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THESIS

Autistic traits, empathizing and systemizing – part of the Broader Autism Phenotype? Preliminary findings in parents of children with Autism Spectrum Conditions

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Abstract

In this preliminary study, the Broader Autism Phenotype (BAP) was investigated in 80 parents of children with an ASC diagnosis and 80 sex and age matched controls. It was hypothesized that ASC parents, and especially fathers, would score lower on measures of empathizing and emotion recognition and higher on measures of systemizing and autistic traits than controls, and that these interpretations of core ASC symptoms were part of the BAP. Sex effects were studied as well. The dependent factors were also interpreted in terms of the 'fractionable autism triad hypothesis' (Ronald & Happé, 2008). Conclusion: empathizing, systemizing and accuracy of emotion recognition do not seem to be part of the BAP. The 'Eyes' test reaction times could be a part of the BAP. Empathizing, systemizing and autistic traits seem to be largely independent factors, a finding that supports The 'Fractionable Autism Triad' for 'smaller' cognitive aspects of ASC. The hypothesized main sex differences were replicated.

Autistic traits, empathizing and systemizing – part of the Broader Autism Phenotype?

Autism Spectrum Condition is the collective term used to encompass the diagnosis of autistic disorder, Asperger syndrome and pervasive developmental disorder – not otherwise specified (PDD-NOS) (American Psychiatric Association, 2000). Although in the Diagnostic and Statistical Manual of Mental Disorders (DSM) IV this covering term has not been used yet, it is most likely that the new edition of the DSM (DSM 5) will use this term (www.dsm5.org). The term is already widely used in research and clinical practice. The main characteristics of this condition are a triad of qualitative impairments in social interaction and communication, and restricted, repetitive and stereotyped patterns of behaviour, interests and activities. Autism Spectrum Conditions (ASC) are an intensely studied subject in fields such as (neuro) psychology, genetics and medicine. Ever since a twin study in 1977 conducted by Folstein and Rutter showed a high heritability of autism, it has been confirmed by many more studies that ASC are among the most heritable psychiatric disorders (e.g. Rutter, 2000). However, the exact genetic causes and the neurodevelopmental and cognitive pathways leading to autism as a behavioural endpoint are still unclear. Considering these questions together with the high prevalence of ASC (an estimated 1% (Rice et al., 2009)) and the impact this disorder has on the daily life quality of affected individuals, it is essential to gain more insight in the condition on a cognitive, neurobiological, as well as on a genetic level.

It has been recognised that relatives of ASC probands not only are at increased risk for a clinical autism diagnosis, but they also frequently show mild autistic symptoms in the same social and cognitive areas of difficulty, as observed in clinical autism (Piven, Palmer, Jacobi, Childress & Arndt, 1997; Pickles, Starr & Kazak, 2000). This phenomenon is referred to by the term 'Broader Autistic Phenotype' (BAP) (Bolton et al., 1994). In the 1940's, Leo Kanner (1943) and Hans Asperger (1944) already noted similarities between parents of autistic children in the area of social and language problems and obsessive behaviour. Most replicated BAP characteristics in parents have been found on the social and communicational level: Szatmari et al. (1995) found that parents of ASC children more often have no friendships and describe themselves as loners compared to control parents. Piven et al. (1994 and 1997) reported ASC parents more often as being socially aloof and untactful, having more social impairments and stereotyped behaviours than control parents. Wolff, Narayan & Moyes (1988 &1990) reported more 'schizoid' personality traits (e.g. solitariness, lack of empathy and unusual modes of communication) in ASC parents than controls. Palermo et al. (2006) found that parents - especially fathers - of autistic children, performed worse than controls on an emotion recognition task with five basic emotions. Gokcen, Bora, Erermis, Kesikci & Aydin (2009) found that parents of ASC children had more trouble than controls on a mental state reasoning task in which they had to reason about others' emotions.

Apart from behavioural characteristics, BAP has been studied on a cognitive level as well. Bölte & Poustka (2006) found faster performance for parents of individuals with ASC than parents of people with early onset schizophrenia and intellectual disability on the Embedded Figures test (EFT), a test measuring a bias for local over global processing, on which people with ASC have found to perform better than average (eg. Shah & Frith, 1983). Baron-Cohen and Hammer (1997) reported superior EFT performance of ASC parents and inferior emotion recognition (using the 'Reading the Mind in the Eyes' test- from now on 'Eyes') compared to controls. Happé, Briskman & Frith (2001) reported significant better performance for ASC children's fathers on the EFT and the Block Design task. Grinter et al. (2009) found that participants with a high degree of mild autistic traits in the normal

population, as measured by the AQ, had faster EFT reaction times, poorer global motion and global form thresholds than low AQ scorers.

However, not all studies have found evidence for a BAP in ASC parents on a cognitive level. For instance, Fombonne, Bolton, Prior, Jordan & Rutter (1997) and Piven & Palmer (1997) did not find superior performance on the EFT and Block Design task in ASC parents, and Scheeren & Stauder (2008) did not find different performances of ASC parents on the Block Design Test. Baron- Cohen et al. (2006) did not find significant EFT and Eyes performance differences between ASC parents and controls. Morgan et al. (2003) did not even find differences in EFT performance between people with an ASC themselves and controls, and in Burnette et al.'s study (2005) controls outperform participants with ASC (Burnette et al., 2005). This raises some questions about cognitive tasks and their usefulness in studying the BAP and ASC in general.

For many years, research on autism spectrum conditions has focused on finding a single cause, or a single cognitive explanation for the ASC triad (social and communicational difficulties and restricted and repetitive behaviours). This approach has not been very successful. Brain studies fail to find one mechanism related to all aspects of ASC (e.g. Geschwind & Levitt, 2007) and cognitive theories fail on finding one underlying cognitive mechanism for the condition. Recently, research has focused on the possibility that there might be no single explanation or cause for the autistic triad, but that different aspects of ASC could have largely independent genetic and cognitive underpinnings (Happé, Ronald & Plomin, 2006 and Ronald & Happé, 2008). This theoretical concept was named the 'fractionable autism triad' hypothesis (Ronald & Happé, 2008) and is supported by the finding that different genes seem to be responsible for largely different fields of difficulties within ASC (Ronald, Happé, Price, Baron-Cohen & Plomin, 2006; Ronald et al., 2006) and the notion that many family members of people with autism display (above average rate) difficulties on one or two fields of the triad but not on all (e.g. Tanguay, Robertson & Derrick 1998; Szatmari et al., 1995; Piven et al., 1997).

Studying subclinical autistic traits by using a continuous scale rather than a strict categorical approach could help to obtain a clearer and more complete image of ASC on both cognitive and genetic level. On the cognitive level, to get a better understanding of the actual mechanisms, and on biological level to study which genes seem to be responsible for different symptoms of ASC. Different studies suggest that autistic traits are normally distributed in the general population, with ASC on the extreme end of the distribution (eg. Constantino and Todd, 2003; Posserud, Lundervold and Gillberg, 2006). The BAP studies show that the condition can be fractionated into different parts (because family members of affected persons can have some but not all symptoms of ASC) and degrees (the severity of symptoms in ASC itself is highly variable and unaffected family members display mild variations of symptoms). This study focuses on parents of children diagnosed with ASC. Parents who themselves are diagnosed with an ASC were excluded.

Empathizing can be defined as "the drive to identify another's mental states and to respond to these with an appropriate emotion, in order to predict and to respond to the behaviour of another person" (Baron-Cohen, Knickmeyer, & Belmonte, 2005). This ability is a core impairment of people with autism (eg. Dyck, Ferguson & Sochet, 2001 and Valla et al., 2010). The Empathizing Quotient (EQ), a self-report questionnaire to measure empathizing abilities, has been used to discriminate people with an ASC from control participants (Baron-Cohen and Wheelwright, 2004; Wakabayashi et al., 2007; Johnson, Filliter & Murphy, 2009).

