Check for updates

RESEARCH ARTICLE

Psychometric Properties of the Chinese Version of Autism Spectrum Quotient-Children's Version: A Sex-Specific Analysis

Fan Sun, Meixia Dai, Lizi Lin, Xiang Sun, Aja Louise Murray, Bonnie Auyeung, and Jin Jing

Abstract: A Simplified Chinese translation of the Autism Spectrum Quotient-Children's Version (AQ-C) is needed for research in mainland China. Autism Spectrum Disorder (ASD) is a condition that differs in presentation and prevalence by sex. Thus, evaluating the psychometric validity of the AQ-C in males and females is an important step in its validation. The present study aims to develop a Chinese translation of the parent-report AQ-C, and test its psychometric properties among Mandarin Chinese speaking boys and girls. A total of 1,020 non-clinical children and 134 children with ASD were assessed. Factor analyses were performed for the whole sample, as well as for girls and boys separately. A 30-item, 5-factor model (the Chinese AQ-C) showed adequate goodness of fit (root mean square error of approximation [RMSEA] = 0.037; comparative fit index [CFI] = 0.907; Tucker-Lewis index [TLI] = 0.901) for the whole sample. According to parents' reports, non-clinical boys had significantly higher scores than non-clinical girls on the Chinese AQ-C. Sex-specific factor structures were identified resulting in a 4-factor model with 32 items for girls (the Chinese AQ-Girls), and a 4-factor model with 34 items for boys (the Chinese AQ-Boys). The cut-off scores of the Chinese AQ-C, AQ-Girls, and AQ-Boys were 44.5, 42.5, and 46.5, respectively. These three Chinese versions of the AQ-C all showed satisfactory internal consistency (α = 0.786–0.840) and concurrent validity with the Social Responsiveness Scale (r = 0.789–0.814) for the total scale. Differences have been found in the sex-specific factor structures of the AQ-C which would be more reliable to use for future research when measuring autistic traits in the general population. ***Autism Research*** *2018.* © 2018 International Society for Autism Research, Wiley Periodicals, Inc.

Lay Summary: This study developed Chinese versions of the Autism Spectrum Quotient-Children's Version (AQ-C) in Chinese boys and girls together and separately. The AQ-C showed good psychometric properties in boys and girls together and separately. There were differences in sex-specific factor structures of the AQ-C. These results suggest that the sex-specific Chinese versions of the AQ-C provide reliable and valid measurement of autistic traits.

Keywords: autism-spectrum quotient; children; sex differences; autistic traits; autism spectrum disorder

Introduction

Autism Spectrum Disorder (ASD) is a heterogeneous neurodevelopmental condition characterized by persistent deficits in social communication and social interaction as well as stereotyped patterns of behavior, interests, or activities [American Psychiatric Association, 2013]. Previous studies have suggested that autistic traits are normally distributed in the general population, while ASD represents the higher quantitative extreme of this neurodevelopmental continuum [Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Robinson, 2011; Bralten et al., 2017]. Individuals with high autistic traits were found to be at higher risk for psychological disorders (e.g., anxiety and depression) [Liew, Thevaraja, Hong, & Magiati, 2015], and behavior problems (e.g., social problems and withdrawn behavior) [Hoekstra, Bartels, Hudziak, Van Beijsterveldt, & Boomsma, 2007]. It is important to identify children who may be at risk for ASD to allow for early identification and support and better subsequent emotional or behavioral outcomes [Saito et al., 2017]. Therefore, there is a growing demand for reliable instruments to quantify autistic traits and screen for high-risk children. However, there are few such instruments available in mainland China, which is the world's most populous country with 12.9% of the global child population [United Nations, DESA, Population Division, 2017].

One of the most widely used instruments for quantifying autistic traits in non-clinical populations is the Autism

From the Department of Maternal and Child Health, School of Public Health, Sun Yat-Sen University, Guangzhou, China (F.S., M.D., L.L., J.J.); MIND Institute, University of California, Davis, California (X.S.); Psychology Department, The Chinese University of Hong Kong, Shatin, Hong Kong, China (X.S.); Autism Research Centre, Department of Psychiatry, University of Cambridge, Cambridge, UK (X.S., B.A.); Institute of Criminology, University of Cambridge, Cambridge, UK (A.L.M.); Psychology Department, School of Philosophy, Psychology and Language Sciences, University of Edinburgh, Edinburgh, UK (A.L.M., B.A.)

Fan Sun and Meixia Dai contributed equally to this work.

Received June 27, 2018; accepted for publication November 6, 2018

Address for correspondence and reprints: Bonnie Auyeung, Psychology Department, School of Philosophy, Psychology and Language Sciences, University of Edinburgh, UK. E-mail: bonnie.auyeung@ed.ac.uk and Jin Jing, Department of Maternal and Child Health, School of Public Health, Sun Yat-sen University, No. 74 Zhongshan Road 2, Guangzhou 510080, China. E-mail: jingjin@mail.sysu.edu.cn

Published online 0 2018 in Wiley Online Library (wileyonlinelibrary.com)
DOI: 10.1002/aur.2053

© 2018 International Society for Autism Research, Wiley Periodicals, Inc.

Spectrum Quotient-Children's Version (AQ-C) [Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008]. The AQ-C is a parent-report instrument consisting of 50 items and measuring autistic traits across five theoretical domains (social skills, attention to detail, attention switching, communication, and imagination) [Baron-Cohen et al., 2001; Auyeung et al., 2008]. Although this scale was originally developed using data from a sample from the UK, it was found to show good reliability and validity across cultures, including in Japan and India [Wakabayashi et al., 2007; Rudra et al., 2014], which provides strong support for the validity of the AQ-C in Eastern cultures. Nevertheless, differences in scoring patterns on the AQ-C were found between Eastern and Western cultures, with Japanese children scoring lower than UK children on the AQ-C total score, as well as all subscales except for the Social Skills subscale [Wakabayashi et al., 2007]. In Japanese sample, there were also some items that were reported to have poor discrimination [Wakabayashi et al., 2007]. This raises the concern that the construct validity and latent structure of the AQ-C may differ between Eastern and Western cultures. In the UK, Auyeung et al. [2008] examined the factor structure of the AQ-C using Principal Components Analysis (PCA) and found a 47-item, four-factor solution (consisting of mind-reading, attention to detail, social skills, and imagination). However, no existing factorial studies of the AQ-C included Eastern samples and the AQ-C has not been validated in mainland China to date. Thus, the first aim of this study was to examine the factor structure and psychometric properties of the Chinese version of the AQ-C among a sample of Mandarin Chinese Speaking children.

