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Psychometric properties of the Chinese version of the Autism Spectrum Quotient (AQ)

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ABSTRACT

The Autism Spectrum Quotient (AQ) has been widely used for measuring autistic characteristics in parents of children with autism spectrum disorders (ASD). Nonetheless, its psychometric validity is yet to be justified. This study tested the factor structure of the AQ by means of principal component analysis and confirmatory factor analysis using, for the first time, data from 4192 Taiwanese parents (1208 with ASD children and 2984 with typically developing children). Results yielded a 35-item, 5-dimensional factor solution that had favorable psychometric characteristics (RMSEA = .054; NNFI = .962; CFI = .969) than any of the previously-published AQ factor solutions. Subscales of this new AQ-Chinese model were statistically and semantically coherent, namely: *Socialness*, *Mind-reading*, *Patterns*, *Attention to Details* and *Attention Switching*. The psychometric properties of the AQ-Chinese did not change between clinic-based and community-based data suggesting good fitting for a continuum of autistic expression. Furthermore, the considerable overlap between the AQ-Chinese and the AQ factor structures derived previously using student samples indicated consistency in the manifestation of the autistic profile across different cultures and age groups. Group differences in the AQ-Chinese scores were in line with previous studies, i.e. males generally scored radically higher than females except in *Attention to Details*. Interestingly, mothers of ASD children reported lower total AQ scores than community mothers yet no significant group difference for the fathers. Important research and clinical implications pertinent to parents with children with ASD and the utility of the AQ were drawn.

1. Introduction

Autism spectrum disorders (ASD; encompassing Autistic Disorder, Asperger's Syndrome [AS] and Pervasive Developmental Disorder-Not Otherwise Specified [PDD-NOS]) are a group of neurodevelopmental disorders characterized

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by: (a) particular deficits in social reasoning skills, (b) marked verbal and/or nonverbal communication skills impairments and, (c) stereotyped patterns of behaviors or interests (American Psychiatric Association, 1994). Though not exclusively determined by heredity, there is compelling evidence that ASD is genetically related (e.g. Eapen, 2011; Folstein & Rutter, 1977; Folstein & Piven, 1991; Ronald & Hoekstra, 2011). Studies on relatives of people with ASD have reliably found normative variants of full-blown autistic profile, known as broader autism phenotype (BAP; e.g. Le Couteur et al., 1996; Pickles et al., 2000; Sucksmith, Roth, & Hoekstra, 2011). There is now a clear recognition of BAP in parents of children with ASD (e.g. Bernier, Gerdts, Munson, Dawson, & Estes, 2011; Bolte & Poustka, 2006; Dawson et al., 2007; Happe, Briskman, & Frith, 2001; Pisula, 2002; Piven, Palmer, Jacobi, Childress, & Arndt, 1997), drawing research and clinical attention towards the effect of ASD symptomatology on these parents' well-being (e.g. Ingersoll, Hopwood, Wainer, & Brent Donnellan, 2011).

Although several questionnaires are currently used to measure BAP, to our best knowledge, only limited psychometric data have been published. Among them, the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) has been most widely used for ascertaining BAP in parents of children with ASD. The AQ consists of five subscales: *Social Skills*, *Communication*, *Attention Switching*, *Attention to Details* and *Imagination* (Baron-Cohen et al., 2001). In an Australian study of 111 parents of children with ASD and 88 parents of typically developing (TD) children, parents of ASD children reported significantly higher autistic traits in the *Social Skills* and *Communication* subscales of the AQ (Bishop et al., 2004). These significant findings were supported by two recent studies in Sicily (Ruta, Mazzone, Mazzone, Wheelwright, & Baron-Cohen, 2012) and in U.K. (Wheelwright, Auyeung, Allison, & Baron-Cohen, 2010) but not supported by one conducted in Netherlands (Scheeren & Stauder, 2008). In view of inconsistent findings across different ethnic groups, whether parents of children with ASD in another ethnic group such as Chinese will exhibit higher autistic trait as measured by the AQ than those of TD children therefore, warrants further investigation.

In fact, the AQ has been administered efficiently to culturally diverse samples over the years demonstrating stable internal consistency on Cronbach's alpha test for population. For instance, cross-cultural comparisons by replicating Baron-Cohen et al. (2001)'s original U.K. study had been conducted in Japan (Wakabayashi, Baron-Cohen, Uchiyama, Yoshida, Kuroda, et al., 2007; Wakabayashi, Baron-Cohen, Uchiyama, Yoshida, Tojo, et al., 2007; Wakabayashi, Baron-Cohen, & Wheelwright, 2006; Wakabayashi, Baron-Cohen, Wheelwright, & Tojo, 2006; Wakabayashi, Tojo, Baron-Cohen, & Wheelwright, 2004), Austria (Voracek & Dressler, 2006), Italy (Ruta et al., 2012), Netherlands (Hoekstra, Bartels, Cath, & Boomsma, 2008), Scotland (Stewart & Austin, 2009) and Canada (Lepage, Lortie, Taschereau-Dumouchel, & Théoret, 2009). Each of these studies validated the usefulness of the AQ in quantifying autistic characteristics in their local general population. A dilemma at hand, nonetheless, is that whilst the AQ shows promise and potential, its use in research and clinical endeavors has outstripped the validation evidence for its psychometric coherence. Indeed, fully convincing evidence of the psychometric validity of the AQ has yet to be demonstrated whether specifically in the context of Taiwanese sample or other ethnic samples. This is particularly true of its factor structure.

Originally, five dimensions were postulated to be discrete subscales within the AQ on purely conceptual ground. Yet no factor analysis was reported to clarify whether these subscales reflected the best reduction of the item set, or whether a different structure exists. Furthermore, the test–retest reliability and internal consistency coefficients (Cronbach's alpha, α, ranging from .63 to .77) on the five domains in the original study (Baron-Cohen et al., 2001) were suboptimal. In response to these shortcomings, several factor analytical studies have been conducted over the past decade to verify the factor structure and reliabilities of the AQ (e.g. Austin, 2005; Hoekstra et al., 2008; Kloosterman, Keefer, Kelley, Summerfeldt, & Parker, 2011). These studies revealed 2–5-factor models of the AQ, suggesting that the AQ is multifactorial and encompasses at least one factor relevant to social behaviors and another cognitive pattern. More specifically, two consistently verified constructs were 'Social Skills/Sociability' and 'Pattern/Attention to Details' (Austin, 2005; Hoekstra et al., 2008). Internal consistencies of the subscales in each model were varied (α ranging from .40 to .86).

All in all, several limitations regarding the structural validation of the AQ remain. First, none of the existing factorial models has achieved adequate goodness of fit indices as recommended for confirmatory factor analysis (CFA; see Browne & Cudeck, 1993; Hu & Bentler, 1999) suggesting the factor solution of the AQ requires further exploration. Second, internal consistencies of the subscales in each model were incongruent, with some as poor as $\alpha = .40$. Third, none of the factorial studies included Asian samples, albeit its radical role in ASD research in this region. Given high AQ scores have been shown to be positively correlated with neuroticism whilst negatively associated with extraversion and conscientiousness (Austin, 2005; Wakabayashi, Baron-Cohen, & Wheelwright, 2006; Wakabayashi, Baron-Cohen, Wheelwright, & Tojo, 2006), and that these personality traits are influenced by culture (Stevens, Kwan, & Graybill, 1993), we cannot disregard latent cultural effect by assuming the existing factor solutions for the AQ fit ethnic Chinese sample adequately. Fourth, the existing models were predominantly built on data from university students who are relatively young among the adult population and prone to higher academic caliber. Parents of children with ASD not only are comparatively older than university students, they probably would exhibit more autistic characteristics compared to the general population, as asserted by the theory of BAP. Collectively, their profile may present with unique ASD pertinent constructs as depicted by the items in the AQ hence require a further factorial analysis. In brief, the factorial validity of the AQ for Chinese parents warrants exploration especially if the AQ is increasingly relied on for genetic and endophenotype studies in ASD in ethnic Chinese population.