Systemizing can be defined as the drive and ability to "extract the underlying rules that govern the system, that not only allows us to understand and predict an existing system,

but to invent a new one" (Baron-Cohen, Knickmeyer & Belmonte, 2005). This could be seen as a more cognitive explanation of the non-social aspects of ASC. This ability may be superior in people with ASC (Goldenfeld, Baron-Cohen and Wheelwright, 2005; Auyeung, Wheelwright, Allison, Atkinson, Samarawickrema & Baron-Cohen, 2009; Falter, Plaisted & Davis, 2008). However, in a number of recent studies the SQ did not discriminate between ASC diagnosed individuals and controls (eg. Izuma, Matsumoto, Camerer & Adolphs, 2011; Johnson, Filliter & Murphy, 2009)

Another frequently used scale in autism research is the autism-spectrum quotient (AQ), a questionnaire developed to assess the extent of autistic traits one self-reports that can be used in both general and ASC populations (Baron-Cohen, 2001). Its questions refer to core aspects of autism spectrum conditions (social and communicational problems, repetitive behaviour, imagination, attention to detail, attention switching). In the general population, AQ scores have been reported to be normally distributed and the scores of people with an ASC are on the extreme (high) end of the distribution. It has been found to distinguish ASC from controls on a satisfying level and found women to obtain lower scores than men (Baron-Cohen et al., 2001; Hoekstra et al., 2007; Wakabayashi et al., 2006; Johnson, Filliter & Murphy, 2009; Woodbury-Smith et al., 2005). However there are conflicting results on the AQ and its ability to differentiate BAP from general populations. For instance, Scheeren & Stauder (2007) found control and ASC parent groups to score similarly on the AQ. In terms of the fractionation theory of ASC and mildness of BAP characteristics an overall high AQ score is not expected and we would be interested in the specific clusters of ASC like scores in unaffected relatives. Hoekstra et al. (2008) identified a two-factor model within the AQ that resulted in the subscales 'Social Interaction'(questions referring to social skill, attention switching, communication and imagination) and 'Attention to detail' (questions referring to attention to detail). The social interaction scale can be interpreted as mainly referring to the social and communicational aspects of ASC (note: the higher the score, the more problems one experiences in this field), whereas the attention to detail scale [aims at measuring the more cognitive aspect of ASC referring to a local processing bias. These subscales are useful to give a more specific analysis of scores which is important when studying mild and possibly fractionated characteristics. Both total AQ and the two subscales will be examined to see if they discriminate BAP parents from controls. The expectancies are that ASC parents (henceforth, 'BAP') will score slightly higher on one of the AQ scales than controls. Men are expected obtain higher scores than women.

A more cognitive task that measures the social-emotional aspect of ASC is the 'Reading the Mind in the Eyes' test (Baron-Cohen et al., 2001). As mentioned, findings on this task are contradictory. Not many studies have tested the Eyes task on parents of autistic children and therefore this test will be taken into account in this study. Also, in this study a replication of Miu, Pana & Avram (2012) who found that neurotypicals with high AQ scores had normal accuracy on the Eyes task but increased latencies. A typical person with ASC is expected to score high on systemizing and the autism-spectrum quotient ,low on empathizing and low on emotion recognition tasks (Lawson, Baron-Cohen & Wheelwright, 2004; Baron-Cohen & Wheelwright, 2004). Baron-Cohen argues that with the 'Empathizing-Systemizing' (E-S) theory of autism both the social and non-social (repetitive behaviour, narrow interests) aspects of ASC can be explained (Baron-Cohen, 2009). In the E-S theory, empathizing is seen as a main 'ingredient' for the social and communicational problems in ASC.

A well-documented finding is that women tend to be better than men in tasks related to empathizing and men are better at systemizing (Baron-Cohen et al., 2003) or tasks related to these concepts (Geary, 1995; Kimura, 1999). In this study, sex differences are expected

with men scoring higher on systemizing and autism-spectrum traits and women scoring higher on empathizing and emotion recognition. Earlier BAP studies mainly found a BAP tendency in male relatives (see for instance: fathers and brothers of ASC diagnosed individuals in Piven et al.,1997; and fathers in Wheelwright, Auyeung, Allison & Baron-Cohen, 2010). Therefore a stronger tendency towards autistic traits is expected in ASC fathers than ASC mothers.

This study aimed to explore the argued independency of factors in the fractionable autism triad stretches further than the triad of impairments. Questioned was if cognitive interpretations of core diagnostic ASC characteristics, systemizing, empathizing and emotion recognition (Wheelwright et al., 2006) are part of the BAP. This study is the first to examine empathizing and systemizing in parents of ASC children. It was hypothesized that ASC parents would either score higher than controls on systemizing, and autistic traits, but lower on empathizing and emotion recognition, but that they would not necessarily score ASC-like on both measures. The potential impairments in ASC parents were expected to be mild. The relationship between measures in the groups was explored to explore how different measures relate to each other for a psychometric interpretation of the findings. Parents of an ASC diagnosed child weree compared to healthy, age matched controls.

Method

Participants

The 'clinical' group of this study consists of 80 parents (40 fathers; mean age 45.3 [7.10]), 40 mothers; mean age 42.8 [5.16]) of children with a formal ASC diagnosis. Participants were recruited by sending out letters to parents via ASC support groups, schools and charities within a 2 hours driving distance from Cambridge. Interested families were contacted by phone and shortly interviewed to check their suitability for the study. The diagnosed child or children had to be between 6 and 18 years old, and have no severe learning difficulties as they had to be able to complete this study's test battery. Therefore the majority of the children were high functioning autistic children or had an Asperger Syndrome diagnosis. Families in which one or both of the parents had an ASC diagnosis were excluded in order to not mix up BAP and actual ASC. Families with children affected with a genetic syndrome (such as Angelman Syndrome and Fragile X Syndrome) were excluded, as the goal of the final study is to find out more about ASC, parents and genetics, and genetic syndromes would confound a model of idiopathic autism. Separated parents were excluded due to former experiences of missing data from these families, and also, families in which the child did not have a formal ASC diagnosis were excluded.

During the home visits, the diagnosis of the child was verified using the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) - a method using semi-structured behavioral observations- and the Developmental, Dimensional and Diagnostic Interview (3di: Skuse et al., 2004). During the ADOS the researcher provoked social, communicational, stereotypical and playful behaviours in a child by using different 'games' and questions, depending on the age of the child. The 3di is a computerized procedure with which diagnostic and symptomatic profiles can be generated in a short interview with the parents or carers of the diagnosed child as to assess the given diagnosis.

The control group consisted of 80 (age and sex selected to resemble the clinical group; 40 men; mean age 43.6 [7.38], 40 women; mean age 43.3 [7.67]) volunteers from the general population who completed questionnaires and tests online (www.cambridgepsychology.com) or took part in another project from the Autism Research Centre (eg. an imaging project or a sibling adoption study). Every volunteer had to complete a

standard account with demographic details and information about their own and familial statuses of ASC diagnosis. People with an ASC or other psychiatric diagnosis, as well as people with first or second degree relatives with an ASC diagnosis, were excluded from this study. From the database with a total of 242 participants a selection of 40 females and 40 males was made that matched the mean age of the ASC fathers and mothers and filled in the EQ, SQ and AQ questionnaire, completed the Eyes and the RAVEN test. T-tests revealed no significant differences in age for the ASC parents and the controls (fathers vs. control males: $t(78)= -1.035$, p=.304, mothers vs. control females: $t(78)= .359$, p=.720).

Procedure

80 Biological parents of ASC diagnosed children from the United Kingdom and 80 controls completed the EQ, AQ and the SQ questionnaires, Eyes and RAVEN tests (among other measures that were not taken into account in this preliminary study). PhD student Edward Sucksmith and the author conducted home visits to the participants. The author joined this project when the research was already on going. She conducted home visits to 19 families but was able to use data from the complete dataset.

The EQ, AQ and SQ questionnaires were collected as a part of the home visits. Data from the control group were derived from an online database (see 'participants').

Once a family was interested and met all inclusion criteria (see 'participants' for exclusion criteria), an appointment was made for a home visit and an information package was sent to them, including the SQ, EQ and AQ questionnaires for both parents. Participants could choose to be tested either at their homes, at the Autism Research Centre in Cambridge or at the Open University in Milton Keynes.