Furthermore, whether there are sex differences in the factor structure and psychometric properties of the AQ-C remains unclear. Previous studies found boys scored higher than girls on the AQ-C in a general population-based samples from different cultures including the UK, Japan, and India [Wakabayashi et al., 2007; Auyeung et al., 2008; Rudra et al., 2014]. Studies have also found sex differences in the patterns of autistic traits in the general population [Williams et al., 2008; Sun et al., 2014]. Furthermore, the prevalence of ASD shows a male bias (male–female ratio ≈4:1) [Adak & Halder, 2017], with a similar trend found in a population with high autistic traits [Constantino & Todd, 2003]. Consequently, diagnostic and assessment tools utilized to evaluate ASD or autistic traits have typically been developed based on samples containing more males. This may lead to a bias of the results toward the male autistic phenotype. Lai, Lombardo, Auyeung, Chakrabarti, and Baron-Cohen [2015] have argued that current measures may not be sensitive enough to identify the female autistic phenotype [Lai et al., 2015]. However, to our knowledge, no previous studies have examined whether there are sex differences in the psychometric properties of the AQ-C. If the psychometric properties of the AQ-C differ by sex, it would be more reliable to use the sex-specific versions of the questionnaire in future research.

Therefore, the objectives of the current study are to: (a) explore the factor structure of Chinese version of the AQ-C and assess its psychometric characteristics in mainland China; (b) examine sex differences in the Chinese version of the AQ-C, including factor structure and psychometric properties.

Method

Participants

Participants were drawn from two samples: a school-based sample of non-clinical children from mainstream schools (mainstream group) and a clinically based sample of children with ASD (clinical group).

The mainstream group was recruited from kindergartens and primary schools in Guangzhou and Shenzhen cities. A total of 1,300 questionnaires were distributed to parents of children aged 4–10 years. Of these, 1,226 (94.3%) were returned. Twenty-three of the 1,226 returned questionnaires were discarded due to missing data on more than two items. The other 1,203 questionnaires were retained. Of these retained questionnaires, 32 had one or two blank items, which were replaced by the individual child's mean scores of the non-missing items. Among the 1,203 children corresponding to the retained questionnaires, 206 were excluded as they had the following conditions: ASD ($n = 10$), Attention Deficit Hyperactivity Disorder ($n = 108$), language delay ($n = 35$), hearing difficulties ($n = 24$), physical disability ($n = 4$), and epilepsy ($n = 2$). Diagnostic information was collected using a checklist administered to parents of children from mainstream schools (see Methods section in the Supporting Information for further details). Finally, a sample of 1,020 non-clinical children (496 girls, 524 boys) was included. The mean age of the mainstream group was 6.36 years (SD = 1.56, range = 4–10 years).

The clinical group consisted of 134 children with ASD (21 girls, 113 boys). They were recruited from the Women and Children's Health Care Hospital in Luohu district of Shenzhen city. Their mean age was 6.95 years (SD = 1.47, range = 4–10 years). These children all had an existing diagnosis of ASD made by pediatricians in this hospital. Diagnoses were re-confirmed by two professional experienced child psychiatrists (Jin Jing and Wenhan Yang) using the Diagnostic and Statistical Manual of Mental Disorders, 4th Revision (DSM-IV) criteria.

Materials

The Autism Spectrum Quotient-Children's version. The Chinese version of AQ-C was revised and used in current study. The AQ-C is a parent-report questionnaire developed to quantify autistic traits in children aged

4–11 years. It comprises 50 items divided into five subscales. Items were rated on 4-point Likert scale ranging from 0 (definitely agree) to 3 (definitely disagree). Some items were reverse-keyed (item 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). The total score of AQ-C is in the range of 0–150, with higher score indicating more autistic traits [Auyeung et al., 2008].

The translation of the AQ-C followed the forward and backward procedure [Hall et al., 2018]. First, two of the authors (Lizi Lin and Meixia Dai) translated the AQ-C items from English into Chinese independently, discussed and resolved the differences arise during the translation. Then the Chinese items were checked by a Chinese-English bilingual developmental and behavioral specialist (Jin Jing) for whether they corresponded with the original items and for culture adjustment. Some items were adjusted based on Chinese culture. For example, item 13 ("S/he would rather go to a library than a birthday party") was changed as "My child prefers to go to libraries or book shops rather than go to birthday parties," because in China, preschoolers may not be taken to a library but a book shop. After that, the Chinese items were back translated into English by an English-Chinese bilingual translator. The translated English items were checked by the authors for whether they corresponded with the original English items. Finally, the Chinese version of the AQ-C was modified via discussion with the original author (BA), and the final version was agreed.

Social responsiveness scale. In order to examine the concurrent validity of the AQ-C, the Mandarin Chinese version of Social Responsiveness Scale (SRS) was used in the present study. The SRS is a 65-item questionnaire developed to assess autistic traits and social communication in children aged 4–18 years. The SRS was designed to be completed by parents, teachers, or other key caregivers. Each item is rated on 4-point Likert scale, with total scores ranging from 0 to 195 (the higher score indicating more autistic traits). A previous study has found that the reliability and validity for Mandarin Chinese version of SRS were satisfactory to good (Cronbach's $\alpha = 0.89$), supporting it as a reliable instrument for children in mainland China [Cen et al., 2017].

Procedure

Questionnaire packs were distributed to parents through the schools in the mainstream group. Each questionnaire pack contained a consent form, a demographic information sheet (collecting data including children's birth date and sex, only child (yes/no), and paternal and maternal educational level), a Chinese version of AQ-C, and a Mandarin Chinese version of SRS. Parents were asked to complete and return the questionnaire packs within 3 days. As for children with ASD, their parents were invited to the University to re-confirm the ASD diagnosis of their children. Because the standard diagnostic instruments (e.g., ADOS and ADI-R) have not been validated in China, the diagnoses of ASD were confirmed by experienced child psychiatrists to meet the DSM-IV criteria for ASD, based on parent interviews and direct interaction with these children. Questionnaire packs were completed by parents during their visit. To examine the test–retest reliability, parents of 56 children completed a second copy of Chinese version of the AQ-C 8 weeks after the first completion (sample size calculation can be found in the Methods section in the Supporting Information). Written informed consent was obtained from parents of all participant children and the protocol was approved by the Ethical Committee of the Sun Yat-Sen University.

Statistical Analysis

Data analysis was conducted using the SPSS22.0 for Windows (SPSS Inc., Chicago, IL) and the AMOS 24.0 software. Item-total correlations were explored for item analysis. Items were discarded if their scores were negatively correlated with the total score of the AQ-C [Hwang, 2000]. The construct validity of the AQ-C was explored by PCA and confirmatory factor analysis (CFA). The mainstream sample was equally and randomly divided into two subgroups for PCA ($n = 510$) and CFA ($n = 510$), respectively. To identify the underlying factor structure of the scale, PCA was conducted with promax rotation, assuming that the latent factors of the AQ-C would be correlated. To test the model fit of the identified factor structure, CFA was then conducted among the other half of the mainstream sample using the maximum likelihood estimation (MLE) procedure. Although MLE is not typically a justifiable method for items on a four-point scale, we prefer to use it over categorical estimation procedure because it is better at handling of missing data [Little & Biometrika, 1985]. A bootstrapping procedure was also adopted considering the non-normal distribution of multivariate data [Bollen & Stine, 1992]. Acceptable model fit was defined as: RMSEA ≤ 0.05 [MacCallum, Browne, & Sugawara, 1996], CFI ≥ 0.90, and TLI values ≥ 0.90 [Byrne, 1998; Brown, 2006].

