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Are the Autism and Positive Schizotypy Spectra Diametrically Opposed in Empathizing and Systemizing?

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Abstract Crespi and Badcock's (Behaviour Brain Sci 31: 241–261, 2008) novel theory, which presents autism and positive schizophrenia as diametrical opposites on a cognitive continuum, has received mixed support in the literature to date. The current study aimed to further assess the validity of this theory by investigating predictions in relation to empathizing and systemizing. Specifically, it is predicted by Crespi and Badcock that while mild autistic traits should be associated with a cognitive profile of superior mechanistic cognition (which overlaps with systemizing) but reduced mentalistic cognition (which overlaps with empathizing), positive schizotypy traits should be associated with the opposite profile of superior mentalistic but reduced mechanistic cognition. These predictions were tested in a student sample using a battery of self-report and behavioural measures. The pattern of results obtained provides no support for Crespi and Badcock's theory.

Keywords Autism · Schizotypy · Empathy · Systemizing · Cognitive profile

Introduction

Crespi and Badcock's (2008) theory, which presents the symptoms of autism (e.g., social impairment, communication difficulties, and restricted interests) and positive schizophrenia (e.g., magical ideation, unusual perceptual experiences, and paranoia) as diametrical opposites, has attracted the attention of researchers from a diverse array of backgrounds. While some studies have provided compelling support for Crespi and Badcock's position (e.g., Brosnan et al. 2010; Del Giudice et al. 2010; Russell-Smith et al. 2010), others have cast significant doubt upon it (e.g., Cheung et al. 2010; Russell-Smith et al. 2011). With investigation of the theory continuing, the current study assesses the validity of the claims these authors make in relation to mentalistic and mechanistic cognition, parallel cognitive systems which Crespi and Badcock propose to be contrastingly affected in the two disorders. Specifically, these authors suggest that mentalistic cognition, which overlaps with empathy (i.e., the capacity to understand others and care about how they feel; Baron-Cohen 2002), is underdeveloped in autism but overdeveloped in positive schizophrenia. In contrast, it is suggested that mechanistic cognition, which overlaps with systemizing (i.e., the drive to understand, predict, control and construct rule-based systems; Baron-Cohen 2002), is overdeveloped in autism but underdeveloped in positive schizophrenia.

With their claims largely embedded in genetic and evolutionary theory, Crespi and Badcock (2008) argue that the general diametric opposition of autism and positive schizophrenia is the result, in part, of an association between autistic traits and an imbalance toward paternally expressed genes (which promote a general pattern of overgrowth), versus an association between positive schizophrenia traits and an imbalance toward maternally expressed genes (which promote undergrowth). Specifically, with regard to the claims made in relation to empathizing and systemizing, Crespi and Badcock predict that integrated social brain systems (which comprise brain regions including the amygdala, orbitofrontal cortex, anterior congulate cortex, medial prefrontal cortex, and the mirror-neuron systems) are

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disrupted in diametrically opposite ways in autistic- and psychotic-spectrum conditions. For example, Crespi and Badcock suggest that the imbalance towards paternally-expressed genes in autism is argued to contribute to an enlarged (and therefore, over-activated) amygdala in individuals affected by the disorder (Crespi & Badcock, p. 248; for supporting evidence see Howard et al. 2000; Sparks et al. 2002; but see Aylward et al. 1999; Pierce et al. 2001). Due to the role of the amygdala in emotion processing, particularly in attention to and interpretation of social cues such as gaze and facial expression, the (proposed) hyperactivation of the amygdala is said to make experiencing social cues uncomfortable for some individuals with autism, and thus avoided. As these cues provide much of the emotional information which makes empathizing possible, avoiding these cues is argued to restrict the ability of those with autism to empathize (Crespi & Badcock, p. 252; see also Markram et al. 2007). In contrast, Crespi and Badcock note that some studies have reported smaller (and underactivated) amygdala for individuals with positive schizophrenia (e.g., Kosaka et al. 2002; but see Velakoulis et al. 2006), as well as abnormal over-responsiveness in attentional orienting to gaze (see Langdon et al. 2006b). This hyperactivation to gaze is proposed to lead to an over-attribution of mental states and intentions to others, which is implicated in the paranoia and delusions experienced by individuals with positive schizophrenia (Crespi and Badcock, p. 253; see also Langdon et al. 2006a, b). While these traits are thus dysfunctional when present at a clinical level, Crespi and Badcock suggest that individuals with milder levels of these traits (i.e., positive schizotypy individuals) may be better at detecting subtle social cues, and thus display a superior ability to attribute mental states and intentions to others, compared to individuals with low levels of these traits. These authors also cite studies which provide evidence of a larger hippocampus in individuals with autistic traits versus a smaller hippocampus in individuals with positive schizophrenia (e.g., Johnson 2005; Schumann et al. 2004), to partially explain why the upper end of the autism dimension is predicted to be associated with enhanced visual-spatial and mechanistic aspects of cognition (including systemizing), while these aspects of cognition are predicted to be diminished in the upper end of the positive schizophrenia dimension.

