotion is present or not). Rump et al. (2009) presented stimuli for 500ms after which participants were asked to select which emotion they had seen from a forced-choice of four options (or 'none'). The authors found decreased performance in all (ASD and typically developing) child and adolescent participants relative to an untimed pre-test. This was also the case in adult participants, although, unlike the younger participants, the adults with ASD underperformed relative to typically developing adults.

Despite potential similarities between a rapid, automatic, non-effortful Empathizing and intuition, no research to date has empirically explored this relationship, nor the relationship between Systemizing and deliberation. Sex differences indicating females registering as more intuitive and males registering as more deliberative have been reported for performance but not self-report, measures (e.g. Epstein et al., 1996; Frederick, 2005). This is the first study to explore both self-report and performance-based measures of Empathizing and Systemizing as well as intuition and deliberation. Given the potential significance of timing, the present study adjusted the performance measure of Empathizing to fast and slow presentations. Finally, to explore if a general impulsivity related to rapid responding, an index of impulsivity was also taken.

## 2. Methods

### 2.1 Participants

Participants were 68 undergraduate psychology students, 25 of whom were male. Participants were aged 17-24 years old (mean=18.5, s.d.=1.0). Participants undertook the assessments described

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below as part of a course requirement. All but one participant were native English speakers, and this one participant had an excellent level of English (International English Language Testing System level 7). The research was approved by the Departmental Ethics Committee which implements the ethical guidelines of the British Psychological Society.

## 2.2 Materials and methods

The following computer-based assessments were undertaken in a random order.

### 2.2.1 Intuition and deliberation

2.2.1.1 The Rational-Experiential Inventory (REI: Epstein et al., 1996) is the most widely used self-report assessment of intuition and deliberation. The short version contains 10 items, equally divided between intuitive and deliberative subscales. Respondents score each item on a 5-point scale, from 1 = completely false to 5 = completely true. Scores range from 5 indicating a low ability/engagement through to 25 indicating a high ability/engagement for each thinking style.

2.2.1.2 The Cognitive Reflection Task (CRT: Frederick, 2005) is a widely used 3-item performance measure of intuition and deliberation. Each question has a potentially intuitive and deliberative answer, as well as the potential for wrong answers. Scores can therefore range from 0-3 for each subscale. (Note, the intuitive response is a wrong answer).

### 2.2.2 Empathizing and Systemizing

The short form of the Empathizing-Quotient (EQ: Wakabayashi et al., 2006) is a self-report questionnaire assessing Empathizing. This is a 22 item scale, scored zero for (strongly or slightly) disagreeing, one for slightly agreeing and two for strongly agreeing with items (some items are reversed). Potential scores ranged from 0 to 44. The short form of the Systemizing-Quotient (SQ: Wakabayashi et al., 2006) is a self-report questionnaire assessing Systemizing. This is a 25 item scale scored in the same way as the EQ, with potential scores ranging from 0 to 50.

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2.2.2.1 The Reading the Mind in the Eyes Test (RMET: Baron-Cohen et al., 2001) is a widely used performance measure of Empathizing. The original format of the RMET presents a rectangle image containing the eye region of a face. A series of 36 images are presented, each surrounded with four emotion-related terms, one of which correctly characterised the expressed emotion. The task therefore requires the attribution of the relevant mental state to the image of the eyes but does not require any inferring of the content of the mental state (e.g. why they may be experiencing that mental state) nor an emotional response. The RMET therefore has been used to assess cognitive rather than affective empathy (e.g. van Honk et al., 2013). The RMET was adjusted so that the images were presented in 2 blocks of 18 images: fast and slow. Following Rump et al., the fast stimuli were presented for 500ms and then removed as the 4 response options immediately appeared. The slow stimuli were presented in exactly the same manner but for 5000ms each. The order of the blocks was randomised as was the images that went into the fast and slow blocks. Timing of responses was initiated as the response options appeared and terminated when the response was made by clicking the chosen emotion with the mouse. To ensure participants could process images at 500ms, 4 practice trials of geometric shapes were presented. Participants identified which geometric shape had appeared from a forced choice of 4. As with the original RMET, there was then a single (5000ms) practice trial with eyes stimuli.