In order to explore the potential sex difference in the factor structures, we also divided girls and boys into two equal subgroups and performed PCA (girls, $n = 248$; boys, $n = 262$) and CFA (girls, $n = 248$; boys, $n = 262$) separately for each sex, following the same procedure mentioned above.

The internal consistency of the AQ-C was assessed by Cronbach's α coefficient for the whole mainstream sample, as well as for each sex. A Cronbach's $\alpha \geq 0.7$ is considered good [Nunnally, 1978]. Test–retest reliability was evaluated using intra-class correlations (ICCs). An

ICC ≥ 0.75 indicated excellent reproducibility. A Pearson correlation analysis was conducted to examine the relationship between the scores of the AQ-C and SRS. The association between scores of the AQ-C and age was explored by Spearman correlation analysis. To test the discriminant validity of the AQ-C, Analysis of Covariance (ANCOVA) was used to compare AQ-C scores between the mainstream and clinical groups after controlling for age and sex. Sex differences were also explored using ANCOVA after controlling for age. Receiver-operating-characteristic (ROC) analyses were conducted in boys and girls together and separately, and cut-off scores were chosen based on maximum Youden's index (sensitivity + specificity − 1) [Lai et al., 2012]. Since age was shown to have no significant effect on predicting ASD diagnosis by logistic regression, ROC analyses were conducted not controlling for age and sex.

Results

General Characteristics of Participants

Demographics were shown in Table 1. The proportion of males was significantly higher in the clinical group than in the mainstream group [$\chi^2(1154) = 52.017$, $P < 0.001$], which was consistent with the male bias in the prevalence of ASD [Adak & Halder, 2017]. Children in the clinical group were slightly but significantly older than those in the mainstream group [$t(1154) = -4.254$, $P < 0.001$]. There were no significant differences in the proportion of only children and parental educational levels between mainstream and clinical groups (all Ps > 0.05). Girls and boys in each group were comparable in age, proportion of being an only child, and paternal and maternal educational levels (all Ps > 0.05).

Item Analysis

To assess the validity of each item, item-total correlations were explored in the whole mainstream sample, as well as in non-clinical girls and boys separately (Supporting Information Table S1). For the whole mainstream sample, there were two items (items 30 and 43) whose scores were negatively correlated with the total score. These items could not help to quantify the target components of autistic traits and were excluded in subsequent factor analysis for the whole mainstream sample. Similarly, three items (items 29, 30, and 43) and one item (item 12) were excluded in the subsequent factor analysis for non-clinical girls and boys, respectively.

Factor Analysis of the AQ-C

To investigate sex differences in the factor structure of the Chinese AQ-C, factor analyses were performed for the whole mainstream sample as well as for non-clinical girls and boys separately. Diagnostic checks were conducted and showed that the AQ-C data were suitable for factor analysis for the whole mainstream sample, as well as for non-clinical girls and boys: all the Kaiser–Meyer–Oklin values were higher than 0.700 (0.847, 0.805, and 0.776, respectively) and all the Bartlett's Tests of Sphericity were significant ($\chi^2 = 6{,}408.81$, $df = 1{,}128$, $P < 0.001$; $\chi^2 = 3{,}788.58$, $df = 1{,}081$, $P < 0.001$; $\chi^2 = 3{,}657.84$, $df = 1{,}176$, $P < 0.001$).

The remaining items after item analysis were subjected to PCA. A five-factor solution was chosen for the whole

Table 1. Demographics and Study Population Characteristics

	Mainstream group				Clinical group				
	All	Girls	Boys	P^a	All	Girls	Boys	P^a	Group difference (P)
	(n = 1,020)	(n = 496)	(n = 524)		(n = 134)	(n = 21)	(n = 113)		
Age (mean ± SD)	6.36 ± 1.56	6.21 ± 1.56	6.50 ± 1.54	0.003	6.96 ± 1.47	6.57 ± 1.29	7.04 ± 1.50	0.186	<0.001
4	147	78	69		8	2	6		
5	191	117	74		2	0	2		
6	222	96	126		53	9	44		
7	165	76	89		27	6	21		
8	208	89	119		20	2	18		
9	80	39	41		16	2	14		
10	7	1	6		8	0	8		
Only children	489 (48.5%)	232 (47.2%)	257 (49.7%)	0.417	76 (56.7%)	12 (57.1%)	64 (56.6%)	0.966	0.073
Paternal educational level									
Junior high school and below	208 (21.0%)	98 (20.4%)	110 (21.6%)	0.436	21 (15.7%)	4 (19.0%)	17 (15.0%)	0.417	0.305
Senior high school	358 (36.2%)	167 (34.8%)	191 (37.6%)		49 (36.6%)	5 (23.8%)	44 (38.9%)		
College and above	422 (42.7%)	215 (44.8%)	207 (40.7%)		64 (47.8%)	12 (57.1%)	52 (46.0%)		
Maternal educational level									
Junior high school and below	303 (30.4%)	146 (30.2%)	157 (30.7%)	0.458	30 (22.4%)	6 (28.6%)	24 (21.2%)	0.612	0.057
Senior high school	336 (33.8%)	156 (32.2%)	180 (35.2%)		43 (32.1%)	5 (23.8%)	38 (33.6%)		
College and above	356 (35.8%)	182 (37.6%)	174 (34.0%)		61 (45.5%)	10 (47.6%)	51 (45.1%)		

[a]Difference between boys and girls.

mainstream sample based on the eigenvalues of components and was confirmed by the scree plot which revealed a clear break after the fifth component [Supporting Information Fig. S1(a)]. In the present study, items with factor loadings lower than 0.30 were eliminated. However, item 16 was retained in the analysis for the whole mainstream sample since it was conceptually congruent with the theme of its designated factor (Attention Switching). As shown in Table 2, a 30-item, five-factor model (named the Chinese AQ-C) was derived in the whole mainstream sample which accounted for 44.45% of the total variance, including Socialness (13.64%), Social Communicative Competence (15.70%), Imagination (4.83%), Patterns (6.08%), and Attention Switching (4.20%) in the whole mainstream sample. The total score of Chinese AQ-C is in the range of 0–90.

We also conducted factor analyses in non-clinical girls and boys separately (Table 2). Scree plots for different sex were shown in Supporting Information Figure S1(b,c). In non-clinical girls, PCA derived a 32-item, four-factor model (named the Chinese AQ-Girls) which accounted for 41.55% of the total variance, including Socialness (19.48%), Social Communicative Competence (11.60%), Imagination (5.31%), and Patterns (5.16%). The maximum score of the Chinese AQ-Girls is 96. As for boys, PCA yielded a 34-item, four-factor model (named the Chinese AQ-Boys) accounting for 37.55% of the total variance, including Socialness (5.75%), Social Communicative Competence (15.91%), Imagination (4.74%), and Patterns (11.15%). The maximum score of the Chinese AQ-Boys is 102. Table 2 also shows eigenvalues of each rotated factor.