The cognitive profile that Crespi and Badcock (2008) predict in relation to the autism spectrum has been identified in numerous previous studies, with higher levels of autistic traits commonly linked to superior systemizing and/or reduced empathizing (e.g., Baron-Cohen et al. 2003; Baron-Cohen and Wheelwright 2004; Baron-Cohen et al. 2001c; Focquaert et al. 2007; Ozonoff et al. 1990; but see Voracek and Dressler 2006). Moreover, the proposed profile is consistent with that predicted by Baron-Cohen's (2002) "extreme male brain" theory of autism. Specifically, this theory states that, as a result of excessively high levels of prenatal testosterone, individuals with autism display an exaggerated form of the pattern seen in typical males where systemizing is more highly developed than empathizing. According to this theory, females generally display the opposite cognitive profile, showing a greater capacity for empathizing over systemizing. Consistent with Crespi and Badcock's claims, Baron-Cohen's theory implies that an "extreme female brain", a counterpart to autism, also exists where individuals would display an excessive capacity for empathizing but show deficits in their ability to systemize. Interestingly, Crespi and Badcock state that a brain that develops under a relatively strong influence of paternally-expressed genes would appear anatomically and cognitively similar to Baron-Cohen's (2002) "male brain", while a brain that develops under the influence of maternally-expressed genes would appear similar to a "female brain". Therefore, while differing in what they propose drives this profile, both theoretical approaches are in agreement about the cognitive profile present in individuals with an autism spectrum diagnosis or with high levels of autistic-like traits.

Further support for Crespi and Badcock's (2008) position comes from the results of the only existing study to directly test the validity of their claims in relation to empathizing and systemizing. This study, conducted by Brosnan et al. (2010), identified a positive correlation between self-reported psychotic symptoms and scores on the Empathy Quotient (EQ; Wakabayashi et al. 2006) in a non-clinical female sample. This relationship became even more evident when hyper-empathizing (i.e., the degree to which empathizing is superior to systemizing) was examined. Notably, Brosnan et al.'s use of a non-clinical sample was in keeping with the recommendations of Crespi and Badcock, who argue that a pathological level of autism and positive schizophrenia traits can disorder behaviour to the extent that identifying the underlying effect of these traits can then be difficult. Accordingly, the current study also draws on the well-evidenced notion that both autism and schizophrenia traits exist on a spectrum of severity with both sets of traits extending beyond disordered individuals to also be present in the general population (see Best et al. 2008; Constantino and Todd 2005), and examines individuals with non-pathological levels of these traits. Studies have previously found typical individuals with high levels of these traits to show cognitive profiles which resemble those of their clinical counterparts (see Almeida et al. 2010; Best et al. 2008; Grinter et al. 2009a; Matsui et al. 2004; Russell-Smith et al. 2010). To identify these individuals, the current study uses the Autism Spectrum Quotient (AQ; Baron-Cohen et al. 2001c), a quantitative measure of autistic-like traits, and the Unusual Experiences subscale of the Oxford-Liverpool Inventory of Feelings and

Experiences (O-LIFE:UE; Mason et al. 2005), a scale designed to assess levels of positive schizotypy traits in the general population. Specifically, the current study compares two pairs of groups on empathizing and systemizing, one pair comprising high and low AQ scorers and the other comprising high and low O-LIFE:UE scorers.

Although Crespi and Badcock (2008) do not explicitly distinguish between cognitive empathy (i.e., the ability to understand the intentions and behaviour of others) and affective empathy (i.e., experiencing an emotional response congruent with the affective state of another), their claims seem to refer most strongly to cognitive empathy with empathy discussed primarily in relation to more cognitive-based concepts including mentalism and theory of mind. Accordingly, a multidimensional view of empathy is adopted for the current study, and both cognitive and affective empathy are examined for their associations with autistic-like and positive schizotypy traits. This approach seems particularly crucial in light of the results of two studies, which together offer some support for Crespi and Badcock's position. The first of these studies, by Rogers et al. (2007), found that when compared to typical individuals, adults with Asperger's Disorder (AD) scored lower on the cognitive subscale of the Interpersonal Reactivity Index (Davis 1983), a multidimensional self-report measure of empathy, but scored in the average range on the affective empathy subscale of this measure (see also Dziobek et al. 2008). Henry et al. (2008), who more recently explored the dissociation between cognitive and affective empathy (using the EQ; Baron-Cohen and Wheelwright 2004) in relation to positive schizotypy traits, found these traits to be positively associated with heightened levels of cognitive empathy, but to be independent of affective empathy. While the results of these studies for self-reported cognitive empathy are consistent with Crespi and Badcock's theory, outcomes are less consistent for the behavioural measures of cognitive empathy used in these and other studies. Of particular note, conflicting with Crespi and Badcock's claims, Henry et al. found higher levels of positive schizotypy traits to relate to more impaired performance on the Reading the Mind in the Eyes Test (Eyes Test; Baron-Cohen et al. 2001a), a behavioural measure of cognitive empathy which requires attribution of mental states to others based on photographs of their eye regions (see also Gooding and Pflum 2011). High and low AQ scorers have also been reported to perform at an equivalent level on this test (Kunihira et al. 2006). However, in keeping with reports of impaired cognitive empathy for individuals on the upper end of the autism spectrum, Rogers et al. did find AD individuals to perform worse than typical individuals on the Strange Stories test (Happé 1994), a different behavioural measure.