In light of the aforementioned gaps in the AQ literature, the present study aims to: 1) build on previous research by assessing the factor structure and internal consistency of existing factor solutions for the Chinese version (Traditional Mandarin) of the AQ using data from Taiwanese population; 2) develop and validate an alternative factor model (if indeed distinct from the existing models) that will fit data from a sample of parents of children with and without ASD. Such a group

is likely to include individuals with BAP and to encompass the autism spectrum more entirely; and 3) test if the AQ shows sensitivity in discriminating parents of children with ASD from their counterpart, and to check if any particular domains of the AQ are more potent in portraying BAP.

2. Methods

2.1. Participants

The sample consisted of two groups: 1) clinic-based group: parents of 604 children with a clinical diagnosis of DSM-IV autistic disorder or Asperger's disorder ($N = 1208$; mean age of fathers, 43.05 ± 6.34 years; mean age of mothers, 40.13 ± 5.81 years), and 2) community-based group: parents of 1492 TD children ($N = 2984$; mean age of fathers, 43.59 ± 5.58 years; mean age of mothers, 40.53 ± 5.10 years). The clinic-based sample was recruited through the National Taiwan University Hospital in Taipei ($n = 367$, 60.8%), the Chang Gung Children's Hospital in Taoyuan ($n = 146$, 24.2%) and several other regional hospitals and schools ($n = 91$, 15.0%) nationwide.

Among the 1208 parents of ASD children, 23.3% were high school graduates, 55.9% obtained a bachelor degree and 19.9% postgraduate degree; 90% were married or in a de facto relationship whereas the remaining either separated or divorced. The clinical diagnoses of ASD in the children were made by board-certified child psychiatrists conversant with clinical and research expertise in the assessment and treatment of ASD. The diagnostic procedures involved clinical interviews with primary caregivers, collateral information from teachers and other professionals, and direct observation and interaction with the children. The clinical diagnoses of ASD were also confirmed by structured interviews using the Chinese version of the *Autism Diagnostic Interview-Revised* (ADI-R; Chien et al., 2010; Gau et al., 2012, 2010, 2011).

The community-based group was parents of an age matched TD sample to children with ASD recruited through randomly selected primary and junior high schools of the same neighborhoods of children with ASD. In this group, about 9% of the couples were separated or divorce and the rest married or in a de facto relationship; 39% were high school graduates, 47.8% obtained a bachelor degree and 13.1% postgraduate degree. To exclude any risk of low intellectual functioning, only participants who had completed junior high school education were included in this study. Parents who have diagnosis of schizophrenia, schizoaffective disorder, or organic psychosis were excluded.

2.2. Instruments

2.2.1. The Chinese version of the AQ

The AQ is a self-report questionnaire developed to quantify autistic traits in adults with normal intelligence. It consists of 50 theoretically-derived statements depicting personal views, habits and preferences pertinent to the unique profile of ASD. The items are equally divided into five subscales: *Communication*, *Social Skills*, *Attention Switching*, *Imagination*, and *Attention to Details*. Sample items from the first two subscales respectively are: "*Other people frequently tell me what I have said is impolite, even though I think it is polite*" and "*I am good at social chit-chat*". Each statement is rated on a four-point scale, with answer categories "definitely agree", "slightly agree", "slightly disagree" and "definitely disagree". Every response that indicates autistic feature is scored '1' if "definitely agree" or "slightly agree", and otherwise '0' if "slightly disagree" or "definitely disagree" leading to the total score of the AQ ranges from 0 to 50 where higher score depicts the autistic end of the continuum. In order to avoid response bias, about half of the statements were reversal items. As in previous studies (Austin, 2005; Hoekstra et al., 2008; Stewart & Austin, 2009), this study first employed an ordinal (4-point Likert) scale (ranging from 1 to 4 for items portraying autistic feature, and inverted for the reversal items) instead of the original dichotomous scale for responses to the AQ so to obtain a better approximate of continuous distribution in order to provide more information for procedures such as factor analysis (Gorsuch, 1983; Swygert, McLeod, & Thissen, 2001). The original scoring protocol was subsequently applied when performing group comparisons.

2.2.2. The Chinese version of the ADI-R

The Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994) is a standardized, comprehensive, semi-structured, investigator-based interview of caregiver covering most developmental and behavioral aspects of ASD, including reciprocal social interaction, communication, and repetitive behaviors and stereotyped patterns, for children with a mental age from about 18 months into adulthood. Gau SS and colleagues have prepared the Chinese version of the ADI-R, which was approved by the Western Psychological Services (WPS) in May 2007, for the use in this study (Chien et al., 2010; Gau et al., 2012, 2010, 2011).

2.3. Procedures

The Chinese AQ was prepared with culture-relevant colloquial expressions and two-way translation by Gau and colleagues after permission was granted by Baron-Cohen et al. to ascertain the linguistic and content validity of this measure. Protocol of this research was approved by the Research Ethics Committee of the National Taiwan University Hospital (IRB ID: 201005041R; ClinicalTrials.gov number, NCT01247662) prior to data collection. Each parent participant was informed with the objectives and procedures of the study, including issues of confidentiality and volunteering nature of this study. Upon

parent participants' consent, parents of children with ASD completed the Chinese AQ and ADI-R interview at the Laboratory of National Taiwan University Hospital and parents of TD children completed the Chinese AQ at home, which was mailed to the researchers via a sealed envelope. Return rate of school-based sample was 81.16%. Of all the returned AQ from clinic- and school-based recruitment, 4192 had complete responses for data analysis.

2.4. Statistical analysis

Data analyses were conducted using Predictive Analytics SoftWare Statistics (PASW), SAS 9.2 (SAS Institute Inc, Cary NC, USA), and LISREL 8.8 (SSI Inc., Chicago, IL, USA) software. First, the existing factor models were examined using confirmatory factor analyses (CFA) in LISREL 8.54 software (Jöreskog & Sörbom, 2002) to determine which of these best fits the data. The 5-subscale model proposed in the original study (Baron-Cohen et al., 2001) was first fitted on the total sample of 3434 parents. A diagonally weighted least square procedure was used considering that each item in the AQ was measured on an ordinal scale. We applied a promax/oblique rotation to allow correlations between the factors assuming various aspects of autistic characteristics measured by the AQ were related. The goodness of fit was tested austerely using χ^2 test statistic, root-mean-square-error of approximation (RMSEA) and non-normed fit index (NNFI). We chose these fit indices based on their demonstrated robust performance under various data and model misspecification conditions. As the χ^2 is often sensitive to trivial deviations in model fit in large samples ($N > 100$), emphasis were placed on the other four indices. The RMSEA index measures the error of approximation in the population and determines whether the model, with unknown but optimally chosen parameter values, fits the population correlation matrix or covariance matrix (Byrne, 1998). The value of this fit index is expected to better approximate or estimate the population and not be affected by sample size. A RMSEA value less than .06 indicates good fit; values ranging from .08 to .10 indicate a mediocre fit; and those greater than .10 indicate poor fit (Hu & Bentler, 1995). In addition to comparing a proposed model's fit to a nested baseline or null model, the NNFI measures parsimony by assessing the degrees of freedom from the proposed model to the degrees of freedom of the null model. The NNFI was also chosen owing to its resilience against variations in sample size. The usual cut-off value for well-fitted factor models are >.90 for NNFI (Bentler, 1990).

