J Autism Dev Disord (2008) 38:1414–1425
DOI 10.1007/s10803-007-0509-7

ORIGINAL PAPER

# The Q-CHAT (Quantitative CHecklist for Autism in Toddlers): A Normally Distributed Quantitative Measure of Autistic Traits at 18–24 Months of Age: Preliminary Report

**Carrie Allison · Simon Baron-Cohen · Sally Wheelwright · Tony Charman · Jennifer Richler · Greg Pasco · Carol Brayne**

Published online: 1 February 2008


**Abstract** We report a major revision of the CHecklist for Autism in Toddlers (CHAT). This *quantitative* CHAT (Q-CHAT) contains 25 items, scored on a 5 point scale (0–4). The Q-CHAT was completed by parents of $n = 779$ unselected toddlers (mean age 21 months) and $n = 160$ toddlers and preschoolers (mean age 44 months) with an Autism Spectrum Condition (ASC). The ASC group (mean (SD) = 51.8 (14.3)) scored higher on the Q-CHAT than controls (26.7 (7.8)). Boys in the control group (27.5 (7.8)) scored higher than girls (25.8 (7.7)). The intraclass correlation for test-retest reliability was 0.82 ($n = 330$). The distribution in the control group was close to normal. Full examination of the clinical validity of the Q-CHAT and test properties is underway.

**Keywords** Autism spectrum conditions · Q-CHAT · Childhood screening

C. Allison (✉) · S. Baron-Cohen · S. Wheelwright · J. Richler · G. Pasco
Autism Research Centre, Department of Psychiatry, University of Cambridge, Douglas House, 18b Trumpington Road, Cambridge CB2 8AH, UK
e-mail: cla29@cam.ac.uk

T. Charman
UCL Institute of Child Health, London, UK

C. Brayne
Department of Public Health and Primary Care, University of Cambridge, Cambridge, UK

*Present Address:*
J. Richler
Institute of Child Development, University of Minnesota, Minneapolis, MN 55455, USA

DSM-IV (American Psychiatric Association 1994) and ICD-10 (World Health Organisation 1993) classify subgroups of 'Pervasive Developmental Disorders' including autistic disorder, Asperger Syndrome and Pervasive Developmental Disorders Not Otherwise Specified (PDD-NOS). They are now understood to consist of a range of neurodevelopmental conditions representing a spectrum of severity. If autism spectrum conditions (ASC) lie on a continuum, we need a quantitative rather than a categorical approach to both screening and diagnosis (Baron-Cohen et al. 2001; Wing 1988). Population based studies indicate that the prevalence of ASC is 0.6% to 1%, if the broad spectrum is included, (Baird et al. 2000; Baird, Simonoff et al. 2006; Baron-Cohen et al. in preparation; Bertrand et al. 2001; Chakrabarti and Fombonne 2001, 2005; Scott et al. 2002).

Diagnosis of ASC may not be until school age or even later (Gillberg et al. 1996; Howlin and Asgharian 1999) and Asperger Syndrome (AS) may go undetected until adulthood (Baron-Cohen et al. 2005). Despite this, the age at which parents first express concern about their child is often as early as 18–24 months old (De Giacomo and Fombonne 1998; Wing 1997). Diagnosis is relatively stable from as early as 2 years old (Charman et al. 2005; Cox et al. 1999; Lord 1995; Lord et al. 2006).

In the UK, there is no routine developmental screening (Mawle and Griffiths 2006). The National Screening Committee (NSC) (which examines the evidence for the benefits of screening for a condition) stated that for autism 'screening could not be recommended' (National Screening Committee Child Health Subgroup 2005). The reasons for this include the lack of a reliable, sensitive, and specific instrument for early screening. In the USA the American Academy of Pediatrics recommends routine surveillance for children showing early signs of autism

(Myers and Johnson 2007). In this study, we report data from an early screening instrument but begin with a review of its history.

The first screening tool to identify 18 month old children with ASC was the CHecklist for Autism in Toddlers (CHAT) (Baron-Cohen et al. 1992). The CHAT is a brief checklist administered by a health professional, with an Observation section and a Parent-Report section. The CHAT was designed on the basis that by 18 months of age the majority of typically developing children initiate and respond to *joint attention* and *pretend play*, and that the absence of these behaviours might indicate the presence of autism. Initially the CHAT was tested on a sample of 18 month old infants who were at high genetic risk for receiving an ASC diagnosis because they were siblings of children with an ASC diagnosis (Baron-Cohen et al. 1992), compared to a control group. By 30 months, 4 toddlers in the sibling sample were identified at 18 months to score above cut-off on the CHAT (because of a lack of joint attention and pretend play) and all 4 went on to be diagnosed with ASC. In contrast, none of the control group developed ASC.

Following this, a large screening study was undertaken to assess the validity of the CHAT in a general population of 18 month olds (Baird et al. 2000). Altogether 16,235 children were screened and followed up at 7 years old (Baird et al. 2000; Baron-Cohen et al. 1996). Positive predictive value was high (83%) because 11 out of 12 children who met 'high risk' on the CHAT at 18 months and at a repeat administration one month later went on to receive an ASC diagnosis at 7 years old. However, sensitivity was poor (38%) and well below acceptable levels (conventionally regarded to be between 70% and 80%) (Glascoe 1996). In other words, only a minority of the children in the population who later received a diagnosis of ASC were 'positive' on the screen. Expressed differently, scoring positively on the CHAT was an excellent indicator of risk of ASC, but the CHAT only picked up 1 in 3 children who went on to receive a diagnosis.