Turning our attention to systemizing, as has been noted previously, a number of existing studies provide support for the notion of superior systemizing in relation to autistic traits. For example, a study by Krajmer et al. (2010) found that a sample of males with AD scored higher than typical individuals on the Systemizing Quotient (SQ; Wakabayashi et al. 2006), a self-report measure of an individual's tendency to engage in rule-based behaviour, and the Intuitive Physics Test (Baron-Cohen et al. 2001b), a behavioural measure of systemizing. Wakabayashi et al. (2007) also reported higher SQ scores for individuals with autism compared to typical individuals. Results obtained in relation to non-clinical samples have been more ambiguous. Baron-Cohen et al. (2001c) showed that students enrolled in science courses purported to require advanced systemizing skills (e.g., computer science, mathematics, and physics), scored higher on the AQ than humanities students. In a follow-up study by Focquaert et al. (2007), science students scored higher than humanities students on the SQ. However, Voracek and Dressler (2006) reported only a weak positive correlation between the SQ and AQ for females and no correlation for males. Literature on the relationship between positive schizotypy traits and systemizing ability is extremely limited. However, one finding which may perhaps indicate a link between positive schizotypy traits and poor systemizing, is Nettle's (2006) report of fewer positive schizotypy traits in mathematicians compared to non-mathematicians. This finding implies an inverse association between positive schizotypy traits and systemizing since mathematicians are generally considered to be strong systemizers (see Baron-Cohen et al. 2003).

Being the first study to compare empathizing and systemizing for both individuals with high and low AQ scores and individuals with high and low O-LIFE:UE scores, the current study provides the first complete test of Crespi and Badcock's (2008) theory in relation to these aspects of cognition. According to this theory, the high AQ group in the current study should score lower than the low AQ group on the empathy measures, but score higher on the systemizing measures. The O-LIFE:UE groups are predicted to display the opposite pattern, with elevated scores on the empathy measures but lower scores on the systemizing measures for the high O-LIFE:UE group compared to the low O-LIFE:UE group. As detailed previously, the results of previous studies suggest that if autistic-like and schizotypy traits are found to be diametrically opposed in how they relate to empathy, it may hold only for the cognitive component of empathy. The current study thus assessed cognitive and affective empathy separately. Cognitive empathy was assessed using the Cognitive scale of the EQ (EQ:Cognitive) and the Eyes Test, while affective empathy was assessed using the Emotional Reactivity scale of the EQ (EQ:Emotional Reactivity) and a passage

rating task adapted from Batson et al. (2007). The measures of systemizing include the SQ, Mental Rotation Test (Peters et al. 1995), and Intuitive Physics Test (Baron-Cohen et al. 2001b).

The inclusion of self-report and behavioural measures of both cognitive and affective empathy in the current study is an important advancement on the work that has been done previously in relation to autistic-like or positive schizotypy traits. Specifically, while previous studies of these traits have included both self-report and behavioural measures of cognitive empathy, affective empathy has been assessed with only self-report measures. Additionally, while research examining systemizing in high positive schizotypy individuals is limited generally, much of the work examining the relationship between autistic-like traits and systemizing has been conducted using only the SQ, and thus little behavioural data is currently available. The importance of including both self-report and behavioural measures of these processes is highlighted by the relatively small correlation previously reported by Henry et al. (2008) between the Cognitive scale of the EQ and the Eyes Test. This low correlation is surprising given that both are commonly used measures of cognitive empathy in the literature, and suggests that further investigation of the relationships between these indices is required. Accordingly, prior to comparing the AQ and O-LIFE:UE groups, the current study will examine the correlations between each of the experimental measures. The inclusion of both self-report and behavioural measures in the current study is also useful to be able to make a distinction between perceived skills or deficits and actual ability. This is particularly relevant when assessing Crespi and Badcock's (2008) theory in relation to the traits of positive schizotypy, since these traits may increase the number of attributions a person makes about the mental states and intentions of others (i.e., superior self-rated empathy), but if the attributions are not accurate then this will not translate to better performance on behavioural measures.

When comparing the pair of AQ groups and pair of O-LIFE:UE groups on the experimental variables, the effects of gender, IQ, and mood, need to be considered. While gender will be controlled in the formation of groups, if any differences in IQ or mood are identified between the pairs of groups, these will be controlled for statistically in the analysis of results. Consideration of the effects of IQ is particularly crucial in the current study given the relationship identified between general intelligence and systemizing ability (see Ozer 1987; Soulières et al. 2011). Mood primarily requires consideration given the effects that both negative and positive emotional arousal have been found to have on an individual's tendency or ability to empathize (see Nezlek et al. 2001).

