

Article

Identifying Autism through Empathizing and Systemizing Abilities

Evi van der Zee * and Jan Derksen

Department of Clinical Psychology, Radboud University, Montessorilaan 3 A7, 6525 HR Nijmegen, The Netherlands; j.derksen@bsi.ru.nl

* Correspondence: evivanderzee@planet.nl

Received: 20 July 2017; Accepted: 12 October 2017; Published: 17 October 2017

Abstract: Baron-Cohen's Empathizing-Systemizing theory plays a central role in this study due to its success in interpreting the core impairments and strengths in autism. The theory states that low empathizing skills are responsible for the social difficulties in autism, and that high levels of systemizing are accountable for the restricted, repetitive patterns of behavior in autism. We therefore hypothesized that there is a significant discrepancy between a child's empathizing and systemizing abilities when autism is present. We developed Dutch versions of the questionnaires that are associated with the theory: the Autism Quotient questionnaire, the Empathizing Quotient questionnaire and the Systemizing Quotient questionnaire. As hypothesized, the scores of children with autism on the Empathizing Quotient questionnaire and on the Systemizing Quotient questionnaire (EQ-SQ Child_NL) show a significant difference. Furthermore, the EQ-SQ Child_NL predicts the score of children in general on the Dutch version of the Autism Quotient questionnaire (AQ Child_NL).

Keywords: autism; empathizing quotient; systemizing quotient; Autism Quotient; Baron-Cohen

1. Introduction

Autism has been described as an empathy disorder, because the core impairments are seen in one's social behavior (Decety and Meyer 2008; Gillberg 1992). Ever since 1943, when Kanner and Asperger wrote about children with typical behavior, theories have been developed to interpret this behavior. The extreme heterogeneity of features within the collective term autism seems to hamper research into interpreting the core impairments and causes of autism. Initially, research concentrated on the environment, then on psychological aspects, and later on biological aspects became part of the research in this area. Psychological theories that are still used by today's professionals focus on executive dysfunction, weak central coherence and impairment in the theory of mind. These three theoretical approaches combined are able to interpret some core impairments of autism (Happé and Frith 2006). The theory of executive dysfunction indicates that people with autism are not able to plan actions or to distribute attention. The weak central coherence theory states that people with autism are unable to understand items of information within their wider context. The theory of mind (TOM) stands for the assumption that autism involves a fundamental problem of understanding the minds of others. TOM assumes that individuals with autism fail to solve even quite simple problems that require empathy (Ellis and Gunter 1999). For that reason, theory of mind incorporates the term 'empathy'. Extends the TOM through the concept of empathizing, and thereby including an emotional response dimension (Baron-Cohen 1995). He states that, while many psychiatric conditions entail an impairment in empathy, autism is specific in this area, along with a heightened drive to systemizing. According to this two-dimensional model, individuals with autism have low empathizing skills combined with high systemizing skills. Consequently, this model is better able to interpret most of the occurring behavioral,

both social and non-social, features of autism. Since its success in interpreting the core impairments and strengths in autism, the present study focuses on the E-S model by reviewing evidence and re-analyzing the concepts.

1.1. The Empathizing-Systemizing Model

According to the E-S model (Baron-Cohen 1995), low empathizing skills are responsible for the social difficulties that individuals with autism experience. Empathizing is the drive to identify another person's thoughts or emotions, and to respond to their mental state with an appropriate feeling. In addition to the social communication deficits, according to DSM, the diagnosis of autism requires the presence of restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association 2013). The E-S model further assumes that high levels of systemizing are accountable for these patterns of behavior (Baron-Cohen 2002). Systemizing is the most powerful way to predict change, because systemizing allows a search for structure (patterns, rules, regularities, and periodicity) in data using an inductive process. The goal of systemizing is to test if the changing data is part of a system. In order to quantify these dimensions, the self-report questionnaires Empathy Quotient (EQ) and Systemizing Quotient (SQ) were developed (Baron-Cohen et al. 2003; Baron-Cohen and Wheelwright 2004). For measuring the degree to which an adult with normal intelligence has the traits associated with autism, the Autism Spectrum Quotient (AQ) was developed (Baron-Cohen et al. 2001). The AQ is also measured by a self-report questionnaire assessing 5 different areas: social skills, attention switching, attention to detail, communication and imagination. Items were selected from the domains in the "triad" of autistic symptoms, and from demonstrated areas of cognitive abnormality in autism (American Psychiatric Association 1994; Rutter 1978; Wing and Gould 1979). Additionally, developed a children's version of the AQ, such that a comparison with adolescent and adult data was possible and changes in the profile of autistic traits with age could be measured (Auyeung et al. 2007). This helps to determine how stable autistic traits are across the lifespan. The AQ-Child is also a useful screening measure that can identify children at risk of autism in a clinical setting. Research shows that the AQ-Child has a good test-retest reliability and a high internal consistency, and that the Total AQ score is a good indicator of autism diagnosis. The EQ-SQ shows good test-retest reliability, a high internal consistency and is capable of identifying the poor empathizing skills typically associated with autism (Auyeung et al. 2009).