2.2.2.2 An automated version of the Group Embedded Figures Test (GEFT) was used to assess Systemizing, which has been validated against the traditional paper-based GEFT (Brosnan et al., 2012; Falter et al., 2008). Efficient performance indicates diminished global processing, reflective of greater Systemizing (Baron-Cohen et al., 2009). Participants first undertook 2 practice trials to ensure they understood the task, then completed 18 experimental trials. In each trial they decided which of 2 simple target figures were embedded within a more complex figure. Once participants responded, the outline of the target appeared in the display with the feedback 'correct' or 'wrong' written at the bottom of the screen. One point was scored for each correctly identified simple figure, so scores ranged from 0 to 18.



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2.3.2.3 A rapid 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 participants were told that beads would be drawn one at a time from one of the jars (with replacement). 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. This was done to a maximum of 20 beads in total. The key dependent variable measured was the number of beads requested before making a decision. 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. Brosnan et al. (2014) report a correlation of .53 ( $p < .001$ ) between the number of beads drawn and a self-report index of Systemizing. See Brosnan et al. (2013) for more details about the task procedures.

## 2.2.3 Impulsivity

The Barratt Impulsivity Scale (BIS-11; Patton et al., 1995) is considered the most widely used and well-validated scale of trait impulsivity. The BIS-11 is a 30-item self-report questionnaire that attempts to ascertain impulsive and non-impulsive behaviours. Participants can score each item from 1 = never/rarely, 2 = occasionally, 3 = often, 4 = almost always/always. Scores potentially range from 30 to 120.

## 3. Statistical analysis

Given the potential multiple comparisons that could be made, the analysis was restricted to examining the relationships between E-S theory and dual process variables. Partial correlations were conducted, controlling for gender and age. We hypothesised that Empathizing and intuition would

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positive correlate with each other as would Systemizing and deliberative thinking. The independence of these two domains was investigated by exploring negative correlations between Empathizing with deliberation and Systemizing with intuition. Independent t-tests were conducted to report any gender differences and repeated measures t-tests were conducted for exploring differences between the fast and slow RMET conditions. Timing data was analysed, noting that many factors may influence this variable.

## 4. Results

The means for males and females for the E-S and dual process variables are reported in Table 1.

*Table 1: Demographic Information (Mean and Standard Deviation) for Males and Females.*

	Males	Females	t value
EQ	24.21(10.12)	29.93(6.14)	t=2.52*
RMET-fast	12.48(2.12)	12.98(2.15)	t=0.92
RMET-slow	12.88(1.99)	13.71(2.23)	t=1.54
SQ	21.08(11.05)	10.79(5.87)	t=4.32***
GEFT	12.76(2.54)	12.37(2.15)	t=0.64
Beads	10.72(7.14)	5.74(4.16)	t=3.18**
REI-intuition	18.48(2.93)	18.37(2.89)	t=0.15
REI-deliberation	19.08(3.67)	18.49(3.70)	t=0.64
CRT-intuition	1.08(1.10)	1.62(0.99)	t=2.04*
CRT-deliberation	1.42(1.10)	0.83(1.08)	t=2.10*
Impulsivity	64.35(10.18)	64.07(9.47)	t=0.11

Note. \* p<.05, \*\*p<.01, \*\*\*p<.001

Females were significantly higher than males on the EQ and CRT-intuition, and males significantly higher than females on the SQ and CRT-deliberation in addition to requesting significantly more beads before making a decision. The relationships between the performance and self-report dual process variables (intuition and deliberation) with the E-S variables (Empathizing and Systemizing) are presented in Table 2.

Table 2. Correlations Between the Variables of E-S Theory and Dual Process Theories of Cognition.