Method

Participants

A total of 804 students (529 females) completing a Psychology elective as part of their broader undergraduate course (e.g., a BA or BSc) were screened on the AQ and the Unusual Experiences subscale of the O-LIFE. The mean age of the students was 19.1 years ($SD = 4.9$ years). A mean score of 104.87 ($SD = 12.49$)[1] was obtained for the AQ (when the four-point scale was retained for scoring) and a mean of 4.19 ($SD = 3.01$) was obtained for the O-LIFE:UE subscale. From these 804 students, two pairs of groups (i.e., four groups in total) were formed, such that each group contained 20 participants. One of these pairs consisted of high and low AQ groups. As displayed in Table 1, these groups were selected such that they were separated substantially in their AQ scores, $F(1, 38) = 298.47$, $p < .001$, $d = 5.46$, but matched as closely as possible on their O-LIFE:UE scores, $F(1, 38) = .17$, $p = .682$, $d = .13$. The other pair of groups, the high and low O-LIFE:UE groups, were selected such that they were separated in their O-LIFE:UE scores, $F(1, 38) = 318.94$, $p < .001$, $d = 5.64$, but matched as closely as possible on their AQ scores, $F(1, 38) = 0$, $p = 1.00$, $d = 0$ (see Table 1). As can also be seen in Table 1, the pairs of groups were additionally selected to be closely matched on gender and age.[2]

Screening Measures

The *Autism Spectrum Quotient* (AQ; Baron-Cohen et al. 2001c) is a 50-item self-report measure used to assess levels of autistic-like traits in the general population. In accord with the four-point response scale (definitely agree, slightly agree, slightly disagree, definitely disagree), items were scored from 1 to 4, with a higher score reflective of a greater endorsement of autistic-like traits. Austin (2005) reported better inter-item reliability for this four-point method of scoring compared to the 0/1 method used by Baron-Cohen et al. (2001c) and several recent studies have used the more fine-grained scoring system for this instrument (e.g., Jobe and White 2007; Russell-Smith et al. 2010, 2011; Russell-Smith et al. in press; Stewart and Austin

[1] When calculated using Baron-Cohen et al. (2001c) 0/1 method of scoring, the mean AQ score obtained for the sample was 21.66 ($SD = 3.86$). This is comparable to the mean score reported for Baron-Cohen et al. (2001c) student sample which comprised students from science, humanities and social science disciplines.

[2] The high and low O-LIFE:UE groups were also found not to differ in their levels of negative schizotypy traits (e.g., social withdrawal and affective flattening), as assessed by the Introvertive Anhedonia factor of the O-LIFE, $F(1, 38) = .25$, $p = .62$.

Table 1 Psychometric characteristics of the high and low AQ groups and the high and low O-LIFE:UE groups (n = 20 per group)

	Low AQ	High AQ	Low O-LIFE:UE	High O-LIFE:UE
Age (in years)	18.8	20.5	19.00	18.35
SD (in years)	2.7	5.1	3.0	2.5
Number of females	11	12	11	11
AQ				
Mean	88.20	128.60	99.80	99.80
SD	3.05	10.00	3.44	7.11
Range	81–94	103–155	90–105	86–116
O-LIFE:UE				
Mean	4.55	4.25	.40	9.55
SD	1.50	2.88	.68	2.19
Range	0–7	0–11	0–2	5–13

2009). The AQ is a well-validated measure of autistic-like traits, able to reliably distinguish individuals with an autism spectrum disorder (ASD) from individuals drawn from the general population (Baron-Cohen et al. 2001c; Hoekstra et al. 2008).

Positive schizotypy traits were assessed using the 15-item "Unusual Experiences" factor from the *Oxford-Liverpool Inventory of Feelings and Experiences* (O-LIFE:UE; Mason et al. 2005) which has been used previously in the student population accessed for the current study (Russell-Smith et al. 2011). Evidence for the validity of this measure comes from the finding that schizophrenia patients obtain higher scores on it than typical individuals (Cochrane et al. 2010). The specific factor used in the current study, which taps perceptual aberrations, hallucinatory experiences, and magical thinking, is reported to have good reliability ($\alpha = .78$) and correlates highly with the original longer subscale from which it was derived (see Russell-Smith et al. 2011). The questionnaire has a yes/no response format, with responses in the positive schizotypy direction scored one point and other responses scored zero.

Experimental Measures

Empathy

Muncer and Ling's (2006) five-item "Cognitive" and "Emotional Reactivity" factors extracted from the *Empathy Quotient* (EQ; Baron-Cohen and Wheelwright 2004) were used to separately assess the cognitive and affective components of empathy. Self-ratings were made on a four-point Likert scale (strongly agree, slightly agree, slightly disagree, strongly disagree). The questionnaire is scored such that responses in the non-empathic direction receive zero points, 'slightly' empathic responses receive one point, and 'strongly' empathic responses receive two points. Note that the factor structure of the EQ used here has been replicated by Kim and Lee (2010), and these factors have been able to successfully dissociate cognitive and affective empathy in previous studies (e.g., Maurage et al. 2011). Muncer and Ling reported Cronbach's alpha to be .74 for the cognitive scale and .63 for the emotional reactivity scale.

To provide a behavioural measure of cognitive empathy, a computerized version of the *Revised Reading the Mind in the Eyes Test* (Baron-Cohen et al. 2001a) was used. This test requires participants to select which of four words best describes the belief or mental state (e.g., jealous or embarrassed) expressed in 36 sets of eyes (half from males). Participants received one point for each correct response.