1.2. The Empathizing-Systemizing Instruments

Using the three empathizing-systemizing instruments, the present study is able to review the E-S model and to re-analyze the two concepts: empathizing and systemizing. The discrepancy between an individual's empathizing and systemizing abilities has been observed in adults, adolescents and children, but never in the Netherlands or in the context of developing an instrument to identify children with autism at an early age. Therefore, the present study aimed to develop a Autism Quotient questionnaire, as well as an Empathy and Systemizing Quotient questionnaire, suitable for children in the Netherlands (AQ Child_NL and EQ-SQ Child_NL). This study is important, because it provides information about the behavior of a Dutch population of typical developing children and children with autism age 4–12 years, as reported by their parents. This information, using AQ, EQ and SQ, has not been collected and analyzed in a Dutch population before. The EQ meets and measures DSM 5 diagnostic criterion A: persistent deficits in social communication and social interaction across multiple contexts. The SQ meets and measures DSM 5 diagnostic criterion B: restricted, repetitive patterns of behavior, interests or activities. Finally, the AQ meets and measures the severity of the impairments. In this way, the results of the present study are useful in future research.

1.3. Identifying Autism in Children

We hypothesize that the EQ-SQ Child_NL predicts the score of children on the AQ Child_NL, and we also hypothesize that children with autism show a significant amount of difference in their

scores on the EQ Child_NL (expected low scores) and SQ Child_NL (expected high scores). As seen in a previous study, where students were compared to a group of adults with autism, their AQ score was successfully predicted from their EQ and SQ scores. That study concluded that the position of an individual on the autism spectrum, as defined by the number of autistic traits an individual possesses, is a function of their empathizing and systemizing scores (Wheelwright et al. 2006). We hypothesize that this outcome will also be found in children aged 4–12. Based on this previous study, we further hypothesize that gender differences will be able to be identified. In the general population, adult males score significantly higher than adult females on the AQ and on the SQ, and significantly lower on the EQ. Therefore, we hypothesize that typical developing girls score higher on the EQ and lower on the SQ than typical developing boys do. Early research (Baron-Cohen et al. 1985; Baron-Cohen et al. 2001) showed that autism is much more common among men than women, and autistic traits are more common among mathematicians, scientists, engineers and their families. These findings led to the assumption that people with autism have a typical male cognitive style; an extreme male brain (Baron-Cohen 2002). Individuals with autism are therefore assumed to have higher systemizing skills. Previous research (Wheelwright et al. 2006) also showed that individuals with autism scored higher than gender-matched controls on the AQ and SQ, and showed no gender difference on any of the three measures. The previous study furthermore showed that the EQ had a weak negative correlation with the SQ, and concluded that empathizing is largely but not completely independent of systemizing. For this reason, we also hypothesize that there is a trade-off between both dimensions. This trade-off suggests that people with autism experience a specific combination of empathizing and systemizing abilities.

In short, the present study focuses on the E-S model by reviewing evidence and re-analyzing the concepts of empathizing and systemizing. Since low empathizing skills combined with high systemizing skills in adults is specific to autism, and because of the cohesion with the DSM 5 criteria for autism, the E-S theory is worthwhile examining.

2. Method

We used a cross-sectional survey research design using questionnaires as a tool. We analyzed the results of two groups: a group of children diagnosed with autism and a group of typical developing children, both aged 4–12 years. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

2.1. Participants

The autism group comprised $N = 37$ parents of children aged 4 to 12 years who stated that their child had been diagnosed with autism (27 males, 8 females, 2 unknown). The sex ratio of 3.4:1 (m:f) is similar to that found in other autism samples (Baron-Cohen et al. 2001; Klin et al. 1995). The mean age of the autism group was 8.54 years, with a standard deviation score of 2.063. The youngest children were 5 years old, and the eldest children were 12 years old. Parents reported the diagnosis, and reported the name of the psychiatrists involved in the diagnostic procedure, as well as the name of the institution involved in the procedure. All children had been diagnosed by psychiatrists or psychologists associated with appropriate establishments. For this reason, we are assured that the diagnosis is accurate. We recruited the participants via several (autism) sources, including schools, autism parent-support groups, specialized clinics and announcements in autism newsletters, Facebook, Twitter and several autism-related web pages. The participants were asked to complete the three translated questionnaires AQ Child_NL, EQ Child_NL and SQ Child_NL. Parents of 37 children with autism completed these three questionnaires. The typical group comprised $N = 93$ parents of children aged 4 to 12 years, who stated that their child had not had a psychological diagnosis (49 males and 44 females). The mean age of the children in the typical group was 7.66 years, with a standard deviation

score of 2.487. The youngest children were 4 years old, and the eldest children were 12 years old. There was a statistical age difference present between the two groups ($t = 1422$, $p = 0.164$). The children in the typical group were slightly younger than the children in the autism group. We recruited the participants in the typical group via 66 randomly chosen regular and normal elementary schools in the Netherlands. We are assured that the children are not in need of any kind of special attention, since this was one of the first questions in the questionnaire. Unfortunately, we did not ask for more information about either group. Adding more questions to the questionnaire would perhaps have led to even fewer parents willing to participate. We are well aware that future research would benefit from knowing more descriptive information on the samples of children with autism.