Tasks

Empathizing

Empathizing ability was measured by using the EQ (Empathizing Quotient) (Baron-Cohen & Wheelwright, 2004, see appendix A), a 40 item self-report questionnaire. Participants score two points if they 'strongly agree', and one point if they 'slightly agree' on items 1, 3, 11, 13, 14, 15, 21, 22, 23, 24, 26, 27, 28, 29, and 34 - 40. An example of such an item is 'Other people tell me I am good at understanding how they are feeling and what they are thinking'. On items 2, 4 – 10, 12, 16, 17, 18, 19, 20, 25, 30, 31, 32, and 33, participants score one point for 'slightly disagree' and two points for 'strongly disagree'. An example of such an item is 'I often find it difficult to judge if something is rude or polite'. The minimum score is 0 and the maximum score is 80. People with ASC on average tend to score low on the EQ (Baron-Cohen et al., 2004). The internal consistency of the EQ questionnaire has been checked in the ASC parents group and was satisfactory with a Cronbach's α of .92.

The EQ questionnaire has been found to be a valid scale; the EQ items showed no association with social desirability and correspond modestly to scales related to *global* empathy of the IRI (Davis, 1980). Mean EQ scores were very comparable across different samples- scale, which indicates good reliability. Test-retest reliability was good over a period of 12 months with a correlation coefficient of r=.83 between the scores found on the different moments (Lawrence et al., 2004).

Systemizing

Systemizing ability was measured by using the SQ-R (Systemizing Quotient Revised) (Wakabayashi et al., 2006, see appendix B), a 75 item self-report questionnaire using a 4 point Likert scale, divided in the categories: "strongly agree", "slightly agree", "slightly disagree" and "strongly disagree". Participants score two points if they 'strongly agree', and one point they 'slightly agree' on items: 1, 2, 4, 5, 7, 9, 11, 12, 13, 14, 16, 18, 19, 20, 21, 23, 25, 27, 29, 30, 32, 36, 38, 41, 42, 43, 46, 50, 53, 55, 60, 61, 61, 62, 66, 68, 69, 72, 74 and 75. An example of such an item is 'I can remember large amounts of information about a topic that interests me e.g. flags of the world, airline logos'. On items 3, 6, 8, 10, 15, 17, 22, 24, 26, 28, 31, 33, 34, 35, 37, 39, 40, 44, 45, 47, 48, 49, 51, 52, 54, 56, 57, 58, 59, 63, 64, 65, 67, 70, 71 and 73 participants score one point for 'slightly disagree' and two points for 'strongly disagree'. An example of such an item is 'I find it difficult to understand instruction manuals for putting appliances together'. The minimum score is 0 and the maximum score is 150, the last score referring to very high systemizing ability. People with ASC tend to score higher on the SQ than controls (Baron-Cohen et al., 2004), and men tend to score higher on the SQ then women (Goldenfeld et al., 2005). The internal consistency of the SQ questionnaire in the ASC parents group was satisfactory with a Cronbach's α of .92.

Autistic traits

Autistic traits were measured by using the autism spectrum quotient (AQ) (Baron-Cohen et al., 2001, see appendix C), a 50 item self-report questionnaire using a 4 point Likert scale, divided in the categories: "strongly agree" (1 point), "slightly agree" (2 points), "slightly disagree" (3 points) and "strongly disagree" (4 points). An example for such an item is 'I find social situations easy'. Scoring was reversed for items 2, 4, 5, 6, 7, 9, 12, 13, 16, 18, 19, 20, 21, 22, 23, 26, 33, 35, 39, 41, 42, 43, 45 and 46 in which an agree answer points to an 'autistic' response. An example for such an item is 'I prefer to do things in the same way over and over again'. The minimum score is 50 (no autistic traits), the maximum score is 200 (maximum score on all autistic traits). The original AQ version has a binary scoring system with 0 as minimum score and 50 as maximum score (Baron-Cohen et al., 2001). Total AQ scores as well as the subscales 'attention to detail' and 'social interaction' (Hoekstra et al., 2008) will be analysed. People with ASC tend to score higher on the AQ than controls and men score higher than women (Baron-Cohen et al., 2001, Hoekstra et al., 2008). Internal consistency of the total AQ questionnaire has been found satisfactory (Cronbach's α=.71 in a general population sample and α=.81 in a student sample) as well as the test-retest reliability (r=.78) (Hoekstra et al., 2008). Hoekstra et al. (2008) identified the subscales 'Social interaction' and 'Attention to detail' from the total AQ in their factor analysis.

Reading the Mind in the Eyes test

Using the computerized version of this test (Baron-Cohen et al., 2001), emotion-recognition ability was measured, both by accuracy and reaction times. A series of 36 photographs of the eye-region were presented on a computer screen, together with 4 words of emotions, 1 word in each corner of the picture. Participants were asked to choose one of the four emotions that best described the emotion in the depicted eyes, and press the corresponding button on the keyboard as soon as possible. The test was preceded by a practise photograph and a testing block.

Intelligence

Intelligence was measured with the RAVEN standard progressive matrices test. Different versions of the RAVEN were used – a pen and paper SPM Plus 1998 version for the BAP group and an online SPM 1979 version for the control group. The SPM Plus includes more difficult items in order to improve the discrimination among more able adolescents and young adults (RAVEN, 2000). These two versions have not been tested on their direct comparability and therefore interpretation of the difference in IQ scores between groups is limited.

Analysis

A series of independent group x gender ANCOVA's was conducted to examine differences on the EQ, SQ and AQ and the Reading the Mind in the Eyes test. The main effect of intelligence was taken into consideration and therefore IQ was used as a covariate. Partial correlations were conducted to explore the relationship between the different measures in the groups, controlling for sex and IQ (see table 4). All analyses were run in SPSS.

First, the data was screened for outliers. 9 BAP and 4 controls were excluded due to 'clinical' AQ scores, that in Hoekstra et al. (2008) were obtained exclusively by individuals with an ASC. A series of two way analyses of variance with covariate (ANCOVA) were conducted. A MANCOVA was considered to analyse the total variance for SQ, EQ and AQ but as these measures were not all correlated and some were correlated too strongly (see table 4) this was dismissed.

The Empathizing Quotient

Mean scores and standard deviations on the EQ per group and sex are displayed in table 1. The distribution did not deviate from normality (BAP skewness and kurtosis respectively: -.163; -.838, controls skewness and kurtosis resp.: -.219; -.578). The EQ scores for the control group are comparable to that of Baron-Cohen et al. (2006) and somewhat lower than that of the control EQ scores in another study (Spek, Scholte & van Berckelaer-Onnes, 2011).

A non-significant Levene's test indicated a lack of evidence that the homogeneity of variance assumption was violated.

The Systemizing Quotient

Mean scores and standard deviations on the SQ per group and sex are displayed in table 1. In both the BAP group and controls, the SQ was not normally distributed (BAP skewness and kurtosis resp: .709; 1.343, controls skewness and kurtosis resp.: .624; .194). Therefore a square root transformation was applied to the scores. The transformed distribution of scores did not deviate from normality (BAP skewness and kurtosis resp: .087; -.073, controls skewness and kurtosis resp.: .054; -.052). Compared to the Baron-Cohen et al. (2006) 'typical group' the SQ scores for controls in this study are high (see table 1). The BAP SQ scores are comparable to the Baron-Cohen et al. typical group.

Table 1 EQ and SQ mean scores with standard deviations from current study: ASC parents and controls, and Baron-Cohen (2006): ASC and controls

Group	N	EQ	SQ
Current study			
ASC parents	80	44.5 (14.11)	53.0 (20.80)
Fathers	40	38.7 (12.70)	60.0 (19.29)
Mothers	40	50.2 (13.20)	46.2 (20.20)
Controls	73	44.0 (14.78)	62.9 (25.29)
Males	36	39.0 (14.20)	68.8 (27.37)
Females	37	48.8 (13.84)	57.2 (21.97)
Baron-Cohen et al. (2006)			
ASC			
Total	125	18.6 (9.9)	77.2 (23.8)
Males	69	18.7 (9.8)	77.8 (22.9)
Females	56	18.5 (10.1)	76.4 (25.1)
Typical group*			
Total	1761	44.3 (12.2)	55.6 (19.7)
Males	723	39.0 (11.6)	61.2 (19.2)
Females	1038	48.0 (11.3)	51.7 (19.2)

* typical group = control group (Cambridge University students, different degrees of subjects)

The Autism-spectrum Quotient

Nine participants from the BAP group and four of the control participants obtained scores of ≥145 on the total AQ scale, scores that in Hoekstra et al. (2008) were exclusively obtained by ASC diagnosed participants. Therefore, these participants were excluded from the study since these participants could have an ASC without diagnoses and distort the data.