Dual process variables:	Empathizing			Systemizing		
	EQ	RMET-fast	RMET-slow	SQ	GEFT	Beads
REI- intuition	.33**	-.20	.06	-.19 <sup>+</sup>	-.30**	-.28*
REI- deliberation	-.12	-.12	.07	.57***	.01	-.18
CRT – intuition	.28*	-.03	.04	-.18 <sup>+</sup>	-.23*	-.13
CRT – deliberation	-.32**	.14	.07	.21 <sup>+</sup>	.39**	.27*

Note. <sup>+</sup> p<.1, \* p<.05, \*\*p<.01, \*\*\*p<.001

df=60, controlling for age and gender.

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Table 2 highlights that overall self-report and performance measures of intuition and deliberation correlated in the predicted direction with self-report and performance measures from E-S theory. Specifically, Self-report and performance intuition correlated positively with the EQ and negatively with the SQ ( $p < .1$ ), GEFT and the beads task. Self-reported deliberation correlated significantly positively with SQ and performance deliberation with SQ ( $p < .1$ ), GEFT and the beads task and negatively with EQ.

The most noticeable exception to this pattern was the RMET measure. This measure had been developed to present stimuli either rapidly (500ms) or slowly (5000ms). A within groups t-test identified that significantly more emotions were identified correctly in the slow compared to the fast condition (means were 12.79 and 13.40 respectively,  $t(66)=2.13$ ,  $p=.037$ , two-tailed). Timing data indicated that more time was spent before responding in the slow compared to the fast condition (5062ms vs. 3733ms,  $t(66)=2.0$ ,  $p=.05$ , two-tailed). Note: timing commenced when the image disappeared. Finally, the BIS-11 total correlated significantly with REI-deliberation ( $r(60)= -.33$ ,  $p=.008$ , 2-tailed) but no other variables (all  $p > .05$ ).

### 4.1 Follow up study with full REI

As this was the first study to report a relationship between Empathizing with intuition and Systemizing and deliberation, this was replicated with the full 40-item REI rather than the 10-item short version (Epstein et al., 1996). 65 adults (31 males and 34 females, mean age 26.5 years,  $s.d.=10.7$ ) from the general population were recruited via email and digital bulletin boards to participate in an online survey. Participants completed the EQ and SQ, as described above and the REI as described above (except for 40 item version – mean divided by four to be comparable to short version). Females self-reported a trend for higher levels of Empathizing but not intuition compared to males (means ( $s.d.$ ) = 21.67(5.77) vs 19.65(5.28);  $t(63)=1.46$ ,  $p=.07$ ; 21.86(4.46) vs 21.03(3.31);  $t(63)=0.84$ , ns; respectively). Males self-reported higher levels of Systemizing and a trend for higher deliberation compared to females (means ( $s.d.$ ) = 22.81(5.21) vs 20.50(4.41);  $t(63)=1.93$ ,  $p < .05$ ;

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20.97(1.99) vs 20.27(1.63);  $t(63)=1.55$ ,  $p=.06$ ; respectively). Partial correlations controlling for gender replicated a significant correlation between Empathizing and intuition ( $r=.54$ ,  $p<.001$ ) but not deliberation ( $r=-.01$ , ns) and between Systemizing and deliberation ( $r=.21$ ,  $p<.05$ ) but not intuition ( $r=-.06$ , ns).

## 5. Discussion

Combining variables from both E-S theory and dual process theory of human cognition identified females registering higher levels of both Empathizing and performance-related intuitive cognition, whilst males registered higher levels of both Systemizing and performance-related deliberative cognition. There were no sex differences in self-reported intuition and deliberation. Controlling for gender, higher levels of Empathizing correlated with greater intuition and higher levels of Systemizing correlated with greater deliberation. This is the first study to demonstrate a significant relationship between Empathizing and intuition as well as Systemizing and deliberation. Taken together, these relationships were in evidence for both self-report and performance data. Correlational analysis is not causal but does suggest that dual process theories of cognition overlap with E-S theory.