2.2. Instruments

Note: The English versions of the instruments used, as well as the Dutch AQ version, were obtained from the Autism Research Centre (UK) website.

This paper is the first to use the AQ Child and the EQ-SQ Child in a Dutch population. Therefore, we needed to translate the original English versions. Because the AQ Adult was thoroughly translated into Dutch using the backward translation procedure by (Hoekstra et al. 2008), and because the AQ Child items do not differ from the items in the AQ Adult, we chose to use their translation in the current paper, leading to the AQ Child_NL (NL stands for The Netherlands). In order to translate the EQ-SQ Child, we asked four university-trained adults to separately translate the EQ-SQ Child questionnaire into Dutch. We discussed and reviewed the four versions, which eventually led to the current version of the EQ-SQ Child_NL. We combined the EQ Child_NL and SQ Child_NL for ease of administration. The EQ-SQ Child_NL has a total of 55 items: 27 EQ items and 28 SQ items. Both translated questionnaires are shown in Appendix A.

The questionnaires have 4-point Likert response scales, with the following answer categories: 'definitely agree'; 'slightly agree'; 'slightly disagree' and 'definitely disagree'. On the AQ Child_NL, participants can produce a score of 0, 1, 2 or 3 on each item. Total AQ Child_NL scores were represented by the sum of each item score. The minimum AQ Child_NL score (0) indicates no autistic traits, and the maximum score (150) suggests full endorsement of all autistic items. On the EQ-SQ Child_NL, participants can produce a score of 2, 1 or 0 on each item. The EQ Child_NL has a maximum score of 54 and the SQ Child_NL has a maximum score of 56. On all questionnaires, approximately half of the items were worded to produce a "disagree" response, and half to produce an "agree" response to avoid a response bias either way. All questionnaires are parent-report questionnaires to avoid inaccuracies related to a child's reading and comprehension abilities.

2.3. Procedure

We recruited parents of children with autism via several (autism-related) sources, and asked them to send an e-mail to sign up so they could receive a digital version of the questionnaires. The parents returned the completed questionnaires again by e-mail. Over 70 parents of children with autism signed up, but only 46 questionnaires were completed and returned. Eventually, 37 questionnaires were appropriate for the study, because the other 9 participants were older than 12 and were therefore excluded. We recruited the parents in the typical group via 66 randomly chosen elementary schools in the Netherlands. The schools placed our request online or in their bulletins. 107 parents completed an online version of the three translated questionnaires. Unfortunately, only 93 questionnaires were appropriate. We excluded 14 questionnaires because these children had been diagnosed with other mental disorders, such as ADHD and anxiety disorder.

2.4. Statistical Analysis

We used SPSS (Statistical Package for Social Science) 22 to analyze the data. The alpha level of significance was set at 0.05, two-tailed. We executed descriptive statistics for all variables to check for normality. We did find outliers in the autism group, but they did not distort the means. Sensitivity

and specificity were set using *receiver-operating-characteristic analysis*. We calculated means and we compared the mean total scores of the AQ Child_NL, EQ Child_NL and SQ Child_NL for both sexes and for both groups with Independent Samples *t*-test. We examined the probable relationship between the three questionnaires using a *bivariate correlation* on the mean total scores of each pair of questionnaires. Finally, we used *multiple linear regression* to examine whether gender and diagnosis predict a child's scores on the Dutch children's versions of AQ, EQ and SQ.

3. Results

In order to analyze and test the Dutch children's versions of the AQ, EQ and SQ, we first examined the psychometric features and set cut-off scores for the Dutch versions. Then, we examined gender differences and the relationship between one's AQ Child_NL, EQ Child_NL and SQ Child_NL score using correlation. Finally, we examined the validity and specificity using multiple linear regression.

3.1. Psychometric Features and Cut-off Scores of the AQ Child_NL and EQ-SQ Child_NL

The AQ Child_NL has good internal consistency (autism group α 0.843; typical group α 0.910). The consistency of the AQ's 5 areas associated with autism was also measured: Social Skills, autism group α 0.706, typical group α 0.789; Attention Switching, autism group α 0.737, typical group α 0.680; Attention to detail, autism group α 0.565, typical group α 0.758; Communication, autism group α 0.636, typical group α 0.830; Imagination, autism group α 0.696, typical group α 0.579. We found a mean total AQ Child_NL score in the autism group of 98.86 (SD 23.401; minimum score = 73; maximum score = 132) and in the typical group of 47.92 (SD 19.153; minimum score 10; maximum score = 109). We conducted an independent-samples *t*-test to compare the mean total AQ score in the autism group with that in the typical group. A difference was found in these scores on the AQ ($t(128) = -12.82, p < 0.001$). We found that children with autism score significantly higher on the AQ Child_NL than typical developing children do. The scores on the AQ Child_NL of parents with a child diagnosed with autism differ significantly from the scores of parents of typical developing children. Receiver-operating-characteristic analyses showed that using a cut-off score of 74 for the AQ Child_NL has high sensitivity (97%), high specificity (99%), and a good area under the ROC-curve (0.977). Therefore, the cut-off score on the AQ Child_NL was set at 74. Children with autism aged 4–12 will produce a score of 74 or higher on the AQ Child_NL.