In order to draw comparisons among the existing models, same procedures were repeated individually with the 2- (Hoekstra et al., 2008), 3- (Austin, 2005), 4- (Stewart & Austin, 2009) and 5- (Kloosterman et al., 2011) factor models to determine if any of them would exhibit better psychometric properties. Then, we compared the comparative fit index (CFI) and Akaike information criterion (AIC) among the five existing models as well as the newly-established factor solution from the present study. The CFI was estimated to indicate whether complete covariation in the data was achieved (Tabachnick & Fidell, 2007). It is generally considered an acceptable fit to the data when the value of CFI exceeds .95 (Browne & Cudeck, 1993). As for the AIC, no convention cut-off has been specified. Instead, smaller values indicate the model is more parsimonious and provides better fit to the data (Akaike, 1987). Finally, model diagnosis was conducted by examining the estimated factor loadings, the estimated correlations between latent variables and between measurement errors, and the standardized residual variance-covariance matrix.

To examine test-retest reliability, a random subsample of 136 parents completed the AQ for a second time after the first administration (8 weeks). Intra-class correlations (ICC) and paired *t*-test were calculated for agreement and difference between the two measurements, respectively. ICC was employed because this method not only assessed the correlations of the subscale and total scores, but also assessed shifts in the grand mean of scores across the test-retest time interval (Koch, 1982).

Cronbach's alpha (α) was calculated for the internal consistency of the total and five subscales of the AQ derived from CFA. An α of .70 or greater is generally considered acceptable in social science (Kline, 2005). Finally, Pearson correlations (γ) among the five subscales were computed to explore the association between the latent factors.

For evaluating discriminative validity, analysis of covariance (ANCOVA) was used to compare the mean score of the five subscales of the AQ as well as the total score between the parents of children with ASD and the community-based counterparts controlling for children's gender and age. The linear mixed model with both fixed and random effects was used to address the lack of independence within the same family when analyzing the differences between fathers and mothers in the AQ scores, controlling for the children's gender and age. Cohen's *d* (*d*) was tabulated manually to determine effect size of the different scores between clinic-based and community-based groups. If the *d* value is approximately .50, the effect size is regarded as medium whereas .80 or larger implies a large effect size (Cohen, 1988).

3. Results

3.1. Testing of Hypothesis 1: Goodness of Fit for existing factor models

Table 1 presents the CFA results of model fit for the five competing models. All of the models, as hypothesized, did not meet the recommended criteria for good fit, i.e. RMSEA < .06 (Hu & Bentler, 1995), NNFI > .90 (Bentler, 1990) or CFI > .95 (Browne & Cudeck, 1993). Internal consistencies as measured with Cronbach's alpha for each of the subscales in all the five models were mostly poor, ranging from .28 to .71.

Table 1
CFA goodness of fit statistics for previous AQ factor models and AQ-Chinese using a Taiwanese sample ($n = 1374$).

Model	# of items	# of factors	Alpha Cronbach	χ^2	RMSEA [90% CI]	NNFI	CFI	AIC
Baron-Cohen et al. (2001)	50	5	Social Skills (.56) Attention Switching (.42) Attention to Details (.45) Communication (.49) Imagination (.39)	10316.43	.108 (.106–.109)	.849	.857	15471.51
Austin (2005)	26	3	Social Skills (.68) Attention to Details/Patterns (.58) Communication/Mindreading(.41)	2642.08	.089 (.085–.091)	.893	.903	2773.34
Hoekstra et al. (2008)	50	2	Social Interaction (.79) Attention to Details (.45)	11035.19	.114 (.112–.115)	.839	.845	17272.22
Stewart and Austin (2009)	43	4	Socialness (.60) Patterns (.55) Understanding Others/ Communication (.54) Imagination (.53)	3207.83	.089 (.086–.092)	.870	.883	3290.85
Kloosterman et al. (2011)	28	5	Social Skills (.71) Communication/Mindreading (.58) Restrictive/Repetitiv Behavior (.28) Imagination (.47) Attention to Details (.60)	8088.31	.099 (.097–.100)	.868	.875	9707.78
AQ-Chinese	35	5		1889.30	.054 (.052–.57)	.962	.969	2242.25

Note: χ^2 = Chi-square test statistics; RMSEA: root-mean-square-error of approximation; 90% CI: 90% confidence interval for RMSEA; NNFI: non-normed fit index; CFI: comparative fit index; AIC: Akaike information criteria.
$^{*}p < .001$.

3.2. Testing of Hypothesis 2: the alternative model

3.2.1. Principal component analysis

Given that none of the existing models fitted the data fully convincingly, the sample was randomly split into two sub-samples to derive and test an alternative model for the factor structure of the AQ.

First, an exploratory principal component analysis (PCA) and factor extraction by the scree criterion in the first sub-sample ($n = 2060$ parents) was conducted. Again, promax rotation was applied to allow correlation because personality characteristics such as depicted in the AQ would unlikely be totally discrete components. The Kaiser–Meyer–Olkin Measure of Sampling Adequacy was .948 indicating high sampling adequacy of the model (.90 or greater is extremely good). Bartlett's Test of Sphericity indicated that the rotated solution was significant at the $p < .0001$ level, confirming significant correlations among a number of the variables and that factor analysis was suitable for the data.

In the rotated solution, 11 factors had eigenvalues greater than one. A 5-factor solution was chosen instead because the last six factors explained only a further 14.2% of the variance. Utility of this model was confirmed by a Scree test (Cattell, 1966). This 5-factor model explained 42.3% of the total variance (Table 2). Item elimination was then performed in an iterative fashion based on theoretical and empirical reasons. Theoretically, items were discarded if not conceptually congruent with the theme of their designated factor. Empirically, items with a factor loading of less than .32 and/or items with strong crossloadings (loaded $\geq$.50 in more than one factor) would be dropped (Tabachnick & Fidell, 2007). Only factors with three or more strongly loading items ($\geq$.50) were considered solid thus justifiable factors (Costello & Osborne, 2005).

3.2.2. Confirmatory factor analysis

For cross validation, this 5-factor solution from PCA was then taken as the initial model for confirmatory factor analysis (CFA) of the ratings of all 50 AQ items in the second sub-sample ($N = 1374$ parents). Basic model-fitting techniques were applied to assure the quality of analysis results. First, with the aid of knowledge and insight, stepwise variable selection was performed by iterating the following two actions: (i) using the Wald's t-test to drop insignificant structural parameter and (ii) using the Modification Index (MI) to add additional meaningful structural parameter. As shown in Table 1, the newly found 5-factor model was by far a favorable fit compared to the existing factor models, meeting the recommended criteria for good fit (RMSEA = .054, NNFI = .962, CFI = .969).

Factorial analyses confirmed this 5-factor solution had reasonably high coherence with factor loadings typically above .50 (see Table 2). Indeed, there were no significant crossloadings between items. Correlations between each factor and the measure as a whole were significantly different from zero ($p < .001$) and the magnitude was generally in the moderate range ($\gamma = .54$–$.79$) suggesting high internal relatedness in this alternative model. Table 3 presents correlations of the five factors stratifying by gender. For both fathers and mothers, *Socialness* and *Mindreading* appeared subjective to *Attention Switching* ($\gamma = .38$–$.59$, $p < .001$) possibly explainable by the mental flexibility the socio-cognitive process entail. As predicted, *Socialness* was strongly correlated with *Mindreading* ($\gamma = .43$ and $\gamma = .46$, $p < .001$) in both genders assuming someone who is

Table 2
Factor loadings for principle component analysis ($n = 2060$) and confirmatory factor analysis ($n = 1374$) of AQ-Chinese.