The results of CFA for the previous factor models [Baron-Cohen et al., 2001; Auyeung et al., 2008] and our three models are shown in Table 3.The CFA confirmed that the goodness of fit of the current five-factor model (the Chinese AQ-C) was satisfactory, and better than those for the previous factor models (RMSEA = 0.037, CFI = 0.907, and TLI = 0.901). Accordingly, the 30-item, five-factor solution (the Chinese AQ-C) was much more suitable for the Chinese sample. CFA also showed adequate goodness of fit for the Chinese AQ-Girls (RMSEA = 0.032, CFI = 0.934, and TLI = 0.933) and the Chinese AQ-Boys (RMSEA = 0.031, CFI = 0.921, and TLI = 0.913) (Table 3).

Concurrent Validity

The total scores of the Chinese AQ-C, the Chinese AQ-Girls, and the Chinese AQ-Boys were all highly correlated with the total scores of SRS ($r = 0.789$, $P < 0.001$, $n = 695$; $r = 0.795$, $P < 0.001$, $n = 266$; $r = 0.814$, $P < 0.001$, $n = 429$, respectively), indicating the great criterion-related validity for these three versions of the scale.

Internal Consistency and Test–Retest Reliability

The Cronbach's α coefficients for total scale and subscales of different versions of the AQ-C are shown in Table 3. The Chinese AQ-C demonstrates adequate internal consistency for the total scale ($\alpha = 0.765$), acceptable for Attention Switching ($\alpha = 0.588$) and good internal consistency for the other subscales ($\alpha = 0.733$–0.807). As for the Chinese AQ-Girls and the Chinese AQ-Boys, all total scales and subscales showed good internal consistency (all $\alpha > 0.700$). In general, the three Chinese versions of AQ-C all showed better internal reliability than the original and the UK factor models (Table 3). The test–retest reliability of the Chinese AQ-C was satisfactory with ICC ranging from 0.536 to 0.791 (Supporting Information Table S2).

Sex Differences

The scores of total scale and subscales on the Chinese AQ-C for mainstream and clinical groups by sex are shown in Table 4. The ANCOVA showed that non-clinical boys scored significantly higher than non-clinical girls on the total scale of the Chinese AQ-C [$F(1020) = 40.470$, $P < 0.001$] after controlling for age, as well as on subscales including Social Communicative Competence [$F(1020) = 9.609$, $P = 0.002$], Imagination [$F(1020) = 19.654$, $P < 0.001$], and Pattern [$F(1020) = 30.539$, $P < 0.001$]. Scores of the other subscales (Socialness and Attention Switching) in non-clinical boys were also higher than non-clinical girls, even though the differences were non-significant (Ps > 0.05).

In clinical group, as compared with girls, boys scored significantly higher on subscale Patterns [$F(134) = 7.777$, $P = 0.006$] but lower on Social Communicative Competence [$F(134) = 4.191$, $P = 0.043$]. There were no significant sex differences in scores of total scale and the other three subscales within the clinical group.

No significant association between age and the total score of the Chinese AQ-C was found in the mainstream ($r = 0.036$, $P = 0.251$) and clinical ($r = 0.083$, $P = 0.341$) groups. Similarly, within boys, the Chinese AQ-Boys scores were not significantly correlated with age in both mainstream ($r = 0.041$, $P = 0.524$) and clinical groups ($r = 0.040$, $P = 0.677$). However, within girls, the Chinese AQ-Girls scores were significantly and positively correlated with age in the mainstream group, although the association was mild ($r = 0.112$, $P = 0.012$).

Discriminant Validity and Cut-Off Score

The clinical group scored significantly higher than the mainstream group on all the total scale and subscales of the Chinese AQ-C after controlling for age and sex (all Ps < 0.05) (Table 4). The similar pattern of group differences was also found in boys on the Chinese AQ-Boys (Supporting Information Table S3). Total and subscale

Table 2. Factor Structures of the Chinese AQ-C, the Chinese AQ-Girls, and the Chinese AQ-Boys

Chinese AQ-C				Chinese AQ-girls		Chinese AQ-boys	
Item	Content	Factor loadings	Original subscale	Item	Factor loadings	Item	Factor loadings
Factor 1 Socialness VR = 13.64%, EV = 3.451 EV = 4.013				VR = 19.48%, EV = 4.778		VR = 5.75%,	
11	Finds social situations easy	0.621	SS	10	0.424	11	0.589
17	Enjoys social chit-chat	0.616	CO	11	0.646	17	0.483
38	Good at social chit-chat	0.716	CO	17	0.643	28	0.412
44	Enjoys social occasions	0.693	SS	37	0.386	37	0.362
47	Enjoys meeting new people	0.756	SS	38	0.720	38	0.677
				44	0.704	44	0.649
				47	0.783	47	0.784
				48	0.370	48	0.399
Factor 2 Social communicative competence VR = 15.70%, EV = 3.586				VR = 11.60%, EV = 3.499			VR = 15.91%, EV = 4.060
7	Is impolite, even though s/he thinks it is polite	0.384	CO	7	0.507	7	0.462
20	Finds it difficult to work out the characters' intentions in a story	0.618	IM	20	0.627	20	0.643
21	Does not particularly enjoy reading fiction	0.361	IM	22	0.586	21	0.424
22	Finds it hard to make new friends	0.55	SS	26	0.681	22	0.475
26	Does not know how to keep up a conversation	0.659	CO	33	0.597	26	0.619
33	Does not know when it is their turn on the phone	0.596	CO	35	0.777	33	0.624
35	Often the last to understand a joke	0.7	CO	39	0.471	35	0.610
39	Keeps going on and on about the same thing	0.516	CO	45	0.654	39	0.608
45	Finds it difficult to work out people's intentions	0.643	SS			45	0.611
						46	0.462
Factor 3 Imagination VR = 4.74%, EV = 3.501				VR = 5.31%, EV = 4.539			
14	Finds making up stories easy	0.517	IM	1	0.444	3	0.475
31	Knows how to tell if someone bored	0.497	CO	3	0.771	8	0.595
36	Finds it easy to work out feelings by looking at faces	0.461	SS	8	0.788	10	0.470
40		0.602	IM	14	0.527	14	0.377

(Continues)

Table 2. Continued

Chinese AQ-C				Chinese AQ-girls		Chinese AQ-boys	
Item	Content	Factor loadings	Original subscale	Item	Factor loadings	Item	Factor loadings
	Enjoyed playing games involving pretending						
50	Finds it easy to play games that involve pretending	0.573	IM	31	0.277	31	0.424
				34	0.345	36	0.378
				36	0.418	40	0.585
				40	0.491	50	0.593
				50	0.591		
Factor 4 Patterns VR = 6.08%, EV = 3.632				VR = 5.16%, EV = 4.176			VR = 11.15%, EV = 3.467
6	Notices numbers or strings of information	0.625	AD	6	0.768	6	0.631
9	Fascinated by dates	0.579	AD	9	0.607	9	0.619
12	Notices details that others do not	0.438	AD	12	0.554	13	0.540
13	Would rather go to a library than a party	0.645	SS	13	0.628	16	0.365
19	Fascinated by numbers	0.764	AD	19	0.682	19	0.752
23	Notices patterns	0.561	AD	23	0.489	23	0.642
41	Likes to collect information	0.498	IM	41	0.466	41	0.481
						43	0.457
Factor 5 Attention Switching VR = 4.20%, EV = 2.772							
2	Prefers to do things the same way	0.713	AS				
4	Gets strongly absorbed in one thing	0.686	AS				
5	Notices small sounds when others do not	0.618	AD				
16	Tends to have very strong interests	0.235	AS				

Note. Chinese AQ-C: the Chinese version of Autism Spectrum Quotient-Children's Version; Chinese AQ-Girls: the Chinese version of Autism Spectrum Quotient-Girls' Version; Chinese AQ-Boys: the Chinese version of Autism Spectrum Quotient-Boys' Version; CO: Communication; SS: Social Skills; AS: Attention Switching; IM: Imagination; AD: Attention to Details; VR: variance; and EV: eigenvalue.