The EQ Child_NL also has good internal consistency (autism group α 0.916; typical group α 0.892), and our study shows a mean total score of 16.84 (SD 6.673) in the autism group and 32.40 (SD 10.352) in the typical group. Independent-samples *t*-test showed a difference between the scores on the EQ of parents with a child diagnosed with autism and parents of typical developing children ($t(128) = 8.46, p < 0.001$). Children with autism score significantly lower on the EQ Child_NL than typical developing children do. For the EQ Child_NL we were unable to set a reliable cut-off score using receiver-operating-characteristic analyses because of a poor area under the curve (0.119). Analyzing the scores qualitatively within the autism group, we were able to set a cut-off score at 24, as shown in Figure 1. Unfortunately, we are well aware that using this method is not an acceptable alternative to the gold standard. Therefore, we have to conclude that we cannot set a reliable cut-off score for the EQ Child_NL.

The SQ Child_NL shows good internal consistency (autism group α 0.772; typical group α 0.720) and our study found a mean total score in the autism group of 26 (SD 8.273) and a score of 20.57 (SD 7.555) in the group of typical developing children. Independent-samples *t*-test showed that there is a difference between these scores in both groups ($t(128) = -3.599, p < 0.001$). Children with autism score significantly higher on the SQ Child_NL than typical developing children do. On the SQ Child_NL, a cut-off score could be set at 21 based on receiver-operating-characteristic analyses, where we found a sensitivity of 68%, a specificity of 62%, and an area under the ROC-curve of 0.685.

In short, children age 4–12 years in the Netherlands diagnosed with autism produce a total AQ score of 74 and higher, a total EQ score of 24 and lower and a total SQ score of 21 and higher. The scores

of children with autism are significantly higher on AQ Child_NL and SQ Child_NL and significantly lower on the EQ Child_NL compared to typical developing children.

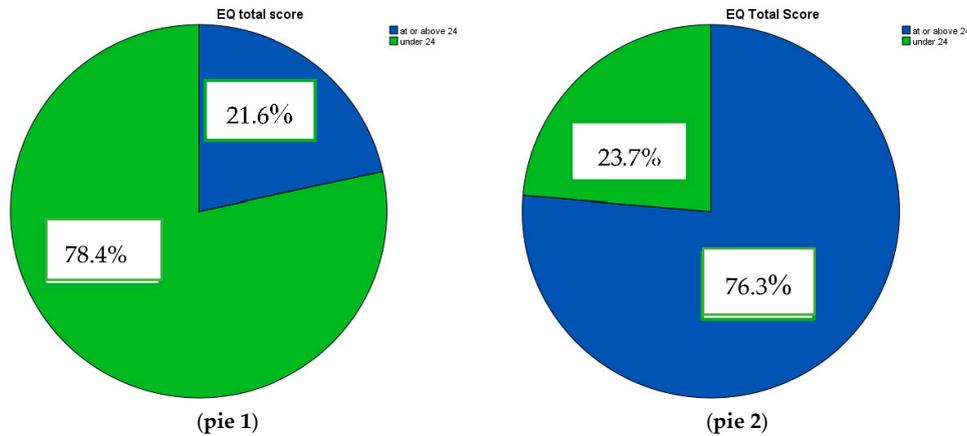


Figure 1. Percentages EQ total score in the autism group (pie 1) and in the typical group (pie 2), divided into scores under 24 and scores above 24.

3.2. Can Gender Differences be Identified?

First, AQ Child_NL mean total scores, EQ Child_NL mean total scores and SQ Child_NL mean total scores of both groups are displayed in Table 1. Second, independent *t*-tests were carried out separately for each questionnaire in order to investigate whether the scores between boys and girls in both groups are significantly different. In the autism group, no significant difference in scores was found between boys and girls for any of the three questionnaires ($t(32) = 0.369, p = 0.715; p > 0.05$ for the AQ Child_NL, $t(33) = -0.661, p = 0.513; p > 0.05$ for the EQ Child_NL and $t(33) = -0.006, p = 0.995; p > 0.05$ for the SQ Child_NL). In the typical group, we did find significant gender differences on the AQ Child_NL ($t(91) = 3.217, p = 0.002; p < 0.05$) and EQ Child_NL ($t(91) = -2.684, p = 0.009; p < 0.05$). On the SQ Child_NL, no significant differences were found ($t(91) = 1.019, p = 0.311; p > 0.05$). We therefore conclude that, when autism is present, the scores of boys and girls do not significantly differ. In the typical group, however significant differences were found on the AQ Child_NL (boys produce higher scores) and on the EQ Child_NL (girls produce higher scores). No differences between boys and girls were found on the SQ Child_NL.