Factors and items		Factor loadings PCA	Factor loadings CFA[a]	Original subscale
Factor 1 Socialness				
48*	I am a good diplomat.	.826	.839	SS
11*	I find social situations easy.	.801	.805	SS
44*	I enjoy social occasions.	.789	.839	SS
38*	I am good a social chit-chat.	.779	.873	CO
10*	In a social group, I can easily keep track of several different people's conversations.	.768	.820	AS
17*	I enjoy social chit-chat.	.764	.722	CO
47*	I enjoy meeting new people.	.669	.759	SS
22	I find it hard to make new friends.	.588	.685	SS
13	I would rather go to a library than a party.	.412	.462	SS
26	I frequently find that I don't know how to keep a conversation going.	.401	.678	CO
46	New situations make me anxious.	.396	.533	AS
1*	I prefer to do things with others rather than on my own.	.350	.442	SS
Factor 2 Mindreading				
45	I find it difficult to work out people's intentions.	.748	.762	SS
35	I am often the last to understand the point of a joke.	.696	.525	CO
27*	I find it easy to 'read between the lines' when someone is talking to me.	.694	.750	CO
36*	I find it easy to work out what someone is thinking or feeling just by looking at their face.	.680	.701	SS
31*	I know how to tell if someone listening to me is getting bored.	.655	.605	CO
33	When I talk on the phone, I am not sure when it's my turn to speak.	.524	.698	CO
20	When I am reading a story, I find it difficult to work out the characters' intentions.	.505	.588	IM
7	Other people frequently tell me that what I've said is impolite, even though I think it is polite.	.331	.447	CO
Factor 3 Patterns				
19	I am fascinated by numbers.	.795	.735	AD
41	I like to collect information about categories of things (e.g. types of cars, birds, trains, plants, etc.).	.636	.389	IM
9	I am fascinated by dates.	.628	.692	AD
6	I usually notice car number plates or similar strings of information.	.570	.630	AD
29*	I am not very good at remembering phone numbers.	.314	.289	AD
Factor 4 Attention to Details				
12	I tend to notice details that others do not.	0.787	.776	AD
5	I often notice small sounds when others do not.	.735	.618	AD
28*	I usually concentrate more on the whole picture, rather than the small details.	.608	.370	AD
23	I notice patterns in things all the time.	.527	.416	AD
Factor 5 Attention Switching				
34*	I enjoy doing things spontaneously.	.657	.424	AS
4	I frequently get so strongly absorbed in one thing that I lose sight of other things.	.589	.407	AS
37*	If there is an interruption, I can switch back to what I was doing very quickly.	.434	.633	AS
16	I tend to have very strong interests which I get upset about if I can't pursue.	.391	.292	AS
32*	I find it easy to do more than one thing at a time.	0.382	.558	AS
39	People often tell me that I keep going on and on about the same thing.	.360	.590	CO

Note: CO: Communication; SS: Social Skills; AS: Attention Switching; IM: Imagination; TD: Attention to Details.
[a] Completely standardised solution.
* Reversed items.

competent in taking others' perspective would be more confident and motivated to socialize. Similarly, *Patterns* and *Attention to Details* were closely related in both genders ($\gamma = .41$ and $\gamma = .44$, $p < .001$), both constructs pertinent to obsessive tendency in work or interests commonly reported by people with ASD (Attwood, 2007; Baron-Cohen & Wheelwright, 1999). Fisher's exact test revealed no significant difference in any subscale correlations between fathers and mothers (all $p > .05$).

Finally, we ascertained if there was divergent AQ factor structure between parents of children diagnosed with ASD ($N = 1045$ parents) and parents with TD children ($N = 2389$ parents). To this end, we conducted three separate CFAs: the 5-factor model fitted to the clinic-based sample only, to the community-based sample only, and to the total sample ($N = 3434$ parents). Factor loadings and goodness-of-fit indices of the three were comparable thus confirming the unassailability of the final, 35-item, 5-factor solution which we henceforth refer to as the AQ-Chinese (Fig. 1).

3.2.3. Test–retest reliability and internal consistency

Table 4 shows that the AQ-Chinese demonstrated good test-retest reliability (ICC = .40–.72). There was no significant difference between the two measurements across all the domains implying sufficient constancy. Internal consistency for the total scale was excellent ($\alpha = .84$) and were somewhat mixed for the subscales (α ranging from .54 to .88) though significantly improved compared to previous models.

Table 3
Pearson correlations between subscales of the AQ-Chinese stratifying by gender.

Females \ Males	Socialness	Mindreading	Patterns	Attention to Details	Attention Switching
Socialness		0.43****	-0.18****	-0.11****	0.39****
Mindreading	0.46****		-0.02	-0.10****	0.52****
Patterns	-0.09***	0.06**		0.41****	-0.04
Attention to Details	-0.03	-0.02	0.44****		-0.06*
Attention Switching	0.38****	0.59****	0.08***	0.04	

* $p < .05$.
** $p < .001$.
*** $p < .001$.
**** $p < .0001$.

Table 4
Test–retest reliability and internal consistency of the AQ Taiwan ($N = 136$).

Scale (# of items)	Correlations		Test–retest reliability				Internal consistency
	γ	ICC	1st Mean ± SD	2nd Mean ± SD	*t*	*p*	Cronbach α
Socialness (12)	.725**	.724	33.259 ± 5.65	33.47 ± 6.02	−7.80	.436	.880
Mindreading (8)	.606**	.605	24.64 ± ± 3.48	24.45 ± 3.33	.989	.324	.767
Patterns (5)	.609**	.608	13.88 ± 2.62	13.70 ± 2.59	1.20	.233	.629
Attention to Details (4)	.399**	.400	9.63 ± 1.98	9.63 ± 1.98	.00	1.00	.543
Attention Switching (6)	.544**	.536	17.69 ± 2.55	17.38 ± 2.24	2.04	.430	.602
Total AQ-Chinese (35)	.648**	.647	99.25 ± 9.52	98.54 ± 9.30	1.35	.179	.836

Note: γ: Pearson correlation; ICC: intraclass correlation; validity: discriminating between clinical and community sample.
** $p < .001$.

3.3. Testing of Hypothesis 3: group differences

3.3.1. Gender and age effects

We first explored gender and age effect on self-reported autism characteristics taking the sample as a whole and confirmed these factors accounted for a large amount of the overall variance. Among the 3434 respondents, age effect was considerable with *Socialness*, *Mindreading*, *Patterns*, *Attention to Details* and total AQ-Chinese scores increased with age [($F_{(1,3434)} = 32.69$, $p < .0001$), ($F_{(1,3434)} = 5.28$, $p < .05$), ($F_{(1,3434)} = 4.27$, $p < .05$), ($F_{(1,3434)} = 13.80$, $p < .001$) and ($F_{(1,3434)} = 6.17$, $p < .05$) respectively]. In terms of gender effect, fathers scored significantly higher than mothers only in the *Mindreading* subscale ($F_{(1,3434)} = 18.85$, $p < .001$). To further stratify by child's diagnostic grouping (i.e. clinic-based versus community-based parents), there was more significant gender difference (Table 5). As expected, fathers generally reported higher scores than mothers on the AQ-Chinese with an exception in the *Attention to Details* subscale in both clinical and community groups. The community fathers and mothers also did not differ in the *Socialness* domain.