Table 3. Goodness of Fit for Previous Factor Models and the Chinese Models of the AQ-C

	# of items	# of factors	Cronbach's α	RMSEA	CFI	TLI
The original model	50	5	Social skills (0.548) Communication (0.568) Imagination (0.364) Attention to detail (0.684) Attention switching (0.225) Total (0.678)	0.057	0.620	0.592
The UK factor model	47	4	Social skills (0.655) Social communicative competence (0.655) Imagination (0.594) Attention to detail (0.772) Total (0.708)	0.055	0.676	0.651
Chinese AQ-C	30	5	Socialness (0.849) Social communicative competence (0.807) Imagination (0.737) Patterns (0.733) Attention switching (0.588) Total (0.800)	0.037	0.907	0.901
Chinese AQ-Girls	32	4	Socialness (0.825) Social communicative competence (0.805) Imagination (0.788) Patterns (0.763) Total (0.786)	0.032	0.934	0.933
Chinese AQ-Boys	34	4	Socialness (0.852) Social communicative competence (0.800) Imagination (0.813) Patterns (0.715) Total (0.840)	0.031	0.921	0.913

Note. AQ-C: Autism Spectrum Quotient-Children's Version; Chinese AQ-C: the Chinese version of Autism Spectrum Quotient-Children's Version; Chinese AQ-Girls: the Chinese version of Autism Spectrum Quotient-Girls' Version; Chinese AQ-Boys: the Chinese version of Autism Spectrum Quotient-Boys' Version; RMSEA: root mean square error of approximation; and CFI: comparative fit index.

scores of the Chinese AQ-Girls were higher in ASD girls than in non-clinical girls, even though the difference was not significant on the Patterns subscale probably limited by the small sample size of ASD girls. Diagnostic validity of the Chinese AQ-C, AQ-Girls, and AQ-Boys were analyzed using the ROC analysis. The areas under the ROC curves (AUCs) were 0.968 (95% CI: 0.955–0.981) for the Chinese AQ-C, 0.990 (95% CI: 0.981–1.000) for AQ-Girls, and 0.964 (95% CI: 0.948–0.960) for AQ-Boys (Fig. 1a–c), indicating good ability of these scales to correctly classify children with and without ASD. Table 5 shows the candidate cut-off scores for the three scales derived through ROC analyses, and their corresponding sensitivity and specificity values. An appropriate cut-off should maximize both sensitivity and specificity [Hajian-Tilaki, 2013]. Accordingly, a cut-off of 44.5 was selected for the Chinese AQ-C, which showed both high sensitivity (94.0%) and specificity (88.2%). As for the Chinese AQ-Girls and AQ-Boys, the cut-off scores were chosen to be 42.5 and 46.5,

Table 4. Mean (and SD) Scores of Total Scale and Subscales on the Chinese AQ-C for the Mainstream and Clinical Groups by Sex

The Chinese AQ-C	Mainstream group				Clinical group				Group difference
	All (n = 1,020)	Girls (n = 496)	Boys (n = 524)	P^a	All (n = 134)	Girls (n = 21)	Boys (n = 113)	P^a	P^b
Total scores	33.85 ± 8.83	32.05 ± 8.37	35.56 ± 8.93	<0.001	57.18 ± 9.27	57.57 ± 8.45	57.11 ± 9.44	0.836	<0.001
Socialness	4.31 ± 3.05	4.16 ± 3.04	4.45 ± 3.05	0.307	10.81 ± 3.23	10.43 ± 4.06	10.88 ± 3.07	0.54	<0.001
Social communicative competence	7.37 ± 4.54	6.91 ± 4.50	7.80 ± 4.54	0.002	15.81 ± 5.42	18.00 ± 4.36	15.40 ± 5.52	0.043	<0.001
Imagination	5.13 ± 2.69	4.74 ± 2.74	5.51 ± 2.60	<0.001	10.88 ± 2.97	11.14 ± 3.57	10.83 ± 2.86	0.737	<0.001
Patterns	9.93 ± 3.97	9.27 ± 4.04	10.55 ± 3.81	<0.001	11.95 ± 2.43	10.67 ± 1.91	12.19 ± 2.45	0.006	<0.001
Attention switching	7.11 ± 2.48	6.98 ± 2.52	7.25 ± 2.44	0.061	7.73 ± 2.47	7.33 ± 2.74	7.80 ± 2.42	0.557	0.023

[a]Adjusted for age.

[b]Adjusted for age and sex; Chinese AQ-C: the Chinese version of Autism Spectrum Quotient-Children's Version.

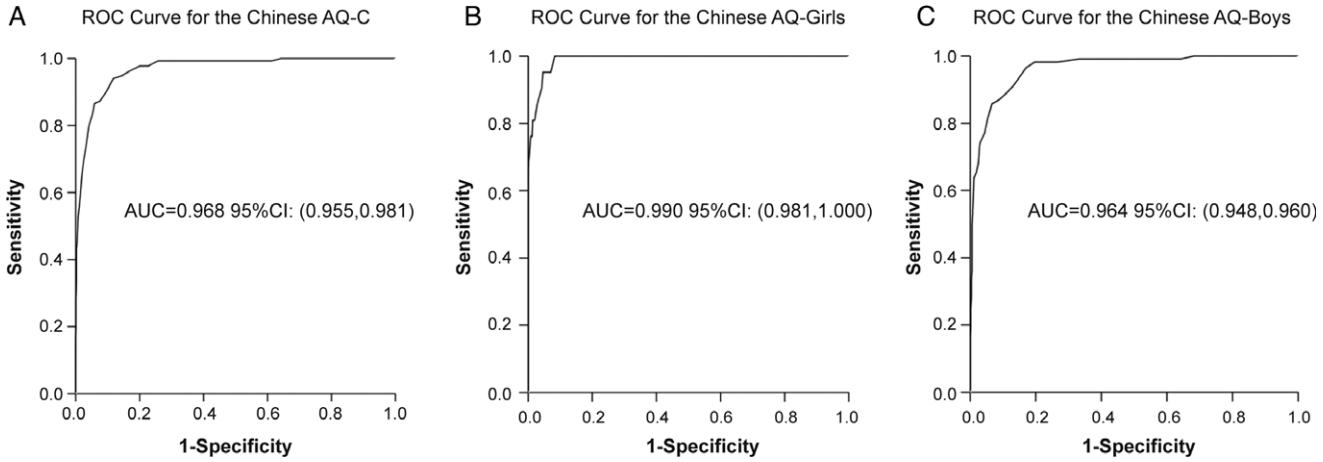

Figure 1. ROC curves for scores of the Chinese AQ-C (a), the Chinese AQ-Girls (b) and the Chinese AQ-Boys (c)*Note.* ROC curve: the curve of the receiver-operating-characteristic analysis; Chinese AQ-C: the Chinese version of Autism Spectrum Quotient-Children's Version; Chinese AQ-Girls: the Chinese version of Autism Spectrum Quotient-Girls' Version; Chinese AQ-Boys: the Chinese version of Autism Spectrum Quotient-Boys' Version; and AUC: area under the ROC curve.

respectively, both with high sensitivity (100% and 96.5%) and specificity (91.7% and 83.0%).