Table 1. Descriptive statistics AQ Child_NL, EQ Child_NL and SQ Child_NL.

Instruments	N		Mean		SD		Min		Max	
	Autism	Typical								
AQ Total Score	34 *	93	101.06	47.92	16.749	19.153	73	10	132	109
AQ Score Boys	26	49	101.65	53.69	17.497	20.971	73	22	132	109
AQ Score Girls	8	44	99.12	41.50	14.952	14.622	75	10	118	83
EQ Total Score	35 **	93	16.83	32.40	6.866	10.352	5	7	33	52
EQ Score Boys	27	49	16.41	29.76	6.541	10.995	5	7	33	51
EQ Score Girls	8	44	18.25	35.34	8.190	8.803	6	11	31	52
SQ Total Score	35 **	93	25.49	20.57	7.845	7.555	11	5	40	39
SQ Score Boys	27	49	25.48	21.33	7.439	7.392	11	6	39	39
SQ Score Girls	8	44	25.50	19.73	9.666	7.729	11	5	40	37

* One participant did not complete the whole AQ questionnaire and is therefore excluded. ** Two participants are excluded because whether they are male or female is unknown.

3.3. Can One’s Empathizing and Systemizing Skills Predict One’s AQ Child_NL Score?

The probable relationship between one’s Autism Quotient and one’s Empathizing and Systemizing skills was examined using correlation. The mean total scores of each questionnaire were therefore

used. In the typical group, a significant negative correlation was found between the AQ Child_NL and the EQ Child_NL ($r = -0.679; n = 93; p < 0.001$). In the autism group, we also found a negative correlation ($r = -0.075; n = 36; p = 0.665$), but it was not statistically significant. For the AQ Child_NL and SQ Child_NL, we found significant positive correlations in both groups (typical group: $r = 0.310; n = 93; p = 0.003$; autism group: $r = 0.656; n = 36; p < 0.001$). No significantly correlations were found in both groups between the EQ Child_NL and SQ Child_NL (typical group: $r = -0.012; n = 93; p = 0.910$; autism group: $r = 0.062; n = 37; p = 0.714$). Figure 2 shows the correlations of the typical group graphically.

In short, in the typical group, when the AQ score increases, the EQ score decreases and the SQ score increases. In the autism group, when the AQ score increases, the SQ score also increases. Therefore, low empathizing skills and high systemizing skills are present when one's AQ Child_NL score increases.

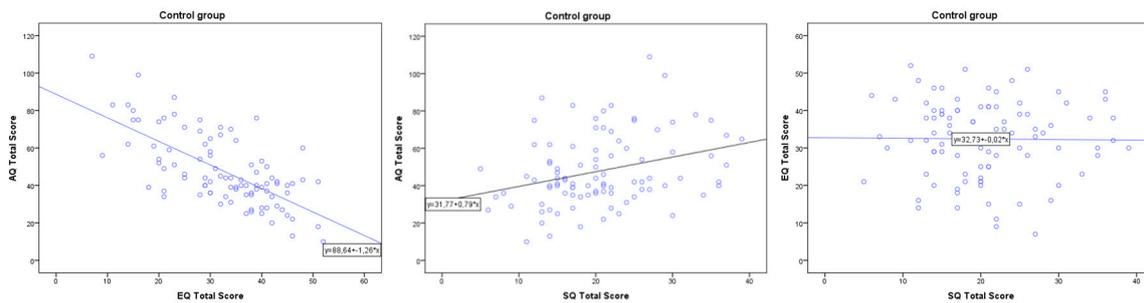


Figure 2. Strong negative relationship between the AQ Child_NL and EQ Child_NL in the typical group; strong positive relationship between the AQ Child_NL and the SQ Child_NL in the autism group.

3.4. Can Gender and Diagnosis Predict One's AQ, EQ or SQ Child_NL Score?

Our results showed that children with autism produce higher scores on AQ and SQ and lower scores on EQ than typical children do. Furthermore, typical boys score higher on AQ and SQ and lower on EQ than typical girls do. These findings raised the question as to whether gender and diagnosis are essential factors in empathizing and systemizing skills and could therefore be central factors in one's AQ, EQ and/or SQ Child_NL scores. Answering this question is important for the specificity and validity of the three instruments.

We used multiple linear regression in order to answer the question as to whether gender and a child's diagnosis can predict one's AQ Child_NL total score. A regression equation was found ($F(3, 124) = 113.73, p < 0.001$), with an R^2 of 0.647. As shown in Tables 2 and 3, children's predicted AQ is equal to $164.34 - 50.71(\text{diagnosis}) - 10.18(\text{gender})$, where diagnosis is coded as 0 and gender is coded as 1. Children's AQ score increased 10.18 points when they were boys, and increased 50.71 points when they were diagnosed with autism. Both gender ($t = -13.77, p < 0.001$) and diagnosis ($t = -3.07, p = 0.003$) are predictors of one's AQ total score.

Table 2. Regression equation AQ gender and diagnosis.