Mean scores and standard deviations on the AQ per group and sex are displayed in table 1. The total AQ scores (BAP skewness and kurtosis resp: .229; -.881, controls skewness and kurtosis resp.: -.086; -.510) and AQ subscale scores for social interaction (BAP skewness and kurtosis resp: .231; -.905, controls skewness and kurtosis resp.: .002; -.541) and attention to detail (BAP skewness and kurtosis resp: .270; 1.066, controls skewness and kurtosis resp.: .322; .089) were normally distributed.

For the replication of Miu et al. (2012)'s study, per group, total AQ scores more than 1 standard deviation above or below the mean were selected to create 'high AQ' and 'low AQ' scores.

The Reading the Mind in the Eyes test

Mean scores and standard deviations on Eyes reaction times and total correct items per group and sex are displayed in table 3. Both RT (BAP skewness and kurtosis resp: .306; -.146, controls skewness and kurtosis resp.: .441; -.069) and accuracy scores (BAP skewness and kurtosis resp: -.419; -.312, controls skewness and kurtosis resp.: -.097; -.735) of the Eyes task were normally distributed.

Table 2 Total mean scores with SD for total AQ scale and SI & AD subscales plus ASC parents and controls from Hoekstra et al. (2008).

Group	N	AQ total	Social interaction*	Attention to detail
Current study				
ASC parents	80	106.4 (20.12)	83.2 (18.04)	23.2 (5.00)
Fathers	40	112.3 (18.00)	88.5 (16.79)	23.8 (4.30)
Mothers	40	100.8 (20.68)	78.2 (18.00)	22.6 (5.60)
Controls	80	109.3 (18.29)	84.6 (17.03)	24.7 (5.12)
Males	40	116.4 (17.14)	93.1 (17.83)	25.3 (5.67)
Females	40	102.4 (16.86)	79.7 (18.01)	24.0 (4.51)
Hoekstra et al. (2008)				
ASC	12	142.3 (22.01)	114.8 (19.12)	27.4 (5.29)
General pop.	302	104.2 (11.29)	79.9 (16.68)	24.3 (4.97)
Males	137	105.7 (10.99)	81.5 (10.98)	24.1 (4.78)
Females	160	102.9 (11.50)	78.5 (10.25)	24.4 (5.18)

***** A higher score indicates more problems in social interaction.

The Reading the Mind in the Eyes test

Mean scores and standard deviations on Eyes reaction times and total correct items per group and sex are displayed in table 3. Both RT (BAP skewness and kurtosis resp: .306; -.146, controls skewness and kurtosis resp.: .441; -.069) and accuracy scores (BAP skewness and kurtosis resp: -.419; -.312, controls skewness and kurtosis resp.: -.097; -.735) of the Eyes task were normally distributed.

RAVEN standard progressive matrices

The RAVEN distribution of scores have a slight negative skew for the control group (BAP skewness and kurtosis resp: -.049; -.290, controls skewness and kurtosis resp.: -1.043; -.998) but this still falls within an acceptable range. Mean raw scores and standard deviation on the RAVEN per group and sex are displayed in table 3. For controls the raw scores correspond to an IQ range of 96-98 (low-average), the BAP raw scores correspond to an IQ range of 118 (above average). A t-test revealed a significant IQ difference between the two groups $t(143) = 14.04$, $p<0.001$, but not between the sexes $t(143) = .81$, $p=.422$. Because of the main effect of IQ between groups, the RAVEN raw scores was used as a covariate in the analyses. See method section for the potential limited interpretational value of these scores.

Results

The Empathizing Quotient

A non-significant Levene's test indicated a lack of evidence that the homogeneity of variance assumption was violated. There was no significant difference on the EQ between groups ($F(1,140) = .819$, $p= .367$). Power to detect was .146. There was a significant effect of sex on the EQ ($F(1,140) = 20.131$, $p< .0005$, partial $\eta^2=.126$). There was no significant interaction effect between sex and group ($F(1,140) = .020$, $p= .888$). The BAP and control

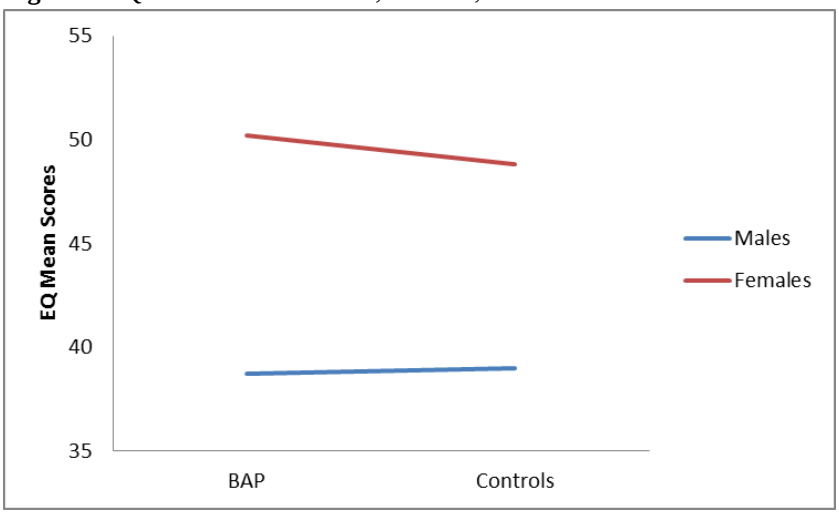
group did not significantly differ on their EQ scores. There is a significant sex difference with women scoring higher on the EQ than men. See figure 1.

Table 3 RAVEN SPM, EFT reaction time (RT) and Eyes* mean scores with standard deviations for ASC parents and controls

Group	N	RAVEN	Eyes RT	Eyes TC
ASC parents	80	39.1 (6.34)	6958.5 (1424.98)	26.2 (3.93)
Fathers	40	40.0 (6.27)	6999.1 (1206.37)	26.3 (3.67)
Mothers	40	38.2 (6.39)	6849.7 (1647.85)	26.2 (4.23)
Controls	77	51.7 (4.44)	6815.0 (1821.88)	26.0 (4.32)
Males	36	51.6 (4.40)	6909.8 (1848.50)	25.3 (4.75)
Females	37	51.8 (4.53)	6722.7 (1816.23)	26.7 (3.82)

* RAVEN SPM = raw scores for RAVEN standard progressive matrices intelligence test but see note in RAVEN section. Raw score 38 equals an IQ of appr. 96, 39 equals IQ=97, 40 equals IQ=98, 52 equals IQ=118. Eyes= The Reading the Mind in the Eyes test, RT=reaction time, TC=total correct.

Figure 1 EQ mean scores for BAP, controls, males and females



The Systemizing Quotient

Levene's test was non-significant. There was no significant difference on the SQ between groups ($F(1,140) = .286$, $p = .593$). Power to detect was .083. There was no significant interaction effect between sex and group ($F(1,140) = .224$, $p = .637$). Power to detect was .076. There was a significant effect of sex on the SQ ($F(1,140) = 11.418$, $p < .01$, partial $\eta^2 = .075$). Power to detect was .919. The BAP and control group do not significantly differ on their SQ scores. There is a significant sex difference with women scoring higher on the SQ than men. See figure 2.