Discussion

This study examined the factor structure and psychometric properties of the Chinese version of the AQ-C among boys and girls together and separately in mainland China. We found that (a) factor analysis indicated a 30-item, five-factor structure (the Chinese AQ-C) with a good fit for the whole sample; (b) there were sex differences in the factor structure. Though a four-factor structure was obtained for both sexes, the item patterns corresponding to the factor structures were different: 32-item for girls (the Chinese AQ-Girls) and 34-item for boys (the Chinese AQ-Boys), and (c) all these three Chinese versions of AQ-C showed satisfactory reliability, concurrent validity, and discriminant validity.

Factor Structure of the Chinese AQ-C

To our knowledge, there is only one previous study that has explored the factor structure of the AQ-C, which supported a 47-item, four-factor solution in UK sample [Auyeung et al., 2008]. Inconsistent with this study, the Chinese version of AQ-C was successfully reduced to a 30-item, five-factor solution, which accounted for a moderate amount of the total variance in our study. CFA demonstrated a good fit for our five-factor structure, while both the original five-theoretical-component [Baron-Cohen et al., 2001] and four-factor structure obtained in UK sample [Auyeung et al., 2008] did not fit well in our whole Chinese sample. The difference in factor structures of the AQ-C could be attributed to the culture differences between China and UK. Previous studies have reported differences in autistic traits between Western and Eastern cultures [Daley & Sigman, 2002; Bernier, Mao, & Yen, 2010]. Another possible explanation for the difference may be the heterogeneity of the sample (e.g., age distribution and sex ratio) and distinct analytical procedures in the two studies.

Similar to the original model [Baron-Cohen et al., 2001], the Chinese AQ-C agreed on an Imagination factor and an Attention Switching factor. However, the conceptual constructs of the AQ-C have been refined in the Chinese version. Some items from the original Communication and Imagination subscales formed a new factor, named Social Communicative Competence. Another factor, Socialness,

Table 5. Potential Cut-Offs, Sensitivity, and Specificity of the Chinese Versions of the AQ-C

Indices	Chinese AQ-C			Chinese AQ-girls			Chinese AQ-boys		
	43.5	44.5	45.5	41.5	42.5	43.5	45.5	46.5	47.5
Sensitivity (%)	94.8	94.0	90.3	100	100.0	95.2	98.2	96.5	93.8
Specificity (%)	85.7	88.2	90.3	89.7	91.7	92.9	80.3	83.0	84.9

Note. AQ-C: Autism Spectrum Quotient-Children's Version; Chinese AQ-C: the Chinese version of Autism Spectrum Quotient-Children's Version; Chinese AQ-Girls: the Chinese version of Autism Spectrum Quotient-Girls' Version; Chinese AQ-Boys: the Chinese version of Autism Spectrum Quotient-Boys' Version.

was essentially a subset of the Social Skill subscale in the original model. Nevertheless, the "socialness" factor places more emphasis on social motivation which is distinctive from the competency in social interaction. A similar adjustment can also be found in the adult version of the AQ based on a Chinese sample [Lau et al., 2013]. Furthermore, the Attention to Detail factor in the original model was replaced by Patterns, which integrated two stereotyped characteristics of autistic traits (the abnormal focus to details and the highly restricted interests with unusual objects). The concept of Patterns first emerged as Details/Patterns in Austin's [2005] work on the adult version of AQ and has since often appeared in subsequent research using the adult AQ [Hurst, Mitchell, Kimbrel, Kwapil, & Nelson-Gray, 2007; Stewart & Austin, 2009; Lau et al., 2013].

Sex Difference in the Chinese AQ-C and Sex-Specific Version of the AQ-C

Our study showed that non-clinical boys scored higher than non-clinical girls on the total scale and subscales of the Chinese AQ-C, which is in line with the results of previous studies based on UK and Japanese samples [Wakabayashi et al., 2007; Auyeung et al., 2008]. Similar patterns of sex differences were reported in other instruments measuring autistic traits, including the SRS and the Childhood Autism Spectrum Test [Sun et al., 2014]. Our study adds evidence that there are sex differences in quantitative autistic traits in the general population. As for the clinical group, although there were no differences in total score of the Chinese AQ-C between boys and girls, we found different patterns of scores, in that boys scored significantly higher on Patterns but lower on Social Communicative Competence than girls. Consistent with our findings, previous studies found that in children with ASD, boys had more stereotyped and repetitive behaviors than girls while girls showed more social-communication problems [Hartley & Sikora, 2009; Szatmari et al., 2012]. Researchers suggested that the sex difference in autistic traits may be due to the current measures potentially not being sensitive enough to identify the female autistic phenotype [Lai et al., 2015]. Therefore, exploring the psychometric validity and factor structure of the AQ-C in different sexes is urgently needed.

In our study, the factor models fit in the sexes separately (the Chinese AQ-Girls and the Chinese AQ-Boys) both contained four factors (Socialness, Social Communicative Competence, Imagination, and Patterns), whereas subtle differences have been found in item patterns corresponding to the two models: (a) the Chinese AQ-Girls comprised 32 items with a maximum score of 96, while the Chinese AQ-Boys comprised 34 items with a maximum score of 102; (b) the items contained in each factor were different between the two models. These findings indicated that there were sex differences in behavioral phenotype, although the core features of autistic traits may be common in boys and girls. For example, circumscribed interests of girls tend to be more social in nature than boys, and are more likely to be animals, dolls, popgroups, and so on [Kopp & Gillberg, 1992; Wolff & McGuire, 1995]. Acknowledging these differences in measures of ASD is essential for ensuring that the condition is not under-recognized in girls.

In this study, we found no significant association between autistic traits and age in the non-clinical group and in the ASD group. These results are consistent with the findings in previous studies based on UK and Japanese samples [Auyeung et al., 2008; Wakabayashi et al., 2007]. Similar results were also reported in study using other instruments, for instance, the SRS [Cen et al., 2017]. A significant and positive correlation was found between the scores of the Chinese-AQ-Girls and age. It does not necessarily undermine the validity of the Chinese-AQ-Girls if it correlates with age. Instead, it may reflect genuine increases of autistic traits in girls. Similar results have been found in previous research, reporting that girls are more likely than boys to experience an escalation of autistic traits [Mandy, Pellicano, St Pourcain, Skuse, & Heron, 2018].