AQ Total Score					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	73,325,840	2	36,662,920	113,728	.000 ^b
Residual	39,974,318	124	322,374		
Total	113,300,157	126			

^b. Predictors: (Constant), Gender, Diagnosis.

Table 3. Regression gender x diagnosis.

AQ Total Score					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1	(Constant)	164,343	7235		22,716 000
	Diagnosis	−50,714	3684	−.752	−13,767 000
	Gender	−10,176	3317	−.168	−3068 003

For the EQ Child_NL, we also found a regression equation ($F(2, 125) = 39.64, p < 0.001$) with an R^2 of 0.388. Children's predicted EQ was equal to $-3.46 + 14.40$ (diagnosis) $+ 4.80$ (gender). Children's EQ total score increased 14.40 points when autism was not present, and increased 4.80 points when they were girls. Both gender ($t = 2.80, p = 0.006$) and diagnosis ($t = 7.62, p < 0.001$) are predictors of one's EQ total score. For the children's SQ score, on the other hand, only diagnosis was found to be a predictor ($t = -2.97, p = 0.004$). We found a regression equation ($F(2, 125) = 5.66, p = 0.004$), with an R^2 of 0.083. Children's predicted SQ was equal to $31.64 - 4.61$ (diagnosis) $- 1.26$ (gender). Children's SQ total score increased 4.61 points when they were diagnosed with autism, and increased 1.26 points when they were boys.

In short, when autism is present, the AQ Child_NL score increases, the EQ Child_NL score decreases and the SQ Child_NL score increases. Gender only influences the scores on the AQ Child_NL (boys score higher) and on the EQ Child_NL (girls score higher).

4. Discussion

According to the E-S model of (Baron-Cohen 1995), impairment in empathizing is specific in autism, along with a heightened drive to systemizing. The statement of Baron-Cohen that his E-S theory is the best theory in explaining the occurring behavior in autism, and because of its success in interpreting the core impairments and strengths in autism, the present study focuses on the E-S model (Baron-Cohen 1995). We translated the three questionnaires in order to review and re-analyze the E-S model among children in the Netherlands.

The AQ Child_NL showed good overall internal consistency. However, the internal consistency of three of the five subscales in the autism group was not satisfactory—i.e., for Attention to detail, Communication, and Imagination—and was not consistent with previous research (Auyeung et al. 2007). Furthermore, in the typical group, the internal consistency of the subscale Imagination was also not satisfactory. It is possible that this inconsistency with previous research is due to the fact that we did not test the children on their IQ. It is also possible that the small sample size of the autism group is responsible for this finding. However, since the internal consistency of the subscales is not fully satisfactory in both groups, we suggest that future research could focus on redesigning the subscales of the AQ Child_NL, perhaps by following the DSM 5 criteria of autism: social communication, social interaction across multiple contexts and restricted, repetitive patterns of behavior.

The Discrepancy between an Individual's Empathizing and Systemizing Abilities are Responsible for Higher Scores on the AQ Child_NL.

The presence of autism was measured by the AQ Child_NL, and autism could be suggested when a child's total score on the AQ is higher than 74. The English version of the AQ Child set a cut-off score at 76 (Auyeung et al. 2007). As predicted, children with autism score higher on the AQ than typical developing children do, which shows the reasonable face validity of the AQ Child_NL. We also found a good internal consistency on the AQ Child_NL and SQ Child_NL. We were unable to set a reliable cut-off for the EQ Child_NL, due to a poor area under the curve (ROC). Therefore, we had to analyze the scores using a qualitative process, and were eventually able to set a reliable cut-off score. The AQ Child_NL shows reasonable construct validity. Items intending to measure each of the 5 domains

of interest (social, communication, imagination, attention to detail, and attention switching) show high alpha coefficients. These findings are consistent with the findings on the English AQ adolescent version (Baron-Cohen et al. 2006) on the English AQ Child version (Auyeung et al. 2007) and on the English EQ-SQ child version (Auyeung et al. 2009).

As predicted, we found that the scores on the AQ Child_NL differ significantly between typical developing boys and girls. Boys produce higher scores on the AQ Child_NL. Also, on the EQ Child_NL, we found significantly different scores between typical developing boys and girls. Girls produce higher scores than boys. No differences between typical boys and girls were found on the SQ Child_NL. When autism is present, the scores of boys and girls do not significantly differ for any of the three questionnaires. These findings are consistent with the findings on the English AQ children's version, where gender differences were found in the control group but not in the autism group. The high male to female ratio, which limits the number of females available to participate in research studies, may be responsible for this issue. Therefore, research was conducted in England in which 811 adults (454 females) with autism and 3906 typical control adults completed the EQ, SQ and AQ (Baron-Cohen et al. 2014). It was found that typical females, on average, scored higher on the EQ, and typical males scored higher on the SQ and AQ. In the autism group, on the AQ, EQ and SQ, normative gender differences were attenuated, but not absent. Gender differences were smaller in the autism group than in the control group. Also, in the study of the English EQ children's version gender differences were found on the EQ (females score higher than males) and children with autism score lower on the EQ than typical developing children do, suggesting that the EQ child is capable of detecting the poor empathizing skills in children typically associated with autism (Auyeung et al. 2009). We do have to state that the gender differences in our study may be underrepresented. The autism group only had 8 females, compared to 27 males. The typical group had a more equal distribution of males ($n = 49$) and females ($n = 44$). On the SQ Child_NL, we did not find gender differences, but the results did show that children diagnosed with autism score significantly higher than typical developing children do. In the English SQ child study, similar results were found, except that they did find gender differences on the SQ in general. Boys scored significantly higher than girls, consistent with studies demonstrating a male advantage for visuo-spatial ability and a preference for 'systems' (Auyeung et al. 2009).