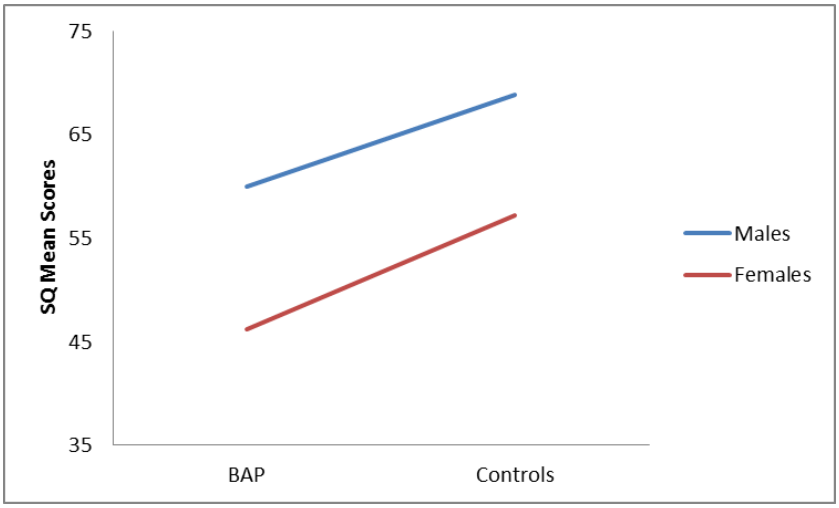
The Autism-spectrum Quotient

Total AQ

See figure 3. Levene's test was non-significant. There was no significant difference on the AQ between groups ($F(1,140) = .345$, $p = .558$). Power to detect was .090. There was no significant interaction effect between sex and group ($F(1,140) = .184$, $p = .668$). Power to detect was .071. There was a significant effect of sex on the AQ ($F(1,140) = 17.589$, $p <$

.0005, partial η^2=.112). Power to detect was .986. The BAP and control group do not significantly differ on their AQ scores. There is a significant sex difference with women scoring higher on the AQ than men.

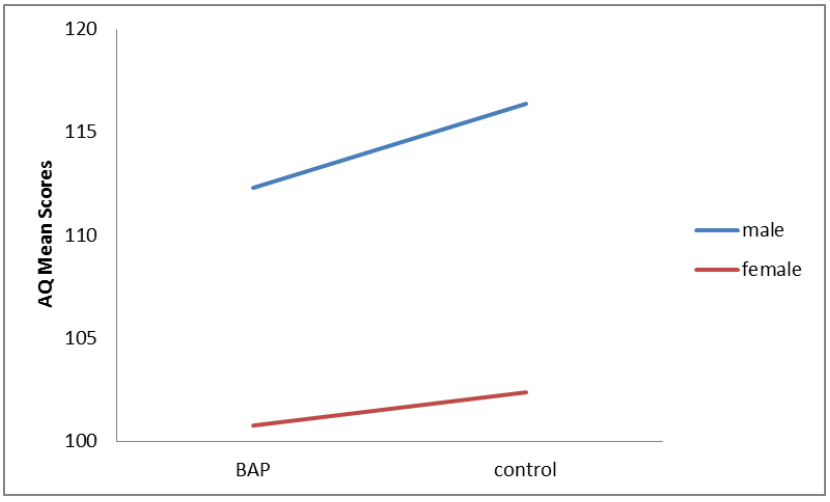
Figure 2 SQ mean scores for BAP, controls, males and females



AQ social interaction (SI) subscale

Levene's test was non-significant. There was no significant difference on the SI between groups (F(1,140) = .068, p= .795). Power to detect was .058. There was a significant effect of sex on the SI (F(1,140) = 17.481, p<.0005, partial η^2=.111). Power to detect was .986. There was no significant interaction effect between sex and group (F(1,140) = .181, p= .671). Power to detect was .071. The BAP and control group do not significantly differ on SI scores. There is a significant sex difference with women scoring higher on the social interaction scale than men.

Figure 3 AQ mean scores for BAP, controls, males and females



AQ attention to detail (AD) subscale

Levene's test was non-significant. There was no significant difference on the AD between groups (F(1,140) = 1.559, p= .214). Power to detect was .237. There was no

significant effect of sex on the SI ($F(1,140) = 1.848$, $p=.176$).There was no significant interaction effect between sex and group ($F(1,140) = .022$, $p= .883$). Power to detect was .052. BAP and controls, men and women do not significantly differ on the attention to detail scale.

The Reading the Mind in the Eyes test

Reaction Times

Levene's test was non-significant. There was a significant difference on the Eyes RT between groups ($F(1,145) = 4.172$, $p< .05$, partial $\eta^2=.028$). Power to detect was .528. Eyes RT are higher for BAP than controls. There was no significant interaction effect sex and group ($F(1,145) = .493$, $p=.484$). Power to detect was .107. There was no significant effect of sex on the Eyes RT scores ($F(1,145) = .011$, $p=.918$). Power to detect was .051. There was a significant effect of the covariate IQ on the Eyes RT ($F(1,145) = 5.352$, $p< .05$, partial $\eta^2=.036$). Power to detect was .632.

A significant effect of the covariate RAVEN scores on the variance of RT was also found ($F(1,145) = 5.352$, $p< .05$, partial $\eta^2=.036$). Power to detect was .632. Eyes RT are higher in people with higher RAVEN scores. Eyes reaction times are significantly higher for the BAP than the control group. The effect size of IQ is larger than the effect of group. No significant sex difference or interaction effect was found.

Accuracy

Levene's test was non-significant. There was no significant difference on the Eyes accuracy between groups ($F(1,133) = 1.377$, $p= .243$). Power to detect was .214. There was no significant effect of sex on the Eyes accuracy scores ($F(1,133) = .952$, $p= .331$). Power to detect was .162. There was no significant interaction effect between sex and group ($F(1,133) = .805$, $p= .371$). Power to detect was .145. BAP and controls, men and women do not significantly differ on their Eyes accuracy scores.

People High and Low on Autistic traits and performance on the Reading the Eyes in the Mind

Levene's test was non-significant. See figure 4. There was no significant difference in Eyes RT between extreme low and extreme high AQ scorers. $F(1,44) =.316$, $p= .577$). There was a significant difference in Eyes accuracy scores between extreme low and extreme high AQ scorers (a trend however for people with high AQs to obtain lower Eyes accuracies than people with low AQs). $F(1,44) = 11.583$, $p< .01$, partial $\eta^2=.208$). Power to detect was .914. There was no significant difference between the extreme high and low scores of the BAP and control group for either accuracy $F(1,44) = .759$, $p= .388$) or RT $F(1,44) =.022$, $p= .882$). People who score high on the AQ, perform worse on the Reading the Mind in the Eyes test, but a high or low AQ score does not influence reaction times on the Eyes task.

Correlations between variables

The correlations between variables (see table 4), controlled by sex and IQ were explored to explore differences in inter-relationships. Most relationships are comparable across the BAP group and the control group. Some interesting findings will be described here.

There is no significant correlation between systemizing and empathizing, however, empathizing and autistic traits are negatively related. In BAP there is a positive relationship between systemizing and autistic traits, but in controls this correlation does not exist. There is a strong, negative relationship between empathizing and social interaction difficulties, and a moderate, positive correlation was found between the Eyes accuracy and empathizing.

For both BAP and controls a near significant, positive correlation exists between RAVEN scores and reaction time on the Eyes test and in BAP, IQ does correlate with Eyes accuracy but in controls there is no such relationship.