The *Simone task,* a task based on those used in Batson et al. (2007), was used to provide a behavioural measure of affective empathy. For this task, participants are presented with a vignette and then asked to rate (on a 6-item measure) the degree to which it makes them feel sympathetic, softhearted, warm, compassionate, tender, and moved. Responses are provided on a seven-point response scale (1—not at all—to 7—extremely), with responses across the six items summed to provide a total score. Rating scales based on these six emotions have been used extensively in previous research to assess feelings of empathic concern (see Batson et al. 2007). The specific vignette used in the current study was one that Devine et al. (2012) adapted from Van Lange (2008), in which 'Simone' describes her distress having just learned that her father has been diagnosed with a terminal brain tumor. Cronbach's alpha for this measure calculated from the current data set was .88.

Systemizing

Participants self-rated their systemizing ability using the 25-item version of the *Systemizing Quotient* (Wakabayashi et al. 2006), which provides an indication of an individual's tendency to understand systems and engage in rule-based behaviour. Wakabayashi et al. reported this measure to have reasonable reliability with good internal consistency (Cronbach's alpha of .88). As is standard, the method used for completing and scoring the SQ was identical to that of the EQ.

The *Intuitive Physics Test* (Physics Test; Baron-Cohen et al. 2001b), a 20-item multiple choice test, was also administered to provide a behavioural measure of systemizing ability. The creators of this test describe it as a measure of folk physics with all questions included on the basis of being solvable from everyday experience of the physical-causal world. Participants were given a maximum of 10 min to complete the test, and obtained one point for each correct response.

As an additional behavioural measure of systemizing, all participants completed Set B of the *Mental Rotation Test*

(MRT; Peters et al. 1995) for which they were shown line drawings of three-dimensional block figures. For each item, a target block figure is shown on the left, followed by four similar figures on the right. The task is to select the two figures on the right that represent the target figure rotated in space. Incorrect choices are mirror images of the target or alternative block configurations. Participants had to identify both of the correct alternatives with a score of one given only if both choices were correct (providing a maximum score of 24). The test was administered in two 12-item halves with participants given 4 min to complete each half. A Cronbach's alpha of .92 has been previously reported for this version of the test (Caissie et al. 2009). According to Baron-Cohen (2002), successful completion of this test requires systemizing because you have to treat each feature in a display as a variable that can be transformed (e.g. rotated) and predict how it will then appear.

IQ

The Vocabulary subtest from the *Wechsler Abbreviated Scale of Intelligence* (WASI; Wechsler 1999) was administered to assess verbal IQ (VIQ). This subtest is reported to have a test–retest reliability estimate of .94 (Wechsler 1999), and was administered and scored according to the manual. An estimate of VIQ was obtained by pro-rating the T scores (by doubling) and then using the conversion tables in the manual.

Mood

Participants were also asked to rate their mood before and after completing the tasks. Four mood states (happy, sad, anxious and relaxed) were assessed using four separate nine-point Likert scales (0—not at all—to 8—a great deal). A mean of the responses for each of the mood states across the two administrations was then calculated.

Procedure

For the screening phase, students voluntarily completed the AQ and O-LIFE:UE measures in their tutorial groups. Students whose scores made them suitable for inclusion in one of the four groups described above were then invited to participate in the experimental phase of the study. Those students who chose to participate and provided consent completed a 1 h individual testing session in which they completed each of the experimental tests. In accordance with ethical approval obtained for the study, participants were not informed that the study related to autistic-like or schizotypy traits until the completion of the testing session.

Results

Prior to running the analyses, all test variables were inspected for univariate (a z-score equivalent below −3.29 or greater than 3.29) and multivariate outliers (Cook's distance > 1). No outliers were detected when the groups were examined separately or combined. An examination of the skewness and kurtosis statistics in SPSS indicated that all of the dependent variables were normally distributed (i.e., skew was <2 and kurtosis <4).

Relationships Between the Tasks

To further investigate the previous suggestion by Henry et al. (2008) of only a modest correlation between self-report and behavioural measures of empathy, the correlations between test variables were examined across all 80 participants (see Table 2). Most significantly, Henry et al.'s report of only a modest correlation between the Eyes Test and Cognitive subscale of the EQ was confirmed, with only a weak, non-significant correlation found between these measures in the current data set. The lack of correlation between these measures suggests incongruity between an individual's actual capacity for cognitive empathy and their perceived capacity, and reiterates the importance of comparing the pairs of groups in the current study on both self-report and behavioural measures. The significance of this finding is explored further in the Discussion.

Interestingly, unlike the measures of cognitive empathy, the two affective empathy measures (i.e., the Emotional Reactivity subscale of the EQ and the Simone task) were

Table 2 Correlations between the measures of empathy and systemizing (n = 80)

	Eyes	EQ:Cog.	Simone	EQ:Emot.	MRT	Physics	SQ
Eyes	–	.16	.00	.12	−.07	.06	−.21
EQ:Cog.		–	.17	.31*	−.28*	−.16	.21
Simone			–	.54*	.03	.07	.00
EQ:Emot.				–	−.14	−.04	−.07
MRT					–	.52**	.28*
Physics						–	.23*
SQ							–

EQ:Cog. Cognitive scale of the Empathy Quotient, *EQ:Emot.* Emotional Reactivity scale of the Empathy Quotient, *MRT* Mental Rotation Test, *SQ* Systemizing Quotient

* $p < .05$; ** $p < .001$

found to correlate strongly. EQ:Emotional Reactivity scores also correlated significantly with EQ:Cognitive scores, as would be expected given that these are both self-report empathy measures. The degree of correlation across the cognitive and affective empathy tasks was consistent with these being separable constructs, with performance on the Eyes Test and Simone task found to be completely unrelated. Furthermore, scores on the empathy and systemizing tasks were found to either be independent or negatively correlated. The systemizing tasks themselves were all correlated in a positive direction, with the strongest correlation identified between the behavioural measures (i.e., the Physics and Mental Rotation Tests). This pattern of correlation again emphasises the need for the inclusion of both self-report and behavioural measures in the group analyses, the results of which are detailed next.