We finally hypothesized that children with autism would score significantly different on the EQ and SQ Child_NL. They scored low on the EQ Child_NL and high on the SQ Child_NL. We found that when the AQ Child_NL total score increases, the EQ Child_NL total score decreases and the SQ Child_NL total score increases. Children with autism indeed have lower empathizing skills and higher systemizing skills than typical developing children do. These findings are consistent with the findings of the adult study where AQ was successfully predicted from EQ and SQ scores, meaning that a higher number of autistic traits and individual possesses is a function of their empathizing and systemizing scores. They stated that empathizing is largely but not completely independent of systemizing because of a weakly significant negative correlation, suggesting a trade-off between them (Wheelwright et al. 2006).

5. Conclusions

In short, we state that the discrepancy between an individual's empathizing and systemizing abilities indeed are responsible for higher scores on the AQ Child_NL, suggesting the presence of a high number of traits associated with autism. Therefore, we state that the three translated questionnaires are useful in a Dutch population of children aged 4–12 years.

Limitations and Future Research

Despite sufficient effort, there were very few parents in the autism group willing to complete the three questionnaires. Parents explained to me in a personal email that the length of the questionnaires played a role in their motivation, as well as a so-called overload of them. There are too many researchers asking parents to participate in a study. This is the reason why this study has its small sample size as limitation. Future research could focus on shortening these questionnaires, so that using these

instruments in research will be easier and less time-consuming, which is currently being addressed by the authors. Another limitation is the fact that the Intelligence Quotient of the children participating in the study remained unknown. The questionnaires were originally designed for children who function at a normal intelligence level. A present intellectual disability may have influenced the results. However, we did find results equivalent to Baron-Cohen's study on the three questionnaires, which included only high-functioning children. To our knowledge, no studies have validated the measures in people with an intellectual disability using these questionnaires. Future research could focus on this topic. Furthermore, this study does not provide a sensitive and specific cut-off score for the EQ Child_NL. We acknowledge the limitation of our study in this regard and have to state that essential properties are missing in order for it to be fully useful as a clinical measure. This limitation will be a subject of our future research. Finally, since the data were all collected online, it is unknown if the findings would generalize to individuals who cannot access the internet to volunteer for research, and there was no independent verification of diagnosis for the majority of the autism group.

Future research could examine whether the AQ Child_NL is also a useful tool for researchers to follow the developmental trajectory in clinical samples, or as a measure of the broader autism phenotype in epidemiological samples as suggested by (Auyeung et al. 2007). Future research could use the AQ Child_NL, EQ Child_NL and SQ Child_NL in testing children with, for example, a depressive disorder or an anxiety disorder in order to examine the relationship between empathizing and systemizing skills and other disorders examining its specificity. Finally, future research could focus on designing a diagnostic instrument based on the E-S-theory, and based on the three questionnaires that could identify autism at an early age, which is currently being addressed by the authors of this study.

Acknowledgments: We would like to thank the Klimop-School Middelburg, Godelindeschool Hilversum, Sint Paulusschool Leeuwarden, Basisschool de Boomgaard Breda, basisschool de Bron Bolsward, Nederlandse Vereniging voor Autisme, Hans van der Muuren and Het Driespan Bergen op Zoom in helping us in our search for participants. We would like to thank Annemiek Backx and Ed Slichgers for translating and discussing the AQ, EQ and SQ Child_NL. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author Contributions: E. van der Zee and J. Derksen conceived and designed the experiments; E. van der Zee performed the experiments; E. van der Zee and J. Derksen analyzed the data; E. van der Zee contributed reagents/materials/analysis tools; E. van der Zee wrote the paper.

Conflicts of Interest: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors. Informed consent was obtained from all individual participants in the study.