3.3.2. Discriminative validity

In order to test the discriminative validity of the AQ between parents of ASD children (previously found to manifest BAP) and parents of TD children, subscale and total scores of the AQ-Chinese were compared, stratified by gender (Table 5). Contrary to previous findings, mothers of ASD children reported significantly lower scores in *Patterns* ($d = -.641$), *Attention to Details* ($d = -.381$) and the total score ($d = -.205$) than mothers of school controls. Fathers of ASD children reported significantly higher scores, though very small effect sizes, in *Socialness* ($d = .297$) and *Attention Switching* ($d = .161$) but lower scores in *Patterns* ($d = -.529$) and *Attention to Details* ($d = -.270$) than fathers of TD children. There was no statistically significant difference between the fathers in their total AQ-Chinese scores.

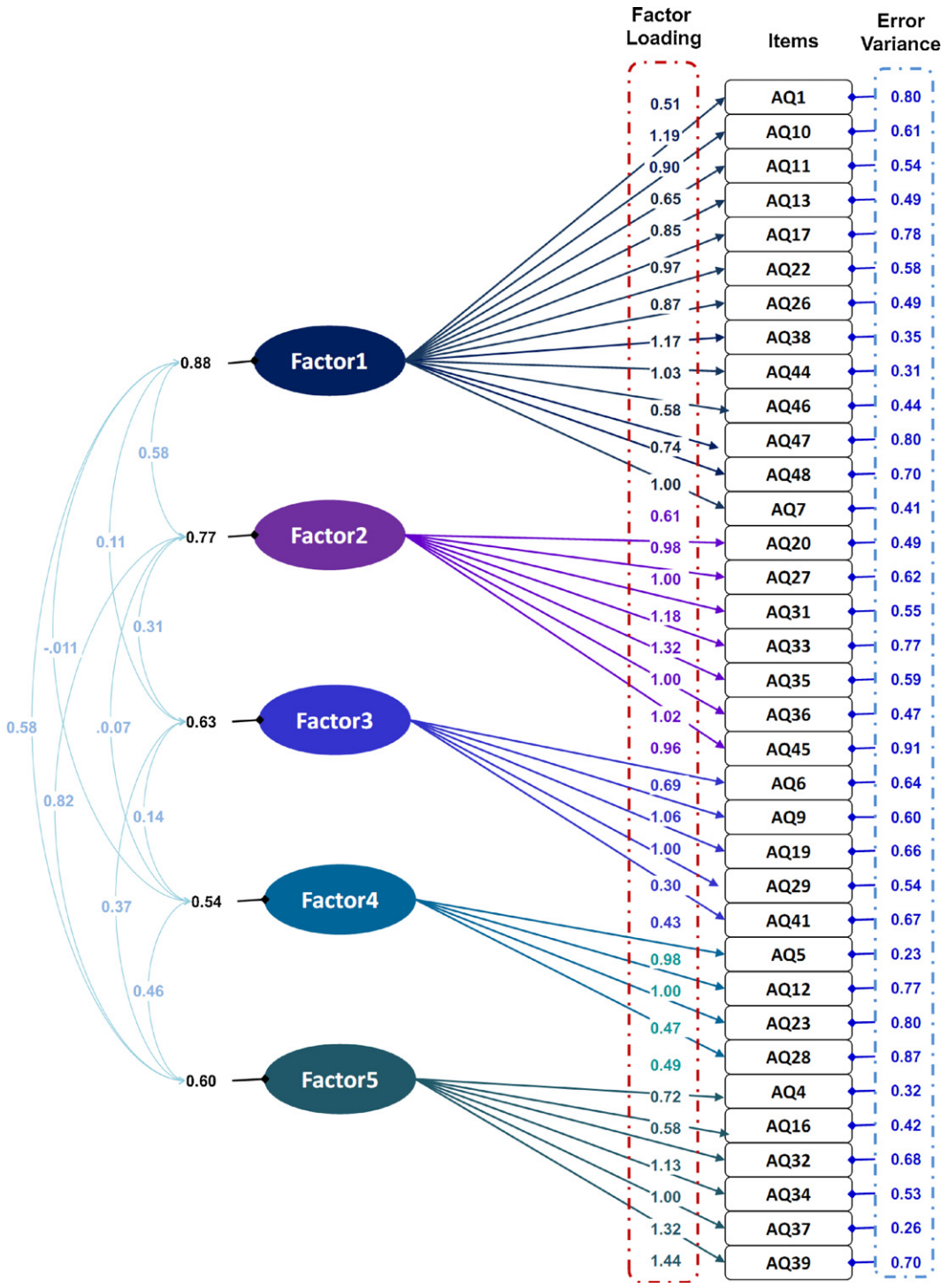

Fig. 1. Factor model of the Chinese version of the Autism Spectrum Quotient.

4. Discussions

The present study examined the factor-analytic structure of the AQ and tested its discriminant validity between parents of children with ASD and those with TD children. None of the existing factorial models fitted our Taiwanese data adequately. As a result, a 35-item, 5-dimensional factor solution that had favorable psychometric characteristics than any of the previously-published AQ factor solutions was developed. This new AQ-Chinese model consisted of five tightly statistically

Table 5
Comparisons of AQ-Chinese scores between clinic-based and community-based subjects.

Variables	Clinical	Community	Cohen's *d*	Clinical vs. community	Mothers vs. fathers	
	Mean ± SD	Mean ± SD			Clinical	Community
Mothers	$N = 542$	$N = 1252$				
Socialness	26.75 ± 6.78	26.70 ± 5.98		$F_{1,1792} = .03$, $p = .868$	$F_{1,1043} = 13.90$, $p = .002$	$F_{1,2387} = 1.31$, $p = .252$
Mindreading	14.65 ± 3.89	14.80 ± 3.58		$F_{1,1792} = .61$, $p = .434$	$F_{1,1043} = 13.39$, $p = .003$	$F_{1,2387} = 21.24$, $p < .001$
Patterns	8.89 ± 2.46	10.52 ± 2.62	−.641	$F_{1,1792} = 151.32$, $p < .001$	$F_{1,1043} = 53.18$, $p < .001$	$F_{1,2387} = 68.20$, $p < .001$
Attention to Details	9.61 ± 2.07	10.38 ± 1.97	−.381	$F_{1,1792} = 56.05$, $p < .001$	$F_{1,1043} = 2.81$, $p = .094$	$F_{1,2387} = .00$, $p = .973$
Attention Switching	11.96 ± 2.74	11.79 ± 2.55		$F_{1,1792} = 1.44$, $p = .230$	$F_{1,1043} = 24.69$, $p < .001$	$F_{1,2387} = 30.27$, $p < .001$
Total scores	71.87 ± 12.29	74.20 ± 10.41	−.205	$F_{1,1792} = 17.47$, $p < .001$	$F_{1,1043} = 38.63$, $p < .001$	$F_{1,2387} = 20.62$, $p < .001$
Fathers	$N = 503$	$N = 1137$				
Socialness	28.32 ± 6.77	26.42 ± 5.99	.297	$F_{1,1638} = 32.26$, $p < .001$		
Mindreading	15.52 ± 3.77	15.47 ± 3.47	–	$F_{1,1638} = .08$, $p = .777$		
Patterns	10.03 ± 2.59	11.39 ± 2.55	−.529	$F_{1,1638} = 98.37$, $p < .001$		
Attention to Details	9.83 ± 2.15	10.38 ± 1.92	−.270	$F_{1,1638} = 26.37$, $p < .001$		
Attention Switching	12.79 ± 2.66	12.37 ± 2.55	.161	$F_{1,1638} = 9.12$, $p = .003$		
Total scores	76.49 ± 11.70	76.03 ± 9.51		$F_{1,1638} = .71$, $p = .401$		

and semantically coherent subscale constructs named as *Socialness*, *Mindreading*, *Patterns*, *Attention to Details* and *Attention Switching*. Statistically, these five factors loaded relatively cleanly on their respective domains, and factors were highly correlated within the subscales. Semantically, the items clustered in a fashion that depicted distinctive dimensions of ASD symptomatology. As a whole, the AQ-Chinese model demonstrated adequate goodness of fit (RMSEA = .054; NNFI = .962; CFI = .969), the internal consistencies although were mix (α ranged from .54 to .88) yet radically enhanced compared to the existing models.