Internal Consistency and Test–Retest Reliability

Our study showed that the Chinese AQ-C had adequate internal consistency and test–retest reliability as a whole with the exception of the Attention Switching subscale [Cronbach, 1951]. Nevertheless, the reliability of the subscales of the Chinese AQ-C was radically improved compared with previous models [Baron-Cohen et al., 2001; Auyeung et al., 2008]. As for the Chinese AQ-Girls and the Chinese AQ-Boys, all total scale and the subscales demonstrated excellent internal reliability.

Concurrent Validity

Previous studies reported strong correlations between the total scores of the AQ-C and SRS in children with high-functioning ASD [Armstrong & Iarocci, 2013]. Similarly, our study found that the total scores of the Chinese AQ-C and SRS were highly correlated both in mainstream and clinical samples. In addition, high correlations were also found between the total scores of the Chinese AQ-Girls, Chinese AQ-Boys, and SRS. These results indicate that all three Chinese versions of AQ-C have good concurrent validity.

Discriminant Validity and Cut-off Score

Our results showed that children with ASD scored higher than non-clinical ones on the total scale and all subscales of

the Chinese AQ-C, the Chinese AQ-Girls, and the Chinese AQ-Boys. These results were in accordance with the findings obtained from UK, Japanese, and Indian children [Wakabayashi et al., 2007; Auyeung et al., 2008; Rudra et al., 2014]. Taken together, our findings add evidence for the discriminant validity of the AQ-C across cultures. In addition, similar score pattern that ASD sample scored higher than general population was also found in research using adolescent and adult versions of the AQ [Baron-Cohen et al., 2001; Baron-Cohen, Hoekstra, Knickmeyer, & Wheelwright, 2006; Sonie et al., 2013; Zhang et al., 2016], indicating the discriminative power of AQ scales across ages.

In clinical practice, the AQ-C is mainly used to quantify autistic traits and identify the high-risk individuals for further diagnostic evaluation in the general population [Wakabayashi et al., 2007], thus requiring high sensitivity and specificity. Our data showed that the total score of the Chinese AQ-C could clearly distinguish children with ASD from those without ASD (AUC = 0.968), which was similar to the result obtained from UK (AUC = 0.99) [Auyeung et al., 2008]. A cut-off score of 44.5 showed high sensitivity (94.0%) and specificity (88.2%) for screening children with ASD in general population. Caution should be taken when making a diagnosis with the cut-off; however, it may provide a useful screen to understand which children should undergo full diagnostic assessment. Considering the sex difference in the scores and factor structure in AQ-C, the discriminant validity of sex-specific versions is also of importance. Both versions showed satisfactory discriminant validity with a cut-off score of 42.5 for the Chinese AQ-Girls and 46.5 for the Chinese AQ-Boys.

Limitations

Several limitations should be noted. First, this study did not use gold standard assessments (e.g., ADI-R and ADOS) to confirm the diagnoses of ASD because these instruments have not yet been validated and widely utilized in mainland china. Nevertheless, the diagnoses of ASD in this study were confirmed by experienced pediatricians from a public hospital and re-confirmed by two professional child psychiatrists. Secondly, it should be noted that the cut-off score of the Chinese AQ-Girls may not be optimal due to the small sample size of girls with ASD, which was limited by the male-predominance in prevalence of ASD. Future studies with larger sample sizes are needed to verify the factor structure and psychometric characteristics of the AQ-C in females.

Conclusion

Our findings confirmed a 30-item, five-factor structure for the Chinese version of the AQ-C, demonstrating adequate internal consistency, test–retest reliability, construct validity, concurrent validity, and discriminant validity. More importantly, our study found sex-specific factor structures (the Chinese AQ-Girls and the Chinese AQ-Boys) with good reliability and validity. It may be more reliable for future research to use the sex-specific model when measuring autistic traits in general population. Future studies with larger sample sizes are warranted to test the effectiveness of the sex-specific versions of the AQ-C on screening children with ASD.

Acknowledgments

J.J. was supported by the National Natural Science Foundation of China (Grant No. 81573169) and Guangzhou Yineng Biological Technology Co., Ltd. (Grant No. 5100071020325). B.A. was supported by the UK Economic and Social Research Council (ESRC, Grant No. ES/N018877/1) during the course of this work. We would like to thank the participants, kindergartens, primary schools, and hospitals for their kind support throughout the course of this study.

Conflict of Interest

The authors declare no conflicts of interest in this work.

References

Adak, B., & Halder, S. (2017). Systematic review on prevalence for autism spectrum disorder with respect to gender and socioeconomic status. Journal of Mental Disorders and Treatment, 3(1), 133. https://doi.org/10.4172/2471-271X.1000133.

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders: DSM-5 (5th ed.). Arlington, VA: American Psychiatric Publishing.

Armstrong, K., & Iarocci, G. (2013). Brief report: The autism spectrum quotient has convergent validity with the social responsiveness scale in a high-functioning sample. Journal of Autism and Developmental Disorders, 43(9), 2228–2232.

Austin, E. J. (2005). Personality correlates of the broader autism phenotype as assessed by the Autism Spectrum Quotient (AQ). Personality and Individual Differences, 38(2), 451–460.

Auyeung, B., Baron-Cohen, S., Wheelwright, S., & Allison, C. (2008). The Autism Spectrum Quotient: Children's Version (AQ-Child). Journal of Autism and Developmental Disorders, 38(7), 1230–1240.

Baron-Cohen, S., Hoekstra, R. A., Knickmeyer, R., & Wheelwright, S. (2006). The Autism-Spectrum Quotient (AQ)--adolescent version. Journal of Autism and Developmental Disorders, 36(3), 343–350.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (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(1), 5–17.

Bernier, R., Mao, A., & Yen, J. (2010). Psychopathology, families, and culture: Autism. Child and Adolescent Psychiatric Clinics of North America, 19(4), 855–867.

Bollen, K. A., & Stine, R. A. (1992). Bootstrapping goodness-of-fit measures in structural equation models. Sociological Methods and Research, 21(2), 205–229.

Bralten, J., van Hulzen, K. J., Martens, M. B., Galesloot, T. E., Arias, V. A., Kiemeney, L. A., … Poelmans, G. (2017). Autism spectrum disorders and autistic traits share genetics and biology. Molecular Psychiatry, 23(5), 1205–1212. https://doi.org/10.1038/mp.2017.127.

Brown, T. (2006). Confirmatory factor analysis for applied research. New York, NY: The Guilford Press.

Byrne, B. (1998). Structural equation modeling with LISREL, PRELIS and SIMPLIS: Basic concepts, applications, and programming. Hillside, JN: Lawrence Erlbaum Associates.

Cen, C., Liang, Y., Chen, Q., Chen, K., Deng, H., Chen, B., & Zou, X. B. (2017). Investigating the validation of the Chinese Mandarin version of the Social Responsiveness Scale in a Mainland China child population. BMC Psychiatry, 17(1), 51.