References

- American Psychiatric Association. 1994. *DSM-IV Diagnostic and Statistical Manual of Mental Disorders*, 4th ed. Arlington: Author.
- American Psychiatric Association. 2013. *DSM 5 Diagnostic and Statistical Manual of Mental Disorders*, 5th ed. Arlington: Author.
- Auyeung, Bonnie, Simon Baron-Cohen, Sally Wheelwright, and Carrie Allison. 2007. The Autism Spectrum Quotient: Children's Version (AQ-Child). *Journal of Autism and Developmental Disorders* 38: 1230–40. [[CrossRef](#)] [[PubMed](#)]
- Auyeung, Bonnie, Sally Wheelwright, Carrie Allison, Matthew Atkinson, Nelum Samarawickrema, and Simon Baron-Cohen. 2009. The children's Empathy Quotient and Systemizing Quotient: Sex differences in typical development and in autism spectrum conditions. *Journal of Autism and Developmental Disorders* 39: 1509. [[CrossRef](#)] [[PubMed](#)]
- Baron-Cohen, Simon. 1995. *Mindblindness: An Essay on Autism and Theory of Mind*. Cambridge: MIT Press.
- Baron-Cohen, Simon. 2002. The extreme male brain theory of autism. *Trends in Cognitive Sciences* 6: 248–54. [[CrossRef](#)]

- Baron-Cohen, Simon, and Sally Wheelwright. 2004. The empathy quotient (EQ). An investigation of adults with asperger syndrome or High functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders* 34: 163–75. [[CrossRef](#)] [[PubMed](#)]
- Baron-Cohen, Simon, Alan M. Leslie, and Uta Frith. 1985. Does the autistic child have a theory of mind? *Cognition* 21: 37–46. [[CrossRef](#)]
- Baron-Cohen, Simon, Sally Wheelwright, Richard Skinner, Joanne Martin, and Emma Clubley. 2001. The autism spectrum quotient (AQ): Evidence from asperger syndrome/high functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders* 31: 5–17. [[CrossRef](#)] [[PubMed](#)]
- Baron-Cohen, Simon, Jennifer Richler, Dheraj Bisarya, Nishanth Gurunathan, and Sally Wheelwright. 2003. The systemizing quotient: An investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Philosophical Transactions of the Royal Society* 358: 361–74. [[CrossRef](#)] [[PubMed](#)]
- Baron-Cohen, Simon, Rosa A. Hoekstra, Rebecca Knickmeyer, and Sally Wheelwright. 2006. The Autism-Spectrum Quotient (AQ)—Adolescent version. *Journal of Autism and Developmental Disorders* 36: 343–50. [[CrossRef](#)] [[PubMed](#)]
- Baron-Cohen, Simon, Sarah Cassidy, Bonnie Auyeung, Carrie Allison, Maryam Achoukhi, Sarah Robertson, Alexa Pohl, and Meng-Chuan Lai. 2014. Attenuation of typical sex differences in 800 adults with autism vs. 3900 controls. *PLoS ONE* 9: e102251. [[CrossRef](#)] [[PubMed](#)]
- Decety, Jean, and Meghan L. Meyer. 2008. From emotion resonance to empathic understanding: A social developmental neuroscience account. *Developmental Psychopathology* 20: 1053–80. [[CrossRef](#)] [[PubMed](#)]
- Ellis, Hadyn, and Hellen L. Gunter. 1999. Asperger syndrome: A simple matter of white matter? *Trends in Cognitive Sciences* 3: 192–200. [[CrossRef](#)]
- Gillberg, Christopher. 1992. Subgroups in autism: Are there behavioral phenotypes typical of underlying medical conditions? *Journal of Intellectual Disability Research* 36: 201–14. [[CrossRef](#)]
- Happé, Francesca, and Uta Frith. 2006. The weak coherence account: Detail-focused cognitive style in autism spectrum disorders. *Journal of Autism and Developmental Disorders* 36: 5–25. [[CrossRef](#)] [[PubMed](#)]
- Hoekstra, Rosa A., Meike Bartels, Danielle C. Cath, and Dorret I. Boomsma. 2008. Factor structure of the broader autism phenotype and its diagnostic validity: A study using the Dutch translation of the autism-spectrum quotient (AQ). *Journal of Autism and Developmental Disorders* 38: 1555–66. [[CrossRef](#)] [[PubMed](#)]
- Klin, Ami, F. Volkmar, Sara S. Sparrow, Domenic Cicchetti, and B. P. Rourke. 1995. Validity and neuropsychological characterization of Asperger Syndrome: Convergence with nonverbal learning disabilities syndrome. *Journal of Child Psychology and Psychiatry* 36: 1127–40. [[CrossRef](#)] [[PubMed](#)]
- Rutter, Michael L. 1978. Diagnosis and definition of childhood autism. *Journal of Autism and Childhood Schizophrenia* 8: 139–61. [[CrossRef](#)] [[PubMed](#)]
- Wheelwright, Sally, Simon Baron-Cohen, Nigel Goldenfeld, Joe Delaney, Debra Fine, Richard Smith, Leonora Weil, and Akio Wakabayashi. 2006. Predicting Autism Spectrum Quotient (AQ) from the Systemizing Quotient-Revised (SQ-R) and Empathy Quotient (EQ). *Brain Research* 1079: 47–56. [[CrossRef](#)] [[PubMed](#)]
- Wing, Lorna, and Judith Gould. 1979. Severe impairments of social interaction and associated abnormalities in children: epidemiology and classification. *Journal of Autism and Developmental Disorders* 9: 11–29. [[CrossRef](#)] [[PubMed](#)]