Figure 4 'Eyes' mean accuracy scores for BAP, controls, males and females

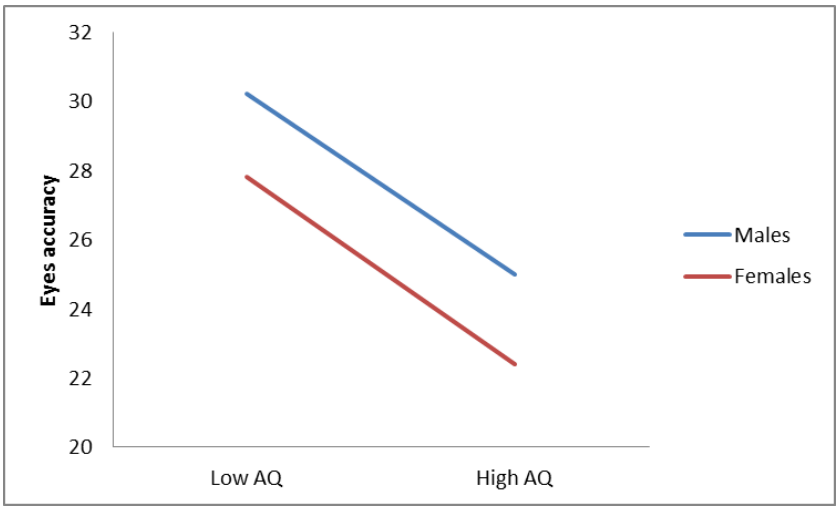


Table 4 Pearson product-moment correlations for SQ, EQ, AQ total and AQ subscales 'attention to detail' and 'social interaction', RAVEN SPM and Reading the Mind in the Eyes RT & accuracy

	1.	2.	3.	4.	5.	6.	7.	8.
1. SQ	-	-.150	.397**	..517***	..293*	.149	-.141	-.012
2. EQ	.013	-	-.696***	-.069	-.759***	-.074	-.092	.257*
3. AQ total	.185	-.709***	-	.516***	.968***	.031	.084	-.220
4. AQ attention to detail	.605***	.007	.360**	-	.284*	.011	-.211	-.145
5. AQ social interaction	.004	-.761***	.954***	.063	-	.031	.154	-.204
6. RAVEN SPM	.058	-.155	.010	-.013	.016	-	.244 #	.237#
7. Eyes RT	-.116	.164	-.131	-.316**	-.038	.230 #	-	-.156
8. Eyes Accuracy	-.129	.276*	-.343**	-.113	-.331**	-.027	-.013	-

Note. Correlations for BAP group are in placed above the diagonal, correlations for controls are placed below the diagonal. *p<.05-.06 ; **p<.01 ; ***p<.001; #p =.05-.06 A high score on the AQ social interaction scale corresponds to a high level of social difficulties.

Discussion

In this study, parents of children with an ASC and healthy, sex and age matched controls, were compared on cognitive and behavioural interpretations of core ASC characteristics: systemizing (measured by the SQ questionnaire), attention to detail perception (measured by the 'attention to detail' AQ subscale), emotion recognition (measured by the 'Reading the Mind in the Eyes' test), empathizing (measured by the EQ questionnaire), social and communicational skills/preferences (measured by the 'social interaction' AQ subscale) and finally autistic traits (measured by the total AQ score), as a general frame of reference to interpret the results.

Recently, the search for the genetic underpinnings of ASCs has brought a focus on two major questions. Firstly: are different, independent genes responsible for different phenotypical traits seen in autism, and therefore could ASC be 'fractionable' into separate aspects that cluster together in ASC. Secondly: does the widely observed and reported broader autism phenotype exist and presuming that it does, how can we 'capture' this with valid psychometric tests and questionnaires? In this study, systemizing and attention to detail were considered cognitive or non-social aspects of ASC as they relate to a general way of information processing in autism: rigid and 'bottom up'. A logical consequence of this way of perceiving are the rigid and repetitive behaviours or the non-social aspects seen in autism. Empathizing and social and communicational skills/preferences are considered aspects that are associated with the social and communicational difficulties in people with an ASC. Emotion recognition can be seen as a cognitive mechanism that applies to the 'social world'. It was studied here if these characteristics were independent and hypothesized that ASC parents (henceforth, BAP) would display some mild ASC characteristics. Sex differences were studied as well, to examine whether the much reported main effect of sex on empathizing, systemizing and autistic traits could be replicated and to examine the expectancy that BAP characteristics occur mainly or exclusively in BAP fathers and to a smaller degree or not at all in BAP mothers. The last aim of this study was to explore relationships between the measures in this study, as there have been contradicting results on BAP studies and the validity of some constructs and instruments frequently used in autism research.

The following hypothesized sex effects were confirmed: women scored higher on empathizing (EQ) and social skills (subscale AQ, from Hoekstra et al., 2008) than men, men scored higher on systemizing (SQ) and autistic traits (AQ) than women. No sex differences were found for attention to detail (in line with Hoekstra et al., 2008) and performance on the Reading the Mind in the Eyes test (Eyes) test.

No evidence was found for empathizing, systemizing, emotion recognition accuracy and a range of self-reported autistic traits to be part of the BAP since no significant group differences nor group x sex interaction effects were found on each of these measures. Interestingly, the SQ means point in the opposite direction: controls score slightly higher. Izuma et al. (2011) also found higher SQ scores for controls than individuals with an ASC. Thus the criterion validity of the SQ is a point of doubt.

The control group in this study were not all Cambridge University (ex-)students but a majority of them might be highly educated, which points to the question of a relationship between intelligence and SQ. However, SQ did not significantly correlate with intelligence in this study, a finding also reported by Ling et al. (2009). Baron-Cohen et al (2001, 2003, 2004, 2006) in multiple studies found physics (eg. physics, mathematics, chemistry, computer science) students to obtain the highest SQ scores and humanities (eg. classics, languages, drama, philosophy) students to obtain the lowest SQ scores among all subject domains (social

and biological sciences students obtained equal SQ's). To put it crudely, physical science is a typical male subject and humanities is a typical female subject. Men obtain higher SQ's than women. The SQ entails many 'manly' items (maps, DIY, technology). The SQ therefore seems to measure sex differences in a higher degree than ASC characteristics. The finding that SQ is not higher in in individuals ASC is counterevidence for the extreme male brain theory, which states that the 'autistic brain' (for both male and female ASC individuals) is a magnification of the stereotype male brain. If more studies replicate this SQ 'null' finding in ASC, it can be concluded that the SQ is not a valid measure for ASC and BAP studies. Possibly this study's control group was overrepresented by people from the 'hard science' field and the BAP parent group was not.

A 2007 study (Billington, Baron-Cohen & Bor) using fMRI to investigate the neural correlates of systemizing during a perceptual conflict task for local or global processing did not find a specific correlate for systemizing, rather systemizers had a cognitive style which increased their ability to maintain an attentional set. The systemizing in ASC arguably is less of an attentional, volutional process but more an innate and automatic process of perception to detail or 'weak central coherence' (Frith, 1989), which is quite hard to measure in everyday life questions like the SQ.

BAP and controls differed on their Eyes reaction times: the BAP group had longer latencies than controls. This finding supports the BAP hypothesis and points to the Eyes test reaction time as an indication for the BAP. Baron-Cohen & Hammer (1997), found BAP parents to score 'slightly less accurate' on the Eyes task and no Eyes RT differences. A significant effect of covariate IQ on the Eyes RT was found as well. Extreme scores on the AQ were analysed and it was found that people with high AQ scores obtained lower accuracies on the Eyes test and people with low AQ scores had higher accuracies on the Eyes test. Thus the Eyes accuracy scores may relate to behavioural traits whereas the Eyes RT may relate to more cognitive aspects of ASC.

Miu and collegues (Miu et al., 2012), the study where this extreme AQ analysis was replicated from, found differences on the Eyes' reaction times and not accuracy. These different findings raise questions on the validity of the test. In this study, the Eyes accuracy was positively related to the EQ, a related concept. There was no significant relationship between the Eyes RT and EQ, however for both BAP and controls, a near correlation was found for the Eyes RT with RAVEN SPM IQ scores. Possibly, with the Eyes RT a more cognitive aspect of empathy is measured. More BAP parent studies are needed to verify the consistency of these Eyes results.

Interestingly, high IQ scores relate to longer latencies. Possibly people with higher intelligence respond more in a cognitive way and people with lower intelligence respond in a more automatic way. A potential moderator for the Eyes RT lies in the speed of information processing (often positively related to overall IQ). Speedy responses on the Eyes could reflect this part of intelligence rather than a superior emotion recognition ability. Interestingly, a recent study found the Eyes to correlate with verbal IQ scores and not with matrix reasoning (Peterson & Miller, 2012). Future studies could incorporate a 'baseline speed' task when using the Eyes RT to control for this effect or search for new, more reliable ways of testing emotion recognition, such as Scheeren & Staunder (2008), who found ASC fathers to respond slower than controls fathers on social cues in a visual reflexive orienting task. Hudson, Nijboer & Jellema (2012) used an eye-gaze task to measure the implicit preference for social or antisocial faces of ASC and control parents (fathers with high AQ scores showed no preference). Implicit, automatic responses, may be more reliable measures of cognitive

processes. Furthermore, brain research could possibly shed some light on altered neuronal functions or connections in ASC and BAP.