Comparison of High and Low Groups

Scores on each of the tasks were compared across the pairs of high and low AQ groups and high and low O-LIFE:UE groups using one-way ANOVAs (with high versus low AQ group or high versus low O-LIFE:UE group entered as the between-subjects factor). Since groups were designed to be matched on gender, and neither verbal IQ or mood was found to differ significantly between the AQ groups (see Table 3 for mean scores), or the O-LIFE:UE groups (see Table 4), controlling for the effects of these variables was not required. Nevertheless, adding these variables as covariates in the analyses did not alter the pattern of results reported below.

High and Low AQ Groups

The mean scores for the low and high AQ groups on each of the empathy and systemizing tasks are displayed in Table 3. From Crespi and Badcock (2008), individuals with higher levels of autistic traits were predicted to display a cognitive profile characterised by highly developed systemizing skills coupled with poorly developed empathizing skills. Consistent with this claim, individuals in the high AQ group in the present study self-reported lower levels of both cognitive and affective empathy, with lower scores on the EQ:Cognitive scale, $F(1, 38) = 9.36$, $p < .01$, and the EQ:Emotional Reactivity scale, $F(1, 38) = 5.29$, $p = .03$. However, when the two groups were compared on the behavioural empathy tasks, no significant differences in either component of empathy were found, with the groups displaying similar scores on the Eyes Test, $F(1, 38) = 2.07$, $p = .16$, and Simone task, $F(1, 38) = .28$, $p = .60$. The high and low AQ groups were also matched in their systemizing ability, with no significant group differences observed for the SQ, Mental Rotation or Physics Test scores (smallest $p = .59$).

Table 3 Means and standard deviations for the high and low AQ groups on the empathy and systemizing measures, verbal IQ, and mood (n = 20 per group)

	Low AQ		High AQ	
	Mean	SD	Mean	SD
Cognitive empathy				
Eyes Test	28.60	2.56	26.95	4.44
EQ:Cognitive	6.80	1.88	4.65	2.52
Affective empathy				
Simone task	30.40	6.44	29.25	7.39
EQ:Emotional Reactivity	6.65	2.41	4.95	2.26
Systemizing				
Mental Rotation	13.15	5.23	12.15	6.38
Physics	11.35	2.94	11.75	2.92
SQ	19.90	9.60	20.2	8.14
IQ				
Verbal	116.00	16.54	109.20	16.21
Mood				
Happy	5.68	1.00	5.05	1.39
Anxious	2.13	1.46	2.70	2.17
Relaxed	5.18	1.30	5.20	1.02
Sad	.85	.81	1.18	1.18

Table 4 Means and standard deviations for the high and low O-LIFE:UE groups on the empathy and systemizing measures, verbal IQ, and mood (n = 20 per group)

	Low O-LIFE:UE		High O-LIFE:UE	
	Mean	SD	Mean	SD
Cognitive empathy				
Eyes Test	29.30	2.64	28.05	2.48
EQ:Cognitive	6.25	1.92	6.95	1.64
Affective empathy				
Simone task	30.80	8.08	30.25	6.34
EQ:Emotional Reactivity	5.45	2.63	6.20	2.19
Systemizing				
Mental Rotation	9.95	6.10	11.10	5.91
Physics	11.45	3.33	11.25	2.59
SQ	14.70	7.03	19.40	8.20
IQ				
Verbal	116.80	17.15	114.30	17.15
Mood				
Happy	5.55	1.01	5.43	1.18
Anxious	1.83	1.34	1.88	1.62
Relaxed	5.55	1.06	5.30	1.29
Sad	.93	1.02	.83	.88

To further explore the finding of reduced perceived levels of cognitive and affective empathy for the high AQ group relative to the low AQ group, a subsidiary analysis

was conducted to follow up on the finding by Rogers et al. (2007) that controlling for self-reported levels of cognitive empathy accounted for a slight (although not significant) trend these authors observed for lower levels of self-reported affective empathy in their AD sample. The current results produced an even more pronounced effect, with the effect of AQ group on EQ:Emotional Reactivity becoming non-significant when EQ:Cognitive scores were added as a covariate to the previously reported between-group analysis, $F(1, 38) = 2.00$, $p = .17$. Notably, the difference in EQ:Cognitive scores between the groups remained significant when EQ:Emotional Reactivity scores were covaried, $F(1, 38) = 5.66$, $p = .02$.