The psychometric properties of the AQ-Chinese did not change between clinic-based and community-based data suggesting the AQ-Chinese model is fitting for a continuum of autistic expression. Group differences in the AQ-Chinese scores were in line with previous studies, i.e. males generally scored radically higher than females (Austin, 2005; Baron-Cohen et al., 2001; Hoekstra et al., 2008; Wakabayashi, Baron-Cohen, Uchiyama, Yoshida, Kuroda, et al., 2007; Wakabayashi, Baron-Cohen, Uchiyama, Yoshida, Tojo, et al., 2007) with an exception in *Attention to Details*. This gender effect dissipated in the *Socialness* domain within the community group. The considerable overlap between the AQ factor structure derived from the present study and previous studies indicated that symptom manifestation of the autistic profile in our Taiwanese parent sample is not overtly different from that in university students and suggested consistency in autistic traits across different cultures.

4.1. Factorial structure

Structurally, this Taiwanese, exclusively parent-based, AQ-Chinese model synchronized with Baron-Cohen et al. (2001)'s original factor formulation using a UK sample. The new *Socialness* and *Attention Switching* and *Attention to Details Mindreading* were essentially a subset of the original *Social Skills*, *Attention Switching* and *Attention to Details* subscales respectively. The AQ-Chinese, however, contributed by refining the conceptual constructs on the original AQ. More specifically, items of the original *Imagination* and *Communication* subscales were dispersed to fortify a more distinct and condensed subscale, namely *Mindreading*. The *Imagination* subscale evidently had had an ambivalent status within the AQ literature including failing to be cross-validated in follow-up CFA (Kloosterman et al., 2011) and attaining dissatisfactory Cronbach alpha's coefficient (Hurst, Mitchell, Kimbrel, Kwapil, & Nelson-Gray, 2007; Stewart & Austin, 2009). The newly formed construct of *Mindreading* depicts difficulty in perspective-taking, or in other words deficit in theory of mind which is the hallmark of ASD (Baron-Cohen, Leslie, & Frith, 1985). In the AQ literature, the concept of *Mindreading* first emerged as *Communication/Mindreading* in Austin (2005)'s 3-factor model. Hoekstra et al. (2008) later in their two-factor hierarchical model asserted the same impression by clustering the *Social Skills*, *Communication*, *Attention Switching* and *Imagination* subscales to make a higher order *Social Interaction* factor. The AQ-Chinese advanced by consolidating this supposition.

Nominating *Mindreading* as a factor in the AQ is not only theoretically meaningful but clinically eminent for two reasons. First, it captures the complex yet subtle social difficulties in higher functioning ASD, commonly presented in adults seeking late-diagnosis. Secondly, it will help distinguish social competency (or incompetency) from interest/motivation in relating to others. The latter is depicted by another subscale in the AQ-Chinese, namely *Socialness.* Social competency and social motivation are two discrete entities; usually stern from distinctive pathology hence can have different clinical implications. Many people with ASD, even socially challenged, are described to be socially interested however could become withdrawn and de-motivated owing to developing secondary mood disorders (Cederlund, Hagberg, & Gillberg, 2010; Punshon, Skirrow, & Murphy, 2009). With these assets, the *Socialness* and *Mindreading* subscales can be used jointly to inform intervention goals.

4.2. Diagnostic nomenclature of ASD

Theoretically, the five factors of AQ-Chinese resembled closely with the diagnostic criteria of ASD. The imminent DSM V (www.dsm5.org) has proposed to characterize ASD with two behavioral dimensions: 1) social/communication deficits

(Criterion A) and 2) fixated interests and repetitive behaviors (Criterion B). Elegantly, the first and second factors in AQ-Chinese (*Socialness* and *Mindreading*) correspond to Criterion A whilst the sequential three (*Patterns*, *Attention to Details* and *Attention Switching*) depict Criterion B. The AQ-Chinese is the first to have had the two diagnostic criterions so precisely and holistically sub-categorized even though '*Social Skills*/*Sociability*' and '*Pattern*/*Attention to Details*' have always been the two most palpable and robust facets extracted from the AQ in previous studies (Austin, 2005; Hoekstra et al., 2008).

In view of the compatibility between AQ-Chinese and the ASD diagnostic guidelines, we suggest future factor analytical studies on the AQ tryout a 2-factor model corresponding to the proposed diagnostic criteria in DSM-V. This can be implemented by merging *Socialness* and *Mindreading* as defined in the AQ-Chinese to make one factor then the remaining to compose another. We can also consider adding items that exemplify the newly identified, diagnostically relevant, constructs in the latest models (e.g. *Mindreading*, *Patterns*) to consolidate the underlying factors intended for this measure. These items can be drawn from the descriptions in commonly used diagnostic protocols for adults with ASD (e.g. tendency for literal interpretation, strict adherence to rituals, special interests and the like). In conjunction with adding new items, items that have consistently been found to be redundant in previous studies (e.g. "I would rather go to the theatre than a museum") should be abandoned, so is the feeble subscale of *Imagination*.

4.3. Discriminative validity

Like previous findings (e.g. Austin, 2005; Hoekstra et al., 2008; Kloosterman et al., 2011), the subscales derived from the AQ-Chinese were stable over time. Mothers of children with ASD in this study reported either no difference or lower scores than mothers with school controls. This was consistent with a Dutch study (Scheeren & Stauder, 2008) which found no distinction between mothers of these two populations. In fact, their mothers of children with ASD even reported significantly lower score on the *Attention to Details* domain. Likewise, previous studies showed fathers of children with ASD reported distinctively higher AQ scores in the *Social Skills* and *Communication* domains (e.g. Bishop et al., 2004), the present study also demonstrated higher scores on the *Socialness* subscale in fathers of the ASD group. There were, however, different directions found in the subscales of *Attention to Details* and *Patterns*, leading to no distinction in the total scores between the two groups.