The CRT task is argued to assess intuition as a prepotent intuitive response needs to be over-ridden for a deliberative response to be considered (Frederick, 2005). The CRT intuition and deliberation responses are yoked, in that providing an intuitive response necessitates a deliberative response cannot be provided which is not the case with the self-report measures. This discrepancy may explain why sex differences were identified in performance but not self-report measures of intuition and deliberation. Consistent with both original sets of research, the present study found sex differences in self-reported Empathizing and Systemizing but not self-reported intuition and

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deliberation (Epstein et al., 2006; Wakabayashi et al., 2006). Thus despite the significant correlations between Empathizing with intuition and Systemizing with deliberation, self-report methodologies vary in the extent to which sex differences are reported. Self-report methodologies may assess deliberative self-reflection upon intuitive abilities, whereas the performance measure of intuition is indicative of deliberation not having occurred.

This interaction of deliberative reflection upon intuition is of potential importance for sex differences research as dual process theories argue that much individual differences research focusses upon differences within Type 2 (deliberative) processing. A fuller account of individual differences would be provided by incorporating assessments of the qualitatively distinct form of Type 1 processing (i.e. both intuitive and deliberative, or 'Type 1' and 'Type 2' respectively, Evans and Stanovich, 2013). Future research can address the extent to which sex differences are characterised by differences within Type 2 processing or differences between Type 1 and Type 2 processing (or an interaction of these, as individual differences in Type 2 processes can determine the probability that a Type 1 response will be expressed, see Evans and Stanovich, 2013). Consistent with this, the present study found some negative relationships between intuition (Type 1) and Systemizing (Type 2) - for both self-report and performance measures. This would suggest that the drive for the Systemizer to 'intuitively' Systemize (e.g. Baron-Cohen, 2003: 3), is distinct from the intuition characterised by Type 1 processing (as assessed by the CRT and REI).

The relationship between Empathizing and intuition is consistent with proposals that basic emotion recognition is an intuitive (Type 1) process. However with the RMET task, greater stimulus presentation time resulted in significantly greater response time (noting that many variables can affect response time) and emotion recognition accuracy. This is consistent with what would be expected for deliberative strategies such as Systemizing being employed for the task (e.g. Rutherford and MacIntosh, 2007; Tracy et al., 2011; Walsh et al., 2013). This may be a feature of the RMET requiring the processing of more complex emotions with four potential answers, compared to

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whether a basic emotion is present in the stimuli or not. To explore this, a fast and slow version of the RMET was developed and the lack of any relationships with the RMET was unexpected. The rapid methodology matched that of Rump et al. but it may be that 500ms is long enough to allow for deliberative Systemizing strategies to impinge upon intuitive strategies (see Clark et al., 2008).

As ASD is conceptualised as extreme Systemizing relative to Empathizing (Baron-Cohen, 2002; 2003; 2009), predictions can be made for future research regarding those with ASD demonstrating relatively enhanced performance upon deliberative relative to intuitive tasks. Some authors have speculated that ASD may be characterised by enhanced deliberation relative to intuition (Allman et al., 2005; Brosnan et al., 2013; De Martino et al., 2008). Conversely psychosis has been associated with greater Empathizing relative to reduced Systemizing and a rapid jumping to conclusions in the beads task (Brosnan et al., 2010; 2013). In the present study, the beads task correlated positively with one measure of intuition and negatively with one measure of deliberation. Consistent with Crespi and Badcock's (2008) autism-psychosis model, contrasting intuition and deliberation biases may be salient avenue of future research for both these clinical conditions.

Finally, significant correlates with impulsivity were largely absent, suggesting that E-S variables may be related to dual process variables specifically, rather than a general tendency to respond impulsively. The study is limited by its constrained samples and measures used, which needs to be borne in mind. The RMET, for example, is argued to assess cognitive, rather than affective, aspects of Empathizing. No significant sex differences were identified in RMET, though they were evident in the EQ which assesses both cognitive and affective Empathizing. As noted above, this may be related to differences in methodology (behavioural vs. self-report) or that sex differences are located within affective Empathizing. This is of interest for future research as ASD is argued to be characterised by an extension of sex differences, but research has suggested that those with ASD have deficits in cognitive, but not affective, empathy (Rogers et al., 2007; Dziobek et al., 2008). There are also important variations within dual process theories and constructs such as intuition may also prove to



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be multi-faceted (see Evans and Stanovich, 2013). In conclusion, assessments of Empathizing related to assessments of intuition and assessments of Systemizing related to assessments of deliberation.