High and Low O-LIFE:UE Groups

The mean scores on each of the measures for the high and low O-LIFE:UE groups are reported in Table 4. From Crespi and Badcock's (2008) theory, these groups would be expected to display the opposite pattern to that predicted for the AQ groups, with superior empathizing but poorer systemizing ability for the high compared to the low O-LIFE:UE group. While an inspection of the group means indicated that the high O-LIFE:UE group obtained very marginally higher levels of self-reported empathy, the magnitude of the difference was not significant for either the EQ:Cognitive scale, $F(1, 38) = 1.54$, $p = .22$, or the EQ:Affective scale, $F(1, 38) = .96$, $p = .33$. No group differences were identified for either component of empathy when the behavioural tasks were examined, with the groups displaying similar scores on both the Eyes Test, $F(1, 38) = 2.38$, $p = .13$, and Simone task, $F(1, 38) = .06$, $p = .81$. The pattern of results obtained for the systemizing tasks offers no support for Crespi and Badcock's position, with the groups matched in their performance on the behavioural measures of systemizing (smallest $p = .55$). Moreover, although not reaching statistical significance, individuals in the high O-LIFE:UE actually trended towards reporting greater strengths in systemizing on the SQ than individuals in the low O-LIFE:UE group, $F(1, 38) = 3.79$, $p = .06$. This is the opposite pattern to that predicted from Crespi and Badcock.

Discussion

Since contrasting patterns of results were not obtained for the high and low AQ versus high and low O-LIFE:UE groups on any of the empathy or systemizing tasks, the current study provides no support for Crespi and Badcock's (2008) position. The specific predictions derived for the current study from Crespi and Badcock were that individuals in the high AQ group should score higher than the low AQ group on the systemizing measures but obtain lower scores on the measures of empathy, particularly those that tap cognitive empathy. The high O-LIFE:UE group was then expected to score lower on the systemizing tasks than the low O-LIFE:UE group, but score higher on at least the measures of cognitive empathy. The only prediction for which the current results offer any support is that of a reduced capacity for empathy in individuals with higher levels of autistic-like traits. Interestingly, however, findings of reduced empathy in the high AQ group compared to the low AQ group were restricted to the self-report measures, with no differences found between these groups on either of the behavioural tasks. No significant differences on any of the tasks were observed for the O-LIFE:UE groups, and notably the (non-significant) trend for higher SQ scores (i.e., self-reported systemizing ability) in the high relative to the low O-LIFE:UE group was in direct contrast to Crespi and Badcock's claims.

As noted, consistent with Crespi and Badcock's (2008) claims, the high AQ individuals in the current study showed some evidence of reduced empathy compared to the low AQ individuals. While findings of reduced empathy in individuals with an ASD or with high levels of autistic-like traits are common, previous studies to examine the cognitive and affective components of empathy separately in relation to ASD individuals have consistently reported that only their capacity for cognitive empathy is impaired (e.g., Dziobek et al. 2008; Rogers et al. 2007). However, the lower scores for the high relative to the low AQ group on both the EQ:Cognitive and EQ:Emotional Reactivity subscales of the EQ in the current study, suggest that individuals with high levels of autistic-like traits have lower levels of both (self-reported) cognitive and affective empathy. Since this is the first study to examine the dissociation between these components of empathy in relation to non-clinical samples differentiated on autistic-like traits, the current findings could reflect a more non-specific empathy deficit in high AQ individuals as compared to that in ASD individuals. However, since the difference in EQ:Emotional Reactivity scores between the high and low AQ groups became non-significant when EQ:Cognitive scores were covaried, the poorer self-reported affective empathy for high AQ individuals identified in the current study appears to be largely driven by their reduced (perceived) capacity for cognitive empathy.

Additionally, the lack of association between self-reported and behavioural measures of cognitive empathy in the current study was particularly striking. The disparity in these tasks was first noted in the correlational analyses, where scores on the Cognitive subscale of the EQ were found to be independent of performance on the Eyes Test. This finding is consistent with the low correlation reported previously between these measures by Henry et al. (2008),

and provides even stronger evidence for the suggestion that individuals are poor at assessing their own capacity for cognitive empathy. While the lack of correlation between these tasks may lead one to question the validity of using self-report measures to assess this component of empathy, the current authors take the view that the discrepant findings between these measures could provide a valuable insight into the functioning of individuals with high levels of autistic-like traits. Although reporting a lesser capacity for cognitive empathy, the performance of high AQ individuals in the current study did not differ significantly from the low AQ individuals on the behavioural measure (i.e., the Eyes Test), arguably a more objective measure of this ability. One of the more obvious possible explanations for this pattern of results is that high AQ individuals have a tendency to underestimate their ability to understand the intentions and behaviour of others.

Looking to the emotional intelligence literature, Mayer and Salovey's (1997) model of emotional intelligence offers an alternative explanation for the discrepant findings for the AQ groups on the Eyes Test and the Cognitive scale of the EQ. These authors have identified four interrelated emotional abilities, including the perception, use, understanding, and management of emotion, arranged in order from the most basic psychological process to the most advanced. Considering this hierarchy of abilities, it may be the case that the Eyes Test relates mostly to perceiving emotions (or mental states) and thus taps lower-level processes, while the EQ enquires about higher level processes including the use and understanding of emotion. Viewing the measures in this light, the current results could indicate that individuals with high levels of autistic-like traits struggle with the more complex processes involved in successful empathizing, while the lower level processes remain largely intact. While speculative, by this account, the lower scores obtained only for the cognitive scale of the EQ may relate not to the fact that it is a self-report measure, but rather to the particular processes that it assesses.