On the whole, the extent of relatively low AQ scores among parents with children with ASD in relation to the community sample was somewhat atypical from the AQ literature. Several speculations could be drawn based on our clinical observations on parents of our clinical sample with ASD. First, since the patients with ASD derived from a cohort of ASD families for clinical and genetic study established by the corresponding author, they are knowledgeable about high heritability in ASD and the typical symptoms and behavioral patterns of different levels and stages of ASD. There may be a conscious avoidance from being labeled as autistic or being responsible for heritability, thus bias towards under-reporting autistic feature on themselves. Second, having a child diagnosed with ASD is likely to increase the parents' knowledge about this condition leading to taking a clinical interpretation on the AQ items. For instance, items denoting attention to details could well be interpreted as competency among mothers of the community group where as mothers of children with ASD would take as connotation of pedanticity. Third, there may be a fear of having passed on the ASD genes leading to a lifelong diagnosis in their child. Stigma towards having a child with special needs in the Chinese society and the guilt incurred in the parents have long been recognized (e.g. McCabe, 2007; Wang, Michaels, & Day, 2011). Each of these three conditions potentially lowers the AQ scores among parents with children with ASD in our sample. The community-based sample on the contrary, is likely to be 'naive' of ASD connotation hence inclined to report more freely and honestly. Indeed, in comparison with findings from another large scale study (Wheelwright et al., 2010), mean AQ total scores reported by our community-based mothers was considerable higher than theirs (17.4 as opposed to 13.1). The same pattern was observed in the fathers' scores (18.2 as opposed to 17.7). Likewise, the clinical sample in our study reported lower, though marginally, total AQ scores compared to Wheelwright et al. (2010)'s sample (18.9 as opposed to 19.2 in fathers and 16.5 as opposed to 16.4 in mothers). More scholastic and clinical endeavors are necessary to demystify the specific explanation to our observations such as exploring the dynamic between parental perception on child's ASD diagnosis and their rating on ASD symptomatology in themselves.

4.4. Methodological considerations

The novelty of this study is two-fold: First, it is for the first time that the factorial structure of the AQ is tested based on a sample of parents of children with and without ASD, a group likely to encompass a full variant of the ASD continuum. Secondly, it is the first to examine the properties of the AQ in an Asian context. Methodologically, this study has employed a rigorous factor analytic procedure involving both PCA and CFA. The PCA was based on a sample size sufficient for statistical power for a 50 item measure with a subject to item ratio of 1:5 (Arrindell & van der Ende, 1985) despite the intricacy of recruiting parents of children with ASD. Finally, our sample consisted of a heterogeneous group of ASD diagnoses in the children of whom intensity and heritability of ASC symptomatology are likely to be diverse and all-encompassing.

There are, on the other hand, inevitable caveats in this study ought to be addressed. Firstly, autistic characteristic in the parents was fully reliant on self report. Whether the relatively low AQ scores in parents of children with ASD reflects that they are actually not having autistic feature, or their behaviors have been modified for the compensation for their children's autistic behavioral problems or to be a competent trainer for their children with ASD, or lastly, had under-report bias, warrants further investigation. Besides, without cross-validating the diagnostic status of the sample, the cut-off points of the

AQ-Chinese cannot be determined. Given the AQ has never been intended to be a standalone diagnostic tool but to be administered in ancillary to clinical assessments (Baron-Cohen et al., 2001), future studies need to incorporate clinical diagnostic procedure on these parents in order to cross-examine reliability of self-report data and sensitivity of the AQ. Secondly, we relied on convenient sample where parents who received the paper questionnaires took the initiative to complete and return their responses via mail. Albeit extensive effort was put in to make the process most convenient possible, certain level of dedication was needed to participate in this study. Hence, the sample pool was self-selected. Finally, our sample only included the parent population which though covered a relatively wide age range and social status, is exclusive. Owing to these plausible sampling biases, generalization of our findings warrants precautions.

5. Conclusions

Our findings confirm that the 35-item AQ-Chinese has good test and retest reliability, comprises of items corresponding to the diagnostic criteria of ASD, can be therapeutically informative, is robust to cultural differences and last but importantly, is quick, easy and economical to use in clinical and community settings. There is, nonetheless, a need for improvement in its psychometric properties, especially in its factor structure and discriminative validity. The factorial analysis in the present study shed lights for future revisions of the AQ, particularly in restructuring the items to depict factors directly correspond with the diagnostic taxonomies of ASD.

Conflicts of interest

All the authors reported no biomedical financial interests or potential conflicts of interest related to this work.

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References

Akaike, H. (1987). Factor analysis and AIC. *Psychometrika, 3*, 317–332.
American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: American Psychiatric Association.
Arrindell, W. A., & van der Ende, J. (1985). An empirical test of the utility of the observations-to-variables ratio in factor and components analysis. *Applied Psychological Measurement, 9*, 165–178.
Attwood, T. (2007). *The complete guide to Asperger's syndrome*. London, England: Jessica Kingsley Publishers.
Austin, E. J. (2005). Personality correlates of the broader autism phenotype as assessed by the Autism Spectrum Quotient (AQ). *Personality and Individual Differences, 38*, 451–460.
Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition, 21*, 37–46.
Baron-Cohen, S., & Wheelwright, S. (1999). 'Obsessions' in children with autism or Asperger syndrome. Content analysis in terms of core domains of cognition. *British Journal of Psychiatry, 175*, 484–490.
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*, 5–17.
Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107*, 238–246.
Bernier, R., Gerdts, J., Munson, J., Dawson, G., & Estes, A. (2011). Evidence for broader autism phenotype characteristics in parents from multiple-incidence autism families. *Autism Research, 5*, 13–20.
Bishop, D. V., Maybery, M., Maley, A., Wong, D., Hill, W., & Hallmayer, J. (2004). Using self-report to identify the broad phenotype in parents of children with autistic spectrum disorders: A study using the Autism-Spectrum Quotient. *Journal of Child Psychology and Psychiatry, 45*, 1431–1436.
Bolte, S., & Poustka, F. (2006). The broader cognitive phenotype of autism in parents: How specific is the tendency for local processing and executive dysfunction? *Journal of Child Psychology and Psychiatry, 47*, 639–645.
Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In *Testing structural equation models* (pp. 136–162). Beverly Hills, CA: Sage.
Byrne, B. (1998). *Structural equation modeling with LISREL, PRELIS and SIMPLIS: Basic conccepts, applications and programming*. Mahwah, NJ: Lawrence Erlbaum Associates.
Cattell, R. B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research, 1*, 245–276.
Cederlund, M., Hagberg, B., & Gillberg, C. (2010). Asperger syndrome in adolescent and young adult males. Interview, self- and parent assessment of social, emotional, and cognitive problems. *Research in Developmental Disabilities, 31*, 287–298.
Chien, W. H., Wu, Y. Y., Gau, S. S., Huang, Y. S., Soong, W. T., Chiu, Y. N., et al. (2010). Association study of the SLC25A12 gene and autism in Han Chinese in Taiwan. *Progress in Neuropsychopharmacology and Biological Psychiatry, 34*, 189–192.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.
Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research and Evaluation, 10*, 1–9.
Dawson, G., Estes, A., Munson, J., Schellenberg, G., Bernier, R., & Abbott, R. (2007). Quantitative assessment of autism symptom-related traits in probands and parents: Broader Phenotype Autism Symptom Scale. *Journal of Autism and Developmental Disorders, 37*, 523–536.
Eapen, V. (2011). Genetic basis of autism: Is there a way forward? *Current Opinion in Psychiatry, 24*, 226–236.
Folstein, S., & Rutter, M. (1977). Infantile autism: A genetic study of 21 twin pairs. *Journal of Child Psychology and Psychiatry, 18*, 297–321.
Folstein, S. E., & Piven, J. (1991). Etiology of autism: Genetic influences. *Pediatrics, 87*(5 Pt 2), 767–773.
Gau, S. S., Chou, M. C., Chiang, H. L., Lee, J. C., Wong, C. C., Chou, W. J., et al. (2012). Parental adjustment, marital relationship, and family function in families of children with autism. *Research in Autism Spectrum Disorders, 6*, 263–270.