These overlaps provide a framework for characterising sex differences within the typical population.

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References:

Allman, J.M., Watson, K.K., Tetreault, N.A. and Hakeem, A.Y. (2005) Intuition and autism: a possible role for Von Economo neurons. *Trends in Cognitive Sciences*, 9, 367-373.

Baron-Cohen, S. (2002) The extreme male brain theory of autism. *Trends in Cognitive Science*, 6, 248-254.

Baron-Cohen, S. (2003). *The essential difference: Men, women and the extreme male brain*. London: Penguin

Baron-Cohen, S. (2009) Autism: The Empathizing–Systemizing (E-S) Theory. *Annals of the New York Academy of Sciences*, 1156, 68–80.

Baron-Cohen, S., Ashwin, E., Ashwin, C., Tavassoli, T. and Chakrabarti, B. (2009) Talent in autism: hyper-systemizing, hyper-attention to detail and sensory hypersensitivity. *Philosophical Transactions of the Royal Society B*, 364, 1522, 1377-1383.

Baron-Cohen, S., Richler, J., Bisarya, D., Gurunathan, N., & Wheelwright, S. (2003). The systemizing quotient: An investigation of adults with Asperger syndrome or high-functioning autism, and normal sex differences. *Philosophical Transactions of the Royal Society of London: Series B-Biological Sciences*, 358, 361–374.

Baron-Cohen, S. and Wheelwright, S. (2004). The empathy quotient: An investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, 34, 163–175.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y. and Plumb, I. (2001a) The “reading the mind in the eyes” test revised version: a study with normal adults, and adults with asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, 42, 241-251.

E-S and dual process

Baron-Cohen, S., Wheelwright, S., Scahill, V., Lawson, J. and Spong, A. (2001b) Are intuitive physics and intuitive psychology independent? A test with children with Asperger Syndrome. *Journal of Developmental and Learning Disorders*, 5, 47-78.

Blair, R.J. (2005) Responding to the emotions of others: Dissociating forms of empathy through the study of typical and psychiatric populations. *Consciousness & Cognition*, 14, 698–718.

Brosnan, M., Ashwin, C. and Gamble, T. (2013) Greater Empathizing and reduced Systemizing in people who show a jumping-to-conclusions bias in the general population: Implications for psychosis. *Psychosis: Psychological, Social and Integrative Approaches*, 5, 71-81.

Brosnan, M., Chapman, E. and Ashwin, C. (2014) Adolescents with Autism Spectrum Disorder show a circumspect reasoning bias rather than 'jumping-to-conclusions'. *Journal of Autism and Developmental Disorders*, 44, 513-520.

Brosnan, M., Ashwin, C., Walker, I., and Donaghue, J. (2010) Can an 'Extreme Female Brain' be characterised in terms of psychosis? *Personality and Individual Differences*, 49, 738-742.

Brosnan, M., Gwilliam, L. R. and Walker, I. (2012) Brief report: the relationship between visual acuity, the embedded figures test and systemizing in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 42, 2491-2497.

Clark, T. F., Winkielman, P., and McIntosh, D. N. (2008) Autism and the extraction of emotion from briefly presented facial expressions: Stumbling at the first step of empathy. *Emotion*, 8, 803–809.

Costa, P.T. and McCrae, R. (1992). *Manual of revised NEO personality inventory (NEO-PR-I)*. Odessa, FL: Psychological Assessment Resources.

Crespi, B. and Badcock, C. (2008) Psychosis and autism as diametrical disorders of the social brain. *Behavioral and Brain Sciences*, 31, 241-261; discussion 261-320.