A limitation of this study must be mentioned, that is, the effect of IQ was not controlled for very well. Although both groups completed the RAVEN SPM test, these were different versions (see method section) which are not completely comparable. Another interesting note in this study is that due to 'clinical' AQ scores (scores that in other studies were exclusively obtained by ASC diagnosed individuals) in 9 of the BAP parents and 4 of the controls, these participants had to be removed from data analysis since in other studies. Removing these participants had an impact on the AQ mean scores, but also on other values (more towards a 'BAP direction'). This points to one of the difficulties in BAP research as there are no strict borders where BAP starts and where it becomes an ASC if there is no diagnosis. One condition for parents in order to join this study was not to be ASC suspicious about themselves. Maybe excluding these participants meant dismissing the BAP itself. This is an important point of discussion for BAP research as there have been many different typifications and methods for BAP (for an overview, see Sucksmith et al., 2011). The finding of more BAP extreme autistic trait scores than controls is in itself interesting. Since this is the first study to find extreme AQ scores in a (potential) non-ASC population, extremely high AQ scorers could be studied to see how many of these people would qualify for an ASC diagnosis. This is important in the BAP field since distinguishing between actual ASC and non-ASC is a very important issue when searching for different phenotypes and ultimately genotypes.

Possibly there are different genetic causes for ASC in these families. Levy et al. (2011), Sebat et al. (2007) and Weiss et al. (2008) argue that in SA families the cause of an ASC is often a rare 'de novo' gene mutation while the MA ASC may be a genetically stronger variant. The risk for ASC is hypothesized to be influenced by common genetic variants with small effects that are inherited from the parents. One of the main goals of the 'mother' study, from which these preliminary findings are drawn, is to investigate the difference between cognitive phenotypes in MA and SA families in the BAP. Losh et al. (2008) found BAP characteristics (on personality, language and social behaviour) in both parents in the majority of MA families whereas in SA families the chance was equal that one, both or neither parents had BAP characteristics.

The relationship between the different measures in this study were analysed to see if this could be an area of interest for the BAP; rather than main effects it could be that different relationships between variables related to ASC point to a broader autism phenotype. A mild empathizing-systemizing trade-off according to Baron-Cohen's E-S theory to explain the social and non-social ASC characteristics, could have been expected as this theory had has much support. However no significant relationship between empathizing and systemizing, or between other social-nonsocial domains was found. This could support the fractionable autism triad since different ASC traits do not co-occur in both BAP and controls (overlap was found between e.g. the AQ and the EQ and the SQ and attention to detail but this can be explained by the fact that these questionnaires partly measure the same characteristics).

A strength of this study is that it investigated ASC traits on a continuous scale rather than on a categorical scale (as opposed to e.g. Bolton et al. (1994), Piven et al. (1994) and Piven & Palmer (1997), who used criteria similar to those to diagnose ASC for selecting their participants). The use of a continuous scale in BAP research is important as subclinical traits as these are not thought of as either present or not, but mildly present. Categorical measures would therefore exclude what BAP studies are actually trying to detect. Also, in this study, relatives with an actual ASC diagnoses were excluded from the study (unlike e.g. Virkud et

al. (2009)) as to not mix up actual ASC and BAP. Future studies investigating the BAP should continue using this continuous scale to select their group of study.

Since most effects on BAP parents so far have been found on the social and communicational skills and pragmatic language use, future studies could focus on these areas, using new methods. For instance Wilson et al. (2012) in a preliminary fMRI study found structural abnormalities in parents of children with an ASC to phonological processing tasks and suggest these could be biological evidence for phonological processing abnormalities to be part of the BAP. Possibly the pure 'cognitive' processes impaired in ASC (and even the more in BAP) are hard to measure in normal or higher intelligent people, who's natural way of perceiving has been moulded to adapt to daily life. For instance, Lang et al. (2006) found a weaker central coherence for adolescents with an intellectual disability and comorbid ASC than age and IQ-matched controls. White et al. (2011) as well share this theory and argue that most studies that found EFT superiority for ASCs used lower functioning groups.

Most important conclusions from this study are that empathizing (as measured with the EQ) and autistic traits (as measured with AQ total score and SI and AD subscores) do not seem to be part of the BAP in a population of ASC parents that were not distinguished on multiplex and simplex status. Eyes reaction times could be part of the BAP.

Future research should be careful using the SQ in ASC and BAP studies since this might not be a valid measure in autism research. Extremely high AQ scores were found in individuals with no ASC diagnosis, this needs further study as it raises questions on the BAP and ASC boundaries. Better methodologies measuring on an automatic level of responses could improve ASC and BAP research. Not many studies have been conducted using low functioning ASC. The BAP could be more pronounced in these low functioning ASC families. Furthermore studies comparing multiplex with simplex families will reveal if this is an important distinction that should be made in the field of BAP research.

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APPENDICES

Appendix A: The EQ

Below is a list of statements. Please read each statement very carefully and rate how strongly you agree or disagree **by writing an 'X' in the appropriate box.** There are no right or wrong answers, or trick questions.

Please note: In order for the scale to be valid, you must answer every question.

		strongly agree	slightly agree	slightly disagree	strongly disagree
1.	I can easily tell if someone else wants to enter a conversation.				
2.	I find it difficult to explain to others things that I understand easily, when they don't understand it first time.				
3.	I really enjoy caring for other people.				
4.	I find it hard to know what to do in a social situation.				
5.	People often tell me that I went too far in driving my point home in a discussion.				
6.	It doesn't bother me too much if I am late meeting a friend.				
7.	Friendships and relationships are just too difficult, so I tend not to bother with them.				
8.	I often find it difficult to judge if something is rude or polite.				
9.	In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking.				
10.	When I was a child, I enjoyed cutting up worms to see what would happen.				
11.	I can pick up quickly if someone says one thing but means another.				
12.	It is hard for me to see why some things upset people so much.				
13.	I find it easy to put myself in somebody else's shoes.				
14.	I am good at predicting how someone will feel.				
15.	I am quick to spot when someone in a group is feeling awkward or				

	uncomfortable.				
16.	If I say something that someone else is offended by, I think that that's their problem, not mine.				
17.	If anyone asked me if I liked their haircut, I would reply truthfully, even if I didn't like it.				
18.	I can't always see why someone should have felt offended by a remark.				
19.	Seeing people cry doesn't really upset me.				
20.	I am very blunt, which some people take to be rudeness, even though this is unintentional.				
21.	I don’t tend to find social situations confusing.				
22.	Other people tell me I am good at understanding how they are feeling and what they are thinking.				
23.	When I talk to people, I tend to talk about their experiences rather than my own.				
24.	It upsets me to see an animal in pain.				
25.	I am able to make decisions without being influenced by people's feelings.				
26.	I can easily tell if someone else is interested or bored with what I am saying.				
27.	I get upset if I see people suffering on news programs.				
28.	Friends usually talk to me about their problems as they say that I am very understanding.				
29.	I can sense if I am intruding, even if the other person doesn't tell me.				
30.	People sometimes tell me that I have gone too far with teasing.				
31.	Other people often say that I am insensitive, though I don’t always see why.				
32.	If I see a stranger in a group, I think that it is up to them to make an effort to join in.				
33.	I usually stay emotionally detached when watching a film.				
34.	I can tune into how someone else feels rapidly and intuitively.				

35.	I can easily work out what another person might want to talk about.				
36.	I can tell if someone is masking their true emotion.				
37.	I don't consciously work out the rules of social situations.				
38.	I am good at predicting what someone will do.				
39.	I tend to get emotionally involved with a friend's problems.				
40.	I can usually appreciate the other person's viewpoint, even if I don’t agree with it.				

Appendix B: The SQ

Below is a list of statements. Please read each statement very carefully and rate how strongly you agree or disagree with it by writing an 'X' in the appropriate box. There are no right or wrong answers, or trick questions.