Constantino, J. N., & Todd, R. D. (2003). Autistic traits in the general population: A twin study. Archives of General Psychiatry, 60(5), 524–530.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 16(3), 297–334.

Daley, T. C., & Sigman, M. D. (2002). Diagnostic conceptualization of autism among Indian psychiatrists, psychologists, and pediatricians. Journal of Autism and Developmental Disorders, 32(1), 13–23.

Hajian-Tilaki, K. (2013). Receiver operating characteristic (ROC) curve analysis for medical diagnostic test evaluation. Caspian Journal of Internal Medicine, 4(2), 627–635.

Hall, D. A., Zaragoza, D. S., Hamdache, L. Z., Manchaiah, V., Thammaiah, S., Evans, C., … International Collegium of Rehabilitative Audiology and TINnitus Research NETwork. (2018). A good practice guide for translating and adapting hearing-related questionnaires for different languages and cultures. International Journal of Audiology, 57(3), 161–175.

Hartley, S. L., & Sikora, D. M. (2009). Sex differences in autism spectrum disorder: An examination of developmental functioning, autistic symptoms, and coexisting behavior problems in toddlers. Journal of Autism and Developmental Disorders, 39(12), 1715–1722.

Hoekstra, R. A., Bartels, M., Hudziak, J. J., Van Beijsterveldt, T. C. E. M., & Boomsma, D. I. (2007). Genetic and environmental covariation between autistic traits and behavioral problems. Twin Research and Human Genetics, 10(06), 853–860.

Hurst, R. M., Mitchell, J. T., Kimbrel, N. A., Kwapil, T. K., & Nelson-Gray, R. O. (2007). Examination of the reliability and factor structure of the Autism Spectrum Quotient (AQ) in a non-clinical sample. Personality and Individual Differences, 43(7), 1938–1949.

Hwang, I. H. (2000). The usability of item-total correlation as the index of item discrimination. Korean Journal of Medical Education, 12(1), 45–51.

Kopp, S., & Gillberg, C. (1992). Girls with social deficits and learning problems: Autism, atypical Asperger syndrome or a variant of these conditions. European Child and Adolescent Psychiatry, 1(2), 89–99.

Lai, C., Tian, L., & Schisterman, E. F. (2012). Exact confidence interval estimation for the Youden index and its corresponding optimal cut-point Computational Statistics & Data Analysis, 56(5), 1103–1114.

Lai, M. C., Lombardo, M. V., Auyeung, B., Chakrabarti, B., & Baron-Cohen, S. (2015). Sex/gender differences and autism: Setting the scene for future research. Journal of the American Academy of Child and Adolescent Psychiatry, 54(1), 11–24.

Lau, W. Y., Gau, S. S., Chiu, Y., Wu, Y., Chou, W., Liu, S., & Chou, M. C. (2013). Psychometric properties of the Chinese version of the Autism Spectrum Quotient (AQ). Research in Developmental Disabilities, 34(1), 294–305.

Liew, S. M., Thevaraja, N., Hong, R. Y., & Magiati, I. (2015). The relationship between autistic traits and social anxiety, worry, obsessive-compulsive, and depressive symptoms: specific and non-specific mediators in a student sample. Journal of Autism and Developmental Disorders, 45(3), 858–872.

Little, R. J. A., & Biometrika, M. D. S. (1985). Maximum likelihood estimation for mixed continuous and categorical data with missing values. Biometrika, 72(3), 497–512.

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. Psychological Methods, 1(2), 130–149.

Mandy, W., Pellicano, L., St Pourcain, B., Skuse, D., & Heron, J. (2018). The development of autistic social traits across childhood and adolescence in males and females. Journal of Child Psychology and Psychiatry, 59, 1143–1151. https://doi.org/10.1111/jcpp.12913.

Nunnally, J. C. (1978). Psychometric theory (2nd ed.). New York: McGraw-Hill.

Robinson, E. B. (2011). Evidence that autistic traits show the same etiology in the general population and at the quantitative extremes (5%, 2.5%, and 1%). Archives of General Psychiatry, 68(11), 1113–1121.

Rudra, A., Banerjee, S., Singhal, N., Barua, M., Mukerji, S., & Chakrabarti, B. (2014). Translation and usability of autism screening and diagnostic tools for autism spectrum conditions in India. Autism Research, 7(5), 598–607.

Saito, A., Stickley, A., Haraguchi, H., Takahashi, H., Ishitobi, M., & Kamio, Y. (2017). Association between autistic traits in preschool children and later emotional/behavioral outcomes. Journal of Autism and Developmental Disorders, 47(11), 3333–3346.

Sonie, S., Kassai, B., Pirat, E., Bain, P., Robinson, J., Gomot, M., … Manificat, S. (2013). The French version of the autism-spectrum quotient in adolescents: A cross-cultural validation study. Journal of Autism and Developmental Disorders, 43(5), 1178–1183.

Stewart, M. E., & Austin, E. J. (2009). The structure of the Autism-Spectrum Quotient (AQ): Evidence from a student sample in Scotland. Personality and Individual Differences, 47(3), 224–228.

Sun, X., Allison, C., Auyeung, B., Matthews, F. E., Sharp, S. J., Baron-Cohen, S., & Brayne, C. (2014). The Mandarin Childhood Autism Spectrum Test (CAST): Sex differences. Journal of Autism and Developmental Disorders, 44(9), 2137–2146.

Szatmari, P., Liu, X., Goldberg, J., Zwaigenbaum, L., Paterson, A. D., Woodbury-Smith, M., … Thompson, A. (2012). Sex differences in repetitive stereotyped behaviors in autism: Implications for genetic liability. American Journal of Medical Genetics Part B: Neuropsychiatric Genetics, 159B(1), 5–12.

United Nations, Department of Economic and Social Affairs, Population Division (2017). Probabilistic population projections based on the world population prospects: The 2017 revision. Retrieved from https://esa.un.org/unpd/wpp/Download/Probabilistic/Population/.

Wakabayashi, A., Baron-Cohen, S., Uchiyama, T., Yoshida, Y., Tojo, Y., Kuroda, M., & Wheelwright, S. (2007). The autism-spectrum quotient (AQ) children's version in Japan: A cross-cultural comparison. Journal of Autism and Developmental Disorders, 37(3), 491–500.

Williams, J. G., Allison, C., Scott, F. J., Bolton, P. F., Baron-Cohen, S., Matthews, F. E., & Brayne, C. (2008). The Childhood Autism Spectrum Test (CAST): Sex differences. Journal of Autism and Developmental Disorders, 38(9), 1731–1739.

Wolff, S., & McGuire, R. J. (1995). Schizoid personality in girls: A follow-up study--what are the links with Asperger's syndrome? Journal of Child Psychology and Psychiatry, 36(5), 793–817.

Zhang, L., Sun, Y., Chen, F., Wu, D., Tang, J., Han, X., … Wang, K. (2016). Psychometric properties of the Autism-Spectrum Quotient in both clinical and non-clinical samples: Chinese version for mainland China. BMC Psychiatry, 16, 213.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1: Supplementary Information.