E-S and dual process

Davis, M. H. (1983) Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, 44, 113–126.

De Martino, B., Harrison, N.A., Knafo, S., Bird, G., and Dolan, R.J. (2008) Explaining enhanced logical consistency during decision-making in autism. *Journal of Neuroscience*, 28, 10746–10750.

Dziobek, I., Rogers, K., Fleck, S., Bahnemann, M., Heekeren, H.R., Wolf, O.T. and Convit, A. (2008) Dissociation of cognitive and emotional empathy in adults with Asperger syndrome using the Multifaceted Empathy Test (MET). *Journal of Autism and Developmental Disorders*, 38, 464-473.

Epstein, S., Pacini, R., Denes-Raj, V., and Heier, H. (1996) Individual differences in Intuitive-Experiential and Analytical-Rational Thinking Styles. *Journal of Personality and Social Psychology*, 71, 390-405.

Evans, J. ST.B.T. (2008) Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, 59, 255–278.

Evans, J. ST.B.T. and Stanovich, K.E. (2013) Dual-Process Theories of Higher Cognition: Advancing the Debate. *Perspectives on Psychological Science*, 8, 223 –241.

Falter, C.M., Plaisted, K.C. & Davis, G. (2008) Visuo-spatial Processing in Autism: Testing the Predictions of Extreme Male Brain Theory. *Journal of Autism and Developmental Disorders*, 38, 507-515.

Frederick, S. (2005) Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19, 25-42.

Kahneman, D. (2011) *Thinking, fast and slow*. New York, NY: Farrar, Straus and Giroux.

Nettle, D. (2007) Empathizing and systemizing: What are they, and what do they contribute to our understanding of psychological sex differences? *British Journal of Psychology*, 98, 237–255.

E-S and dual process

Patton, J.H., Stanford, M.S., and Barratt, E.S. (1995) Factor structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology*, 51, 768–774.

Rogers, K., Dziobek, I., Hassenstab, J., Wolf, O. T. and Convit, A. (2007). Who cares? Revisiting empathy in Asperger syndrome. *Journal of Autism and Developmental Disorders*, 37, 709–715.

Rump, K.M., Giovannelli, J.L., Minshew, N.J. and Strauss, M.S. (2009) The development of emotion recognition in individuals with autism. *Child Development*, 80, 1434–1447.

Rutherford, M.D. and McIntosh, D.N. (2007) Rules versus prototype matching: Strategies of perception of emotional facial expressions in the autism spectrum. *Journal of Autism and Developmental Disorders*, 37, 187–196.

Stanovich, K.E. and West, R.F. (2000) Individual differences in reasoning: Implications for the rationality debate. *Behavioral and Brain Sciences*, 23, 645–726.

Stanovich, K.E. and West, R.F. (2008) On the relative independence of thinking biases and cognitive ability. *Journal of Personality and Social Psychology*, 94, 672–695.

Stone, V.E., Baron-Cohen, S. and Knight, R.T. (1998) Frontal Lobe Contributions to Theory of Mind. *Journal of Cognitive Neuroscience*, 10, 640–656.

Tracy, J.L., Robins, R.W., Schriber, R.A. and Solomon, M. (2011) Is Emotion Recognition Impaired in Individuals with Autism Spectrum Disorders? *Journal of Autism and Developmental Disorders*, 41, 102–109.

van Honk, J., Schutter, D.J., Bos, P.A., Kruijt, A., Lentjes, E.G. and Baron-Cohen, S. (2013) Testosterone administration impairs cognitive empathy in women depending on second-to-fourth digit ratio. *PNAS* 108 (8): 3448.

E-S and dual process

Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., Goldenfeld, N., Delaney, J., Fine, D. and Weil, L. (2006) Development of short forms of the Empathy Quotient (EQ-Short) and the Systemizing Quotient (SQ-Short). *Personality and Individual Differences*, 41, 929-940.

Walsh, J.A., Vida, M.D. and Rutherford, M.D. (2013) Strategies for Perceiving Facial Expressions in Adults with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*. (online first).