Please note: In order for the scale to be valid, you must answer every question.

		strongly agree	slightly agree	slightly disagree	strongly disagree
1.	I find it very easy to use train timetables, even if this involves several connections.				
2.	I like music or book shops because they are clearly organized.				
3.	I would not enjoy organizing events e.g. fundraising evenings, fetes, conferences.				
4.	When I read something, I always notice whether it is grammatically correct.				
5.	I find myself categorizing people into types (in my own mind).				
6.	I find it difficult to read and understand maps.				
7.	When I look at a mountain, I think about how precisely it was formed.				
8.	I am not interested in the details of exchange rates, interest rates, stocks and shares.				
9.	If I were buying a car, I would want to obtain specific information about its engine capacity.				
10.	I find it difficult to learn how to program video recorders.				
11.	When I like something I like to collect a lot of different examples of that type of object, so I can see how they differ from each other.				
12.	When I learn a language, I become intrigued by its grammatical rules.				
13.	I like to know how committees are structured in terms of who the different committee members represent or what their functions are.				

14.	If I had a collection (e.g. CDs, coins, stamps), it would be highly organized.				
15.	I find it difficult to understand instruction manuals for putting appliances together.				
16.	When I look at a building, I am curious about the precise way it was constructed.				
17.	I am not interested in understanding how wireless communication works (e.g. mobile phones).				
18.	When travelling by train, I often wonder exactly how the rail networks are coordinated.				
19.	I enjoy looking through catalogues of products to see the details of each product and how it compares to others.				
20.	Whenever I run out of something at home, I always add it to a shopping list.				
21.	I know, with reasonable accuracy, how much money has come in and gone out of my bank account this month.				
22.	When I was young I did not enjoy collecting sets of things e.g. stickers, football cards etc.				
23.	I am interested in my family tree and in understanding how everyone is related to each other in the family.				
24.	When I learn about historical events, I do not focus on exact dates.				
25.	I find it easy to grasp exactly how odds work in betting.				
26.	I do not enjoy games that involve a high degree of strategy (e.g. chess, Risk, Games Workshop).				
27.	When I learn about a new category I like to go into detail to understand the small differences between different members of that category.				
28.	I do not find it distressing if people who live with me upset my routines.				
29.	When I look at an animal, I like to know the precise species it belongs to.				

30.	I can remember large amounts of information about a topic that interests me e.g. flags of the world, airline logos.				
31.	At home, I do not carefully file all important documents e.g. guarantees, insurance policies.				
32.	I am fascinated by how machines work.				
33.	When I look at a piece of furniture, I do not notice the details of how it was constructed.				
34.	I know very little about the different stages of the legislation process in my country.				
35.	I do not tend to watch science documentaries on television or read articles about science and nature.				
36.	If someone stops to ask me the way, I'd be able to give directions to any part of my home town.				
37.	When I look at a painting, I do not usually think about the technique involved in making it.				
38.	I prefer social interactions that are structured around a clear activity, e.g. a hobby.				
39.	I do not always check off receipts etc. against my bank statement.				
40.	I am not interested in how the government is organised into different ministries and departments.				
41.	I am interested in knowing the path a river takes from its source to the sea.				
42.	I have a large collection e.g. of books, CDs, videos etc.				
43.	If there was a problem with the electrical wiring in my home, I'd be able to fix it myself.				
44.	My clothes are not carefully organized into different types in my wardrobe.				
45.	I rarely read articles or webpages about new technology.				
46.	I can easily visualize how the motorways in my region link up.				

47.	When an election is being held, I am not interested in the results for each constituency.				
48.	I do not particularly enjoy learning about facts and figures in history.				
49.	I do not tend to remember people's birthdays (in terms of which day and month this falls).				
50	When I am walking in the country, I am curious about how the various kinds of trees differ.				
51.	I find it difficult to understand information the bank sends me on different investment and saving systems.				
52.	If I were buying a camera, I would not look carefully into the quality of the lens.				
53.	If I were buying a computer, I would want to know exact details about its hard drive capacity and processor speed.				
54.	I do not read legal documents very carefully.				
55.	When I get to the checkout at a supermarket I pack different categories of goods into separate bags.				
56.	I do not follow any particular system when I'm cleaning at home.				
57.	I do not enjoy in-depth political discussions.				
58.	I am not very meticulous when I carry out D.I.Y or home improvements.				
59.	I would not enjoy planning a business from scratch to completion.				
60.	If I were buying a stereo, I would want to know about its precise technical features.				
61.	I tend to keep things that other people might throw away, in case they might be useful for something in the future.				
62.	I avoid situations which I cannot control.				
63.	I do not care to know the names of the plants I see				
64.	When I hear the weather forecast, I am not very interested in the meteorological patterns				
65.	It does not bother me if things in the house are not in their proper				

	place.				
66.	In maths, I am intrigued by the rules and patterns governing numbers.				
67.	I find it difficult to learn my way around a new city.				
68.	I could list my favourite 10 books, recalling titles and authors' names from memory.				
69.	When I read the newspaper, I am drawn to tables of information, such as football league scores or stock market indices.				
70.	When I'm in a plane, I do not think about the aerodynamics				
71.	I do not keep careful records of my household bills.				
72.	When I have a lot of shopping to do, I like to plan which shops I am going to visit and in what order.				
73.	When I cook, I do not think about exactly how different methods and ingredients contribute to the final product.				
74.	When I listen to a piece of music, I always notice the way it's structured.				
75.	I could generate a list of my favourite 10 songs from memory, including the title and the artist's name who performed each song.				

Appendix C: The AQ

How to fill out the questionnaire

Below are a list of statements. Please read each statement very carefully and rate how strongly you agree or disagree with it by circling your answer.

DO NOT MISS ANY STATEMENT OUT.

		strongly agree	slightly agree	slightly disagree	strongly disagree
1.	I prefer to do things with others rather than on my own.				
2.	I prefer to do things the same way over and over again.				
3.	If I try to imagine something, I find it very easy to create a picture in my mind.				
4.	I frequently get so strongly absorbed in one thing that I lose sight of other things.				
5.	I often notice small sounds when others do not.				
6.	I usually notice car number plates or similar strings of information.				
7.	Other people frequently tell me that what I've said is impolite, even though I think it is polite.				
8.	When I'm reading a story, I can easily imagine what the characters might look like.				
9.	I am fascinated by dates.				
10.	In a social group, I can easily keep track of several different people's conversations.				
11.	I find social situations easy.				
12.	I tend to notice details that others do not.				
13.	I would rather go to a library than a party.				
14.	I find making up stories easy.				
15.	I find myself drawn more strongly to people than to things.				

16.	I tend to have very strong interests which I get upset about if I can't pursue.				
17.	I enjoy social chit-chat.				
18.	When I talk, it isn't always easy for others to get a word in edgeways.				
19.	I am fascinated by numbers.				
20.	When I'm reading a story, I find it difficult to work out the characters' intentions.				
21.	I don't particularly enjoy reading fiction.				
22.	I find it hard to make new friends.				
23.	I notice patterns in things all the time.				
24.	I would rather go to the theatre than a museum.				
25.	It does not upset me if my daily routine is disturbed.				
26.	I frequently find that I don't know how to keep a conversation going.				
27.	I find it easy to "read between the lines" when someone is talking to me.				
28.	I usually concentrate more on the whole picture, rather than the small details.				
29.	I am not very good at remembering phone numbers.				
30.	I don't usually notice small changes in a situation, or a person's appearance.				
31.	I know how to tell if someone listening to me is getting bored.				
32.	I find it easy to do more than one thing at once.				
33.	When I talk on the phone, I'm not sure when it's my turn to speak.				
34.	I enjoy doing things spontaneously.				
35.	I am often the last to understand the point of a joke.				

36.	I find it easy to work out what someone is thinking or feeling just by looking at their face.				
37.	If there is an interruption, I can switch back to what I was doing very quickly.				
38.	I am good at social chit-chat.				
39.	People often tell me that I keep going on and on about the same thing.				
40.	When I was young, I used to enjoy playing games involving pretending with other children.				
41.	I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).				
42.	I find it difficult to imagine what it would be like to be someone else.				
43.	I like to plan any activities I participate in carefully.				
44.	I enjoy social occasions.				
45.	I find it difficult to work out people's intentions.				
46.	New situations make me anxious.				
47.	I enjoy meeting new people.				
48.	I am a good diplomat.				
49.	I am not very good at remembering people's date of birth.				
50	I find it very easy to play games with children that involve pretending.				

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