As previously noted, the results obtained in relation to systemizing provide no support for Crespi and Badcock's (2008) position, with no significant group differences found for the SQ, Mental Rotation, or Physics Test. Moreover, the only difference to approach significance was in the opposite direction to that predicted from these authors' claims, with a trend for higher scores on the SQ obtained by individuals in the high O-LIFE:UE group compared to those in the low O-LIFE:UE group. While the results obtained in relation to the pair of AQ groups stands in contrast to the results of previous studies which have reported a link between higher levels of autistic-like traits and superior systemizing (e.g., Baron-Cohen et al. 2001c; Focquaert et al. 2007), the current findings are in line with the non-significant association between AQ scores and systemizing reported by Voracek and Dressler (2006). The present study also provides the first direct test of the degree to which positive schizotypy traits relate to systemizing.

However, the broad definition of systemizing in the literature deserves some consideration in the interpretation of these results, since the broad nature of the construct leaves it open to being operationalized in diverse ways. For example, in addition to being linked to the tasks selected for inclusion in the current study, systemizing has also been linked to more skilled performance on visual search tasks such as the Embedded Figures Test (see Walter et al. 2009). This is significant since studies have consistently reported that performance on this task by individuals on the upper end of the autism spectrum is consistently superior to that displayed by individuals at the lower end of the spectrum (e.g., Grinter et al. 2009a, b; Russell-Smith et al. 2010). Therefore, it is possible that a different pattern of results may have been obtained in relation to the systemizing construct had another set of tasks been used. Accordingly, it may be useful for this construct to be the focus of further investigation itself, such that it can be more clearly defined and operationalized. Additionally, since Crespi and Badcock (2008) discuss systemizing in the wider context of mechanistic cognition, the current study is admittedly a specific test of these authors' position.

While the current results are not consistent with Crespi and Badcock's (2008) claims, they are partially consistent with Baron-Cohen's (2002) extreme male brain theory of autism, with some evidence found for a profile of stronger systemizing over empathizing in high AQ individuals. However, the current results suggest that Baron-Cohen's theory may need to be refined, and investigated further with greater consideration given to disparate outcomes obtained with self-report versus behavioural measures of empathy, as well as to the dissociation between cognitive and affective empathy. The general lack of significant correlations between the empathizing and systemizing measures also adds to the body of literature which argues that these represent independent processes, rather than the suggestion of a trade-off between them (see Valla et al. 2010). However, having said that, scores on the EQ:Cognitive scale were found to negatively correlate with performance on the Mental Rotation Test, offering some limited support for claims of a trade-off between these processes (Crespi and Badcock 2008). The range of correlations obtained indicates that the extent to which these processes are found to be related is likely to vary quite substantially depending on the particular set of tasks used to assess them.

While the results of the present study offer no support for Crespi and Badcock's (2008) theory we conclude with some additional possible reasons for this lack of support and provide suggestions for the further investigation of

these authors' claims. Firstly, although Crespi and Badcock call for their theory to be examined in individuals with mild levels of autistic-like and positive schizophrenia traits, the range of empathizing and systemizing skills may be restricted in a student sample (see Carroll and Chiew 2006). Accordingly, the chances of finding significant differences with the current sample may have been reduced, and thus it might be useful for the current study to be replicated with a community-based sample. This being said, the design of the study ensured that the AQ groups were substantially separated in their levels of autistic-like traits, while the O-LIFE:UE groups were substantially separated in their levels of positive schizotypy traits, and thus these pairs of groups should have been suitable for assessing Crespi and Badcock's claims. It is worth noting that a previous study to investigate these authors' claims in relation to preference for local versus global processing used the same population and similar selection methods for the AQ and O-LIFE:UE groups, and reported significant differences in line with the predictions of Crespi and Badcock for both pairs of groups (Russell-Smith et al. 2010). Additionally, the study by Brosnan et al. (2010), which provided support for Crespi and Badcock's claims of superior empathizing in relation to psychotic traits, was also conducted with a student sample.

Future tests of Crespi and Badcock's (2008) theory should also give greater consideration to the specific clusters of traits that are evident in autistic-like and schizotypy individuals. Factor analytic studies of the AQ have confirmed that autistic-like traits comprise at least two largely independent factors ("Social Skills" and "Details/Patterns"; see Austin 2005; Hurst et al. 2007; Russell-Smith et al. 2011). Positive schizotypy also comprises a range of specific symptoms including hallucinations, delusions and magical thinking. Perhaps it is the case that the diametrically opposed nature of these disorders is restricted to specific autistic-like and positive schizotypy traits, and thus an investigation which explores empathizing and systemizing in relation to more specific subsets of these traits may yield a more favourable pattern of results (see Valla et al. 2010).

It appears likely that this may be the case for the opposing processing styles identified for the autism and positive schizotypy spectra in the Russell-Smith et al. (2010) study, since the preference for local processing found in relation to higher levels of autistic-like traits has since been linked specifically to the dimension of these traits which relates to social difficulty (Russell-Smith et al. in press). Therefore, while the current results do not offer any support for Crespi and Badcock's theory that the autism and positive schizotypy spectra are diametrically opposed, further investigation of this theory is warranted.

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