Gau, S. S., Chou, M. C., Lee, J. C., Wong, C. C., Chou, W. J., Chen, M. F., et al. (2010). Behavioral problems and parenting style among Taiwanese children with autism and their siblings. *Psychiatry in Clinical Neuroscieince, 64*, 70–78.
Gau, S. S., Lee, C. M., Lai, M. C., Chiu, Y. N., Huang, Y. F., Kao, J. D., et al. (2011). Psychometric properties of the Chinese version of the Social Communication Questionnaire. *Research in Autism Spectrum Disorders, 5*, 809–818.
Gorsuch, R. L. (1983). *Factor analysis*. Hillsdale, NJ: Erlbaum.
Happe, F., Briskman, J., & Frith, U. (2001). Exploring the cognitive phenotype of autism: Weak "central coherence" in parents and siblings of children with autism: I. Experimental tests. *Journal of Child Psychology and Psychiatry, 42*, 299–307.
Hoekstra, R. A., Bartels, M., Cath, D. C., & Boomsma, D. I. (2008). Factor structure, reliability and criterion validity of the Autism-Spectrum Quotient (AQ): A study in Dutch population and patient groups. *Journal of Autism and Developmental Disorders, 38*, 1555–1566.
Hu, L. T., & Bentler, P. (1995). Evaluating model fit. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications* (pp. 76–99). Thousand Oaks, CA: Sage Publications.
Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1–55.
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*, 1938–1949.
Ingersoll, B., Hopwood, C. J., Wainer, A., & Brent Donnellan, M. (2011). A comparison of three self-report measures of the broader autism phenotype in a non-clinical sample. *Journal of Autism and Developmental Disorders, 41*, 1646–1657.
Jöreskog, K. G., & Sörbom, D. (2002). *LISREL 8: Structural equation modeling with the SIMPLIS command language*. Lincolnwood, IL: Scientific Software International, Inc.
Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). New York, NY: Guilford Press.
Kloosterman, P. H., Keefer, K. V., Kelley, E. A., Summerfeldt, L. J., & Parker, J. D. A. (2011). Evaluation of the factor structure of the Autism-Spectrum Quotient. *Personality and Individual Differences, 50*, 310–314.
Koch, G. G. (1982). Intraclass correlation coefficient. In *Encyclopedia of statistical sciences* (4th ed., pp. 213–217). New York, NY: John Wiley & Sons.
Le Couteur, A., Bailey, A., Goode, S., Pickles, A., Robertson, S., Gottesman, I., et al. (1996). A broader phenotype of autism: The clinical spectrum in twins. *Journal of Child Psychology and Psychiatry, 37*, 785–801.
Lepage, J.-F., Lortie, M., Taschereau-Dumouchel, V., & Théoret, H. (2009). Validation of French-Canadian Versions of the Empathy Quotient and Autism Spectrum Quotient. *Canadian Journal of Behavioural Science, 41*, 272–276.
Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview-Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*, 659–685.
McCabe, H. (2007). Parent advocacy in the face of adversity: Autism and families in the People's Republic of China. *Focus on Autism and Other Developmental Disabilities, 22*, 39–50.
Pickles, A., Starr, E., Kazak, S., Bolton, P., Papanikolaou, K., Bailey, A., et al. (2000). Variable expression of the autism broader phenotype: Findings from extended pedigrees. *Journal of Child Psychology and Psychiatry, 41*, 491–502.
Pisula, E. (2002). Parents of children with autism: Recent research findings. *Psychiatry Politics, 36*, 95–108.
Piven, J., Palmer, P., Jacobi, D., Childress, D., & Arndt, S. (1997). Broader autism phenotype: Evidence from a family history study of multiple-incidence autism families. *American Journal of Psychiatry, 154*, 185–190.
Punshon, C., Skirrow, P., & Murphy, G. (2009). The 'not guilty verdict': Psychological reactions to a diagnosis of Asperger syndrome in adulthood. *Autism, 13*, 265–283.
Ronald, A., & Hoekstra, R. A. (2011). Autism spectrum disorders and autistic traits: A decade of new twin studies. *American Journal of Medicine Genetics, Part B: Neuropsychiatry Genetics, 156B*, 255–274.
Ruta, L., Mazzone, D., Mazzone, L., Wheelwright, S., & Baron-Cohen, S. (2012). The Autism-Spectrum Quotient-Italian Version: A cross-cultural confirmation of the broader autism phenotype. *Journal of Autism and Developmental Disorders, 42*, 625–633.
Scheeren, A. M., & Stauder, J. E. A. (2008). Broader autism phenotype in parents of autistic children: Reality or myth? *Journal of Autism and Developmental Disorders, 38*, 276–287.
Stevens, M. J., Kwan, K. L., & Graybill, D. (1993). Comparison of MMPI-2 scores of foreign Chinese and Caucasian-American students. *Journal of Clinical Psychology, 49*, 23–27.
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*, 224–228.
Sucksmith, E., Roth, I., & Hoekstra, R. A. (2011). Autistic traits below the clinical threshold: Re-examining the broader autism phenotype in the 21st century. *Neuropsychological Review, 21*, 360–389.
Swygert, K. A., McLeod, L. D., & Thissen, D. (2001). Factor analysis for items or testlets scored in more than two categories. In D. T. H. Wainer (Ed.), *Test scoring*. Mahwah, NJ: Lawrence Erlbaum.
Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). New York, NY: Allyn and Bacon.
Voracek, M., & Dressler, S. G. (2006). Lack of correlation between digit ratio (2D:4D) and Baron-Cohen's "Reading the Mind in the Eyes" test, empathy, systemising, and autism-spectrum quotients in a general population sample. *Personality and Individual Differences, 41*, 1481–1491.
Wakabayashi, A., Baron-Cohen, S., Uchiyama, T., Yoshida, Y., Kuroda, M., & Wheelwright, S. (2007). Empathizing and systemizing in adults with and without autism spectrum conditions: Cross-cultural stability. *Journal of Autism and Developmental Disorders, 37*, 1823–1832.
Wakabayashi, A., Baron-Cohen, S., Uchiyama, T., Yoshida, Y., Tojo, Y., Kuroda, M., et al. (2007). The autism-spectrum quotient (AQ) children's version in Japan: A cross-cultural comparison. *Journal of Autism and Developmental Disorders, 37*, 491–500.
Wakabayashi, A., Baron-Cohen, S., & Wheelwright, S. (2006). Are autistic traits an independent personality dimension? A study of the Autism-Spectrum Quotient (AQ) and the NEO-PI-R. *Personality and Individual Differences, 41*, 873–883.
Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., & Tojo, Y. (2006). The Autism-Spectrum Quotient (AQ) in Japan: A cross-cultural comparison. *Journal of Autism and Developmental Disorders, 36*, 263–270.
Wakabayashi, A., Tojo, Y., Baron-Cohen, S., & Wheelwright, S. (2004). The Autism-Spectrum Quotient (AQ) Japanese version: Evidence from high-functioning clinical group and normal adults. *Shinrigaku Kenkyu, 75*, 78–84.
Wang, P., Michaels, C. A., & Day, M. S. (2011). Stresses and coping strategies of Chinese families with children with autism and other developmental disabilities. *Journal of Autism and Developmental Disorders, 41*, 783–795.
Wheelwright, S., Auyeung, B., Allison, C., & Baron-Cohen, S. (2010). Defining the broader, medium and narrow autism phenotype among parents using the Autism Spectrum Quotient (AQ). *Molecular Autism, 1*, 10. http://dx.doi.org/10.1186/2040-2392-1-10.