A modified parent report version of the CHAT (called the M-CHAT) (Robins et al. 2001) used all the key items from the original CHAT, as well as some items relating to sensory abnormalities and repetitive behaviours. The authors screened 1,122 children between 18 and 24 months recruited from baby clinics, and a clinic sample of 171 children who were undiagnosed but referred for early intervention. Early indications of sensitivity and specificity were high, but because this was largely a referred sample, the sensitivity of the M-CHAT in the general population remains unknown.

There are many other instruments that screen for ASC in the general population (level 1 screener) and in referred samples (level 2 screener). These include the Pervasive Developmental Disorders Screening Test (Siegel 2004), the Developmental Behaviour Checklist—Early Screen (Gray and Tonge 2005), the Communication and Symbolic Behavior Scales Developmental Profile (Wetherby et al. 2002, 2004), the CHAT-23 (a Chinese version of the CHAT and M-CHAT) (Wong et al. 2004), the Screening Test for Autism in Two Year Olds (Stone et al. 2000, 2004) and the Systematic Observation of Red Flags for Autism Spectrum Disorders in Young Children (Wetherby and Woods 2004). While many of these instruments have been tested on referred populations and have good psychometric properties, none have been evaluated in the general population.

One instrument that has been evaluated in the general population is The Early Screening of Autistic Traits Questionnaire (ESAT) (Dietz et al. 2006; Swinkels et al. 2006). The ESAT is administered by a clinician when the child is 14 months old. A provisional 19-item dichotomous response questionnaire contained the three key items from the CHAT, which were subsequently dropped from the final 14-item version since these proved to be less useful before 18 months of age. Preliminary data revealed the ESAT retrospectively detected over 90% of children with ASC. It was able to discriminate well between typically developing infants and children with ASC, but the ESAT also detected 19% of children with ADHD. Further analyses indicated that a four-item version may be useful as a pre-screening instrument as it detected almost all (91%) of children with ASC. These four items were tested in a population of over 30,000 14–15 month old infants. 1.2% of the population screened positive and were screened with the full 14-item ESAT, of which 39% screened positive. Of these, 18 children (25%) were diagnosed with ASC, and the remaining false positives did not include any children who were typically developing, but included children who had Language Delay and Developmental Delay.

Another screen that has been investigated in a typically developing sample as well as a clinical sample is The First Year Inventory (FYI (Reznick et al. 2007; Watson et al. 2007)). The FYI is a parent-report instrument that aims to identify risk for a diagnosis of ASC at 12 months old. The 63 questions have a variety of response patterns: 46 items with a Likert scale, 14 items with multiple choice answers, a question asking the parent about which sounds the infant produces, and two open ended questions. Normative data were initially collected with the FYI to assign risk points for answers that had a low frequency of endorsement. The distribution of FYI risk scores was positively skewed, possibly because items were assigned risk status using a quasi-logarithmic scale, resulting in higher risk status being assigned to children with the most unusual answers. Eight constructs were derived, four in the Social-Communication

domain, and four in the Sensory-Regulatory domain. The FYI was administered retrospectively to parents of preschoolers with ASC, preschoolers with DD but no ASC, and a group of typically developing children. Results indicated that the group with ASC were rated by their parents at significantly higher risk than the children with DD, who were rated significantly higher at risk than the typically developing group.

While this instrument is promising, the FYI has some limitations. First, it focuses on behaviours at 12 months of age, and therefore will miss individuals who show a pattern of typical development followed by a period of regression (Volkmar and Klin 2005). Furthermore, screening for ASC at 12 months will inevitably generate a higher number of false positives than screening at later ages when parents can be more confident about the presence or absence of key behaviours. This has public health implications both in terms of the cost of referring children and raising parental concerns unnecessarily. Psychometric properties such as sensitivity and specificity of the instrument have not yet been published, and the authors acknowledge that large-scale longitudinal research is warranted to determine whether the FYI can predict an eventual diagnosis of ASC.

## Development of the Quantitative CHecklist for Autism in Toddlers (Q-CHAT)

There are several reasons why the sensitivity of the CHAT in the general population may have been low (Baird et al. 2000) and which could be improved in a revision of the instrument. First, the wording of the questions is of the form 'Has your child *ever* (pointed, pretended)?' This means that to 'fail' an item, the child must never have produced the behaviour. It is likely that a complete absence of the relevant behaviour is too stringent in determining whether a child may be at risk for ASC. More likely is that reduced *frequency* of behaviours such as protodeclarative pointing or pretending may be important in detecting milder cases of ASC, particularly AS. Second, the key items in the CHAT focused solely on joint attention behaviours and pretend play. It could be that by not including other behaviours characteristic of ASC, such as repetitive and stereotyped behaviour or sensory abnormalities, the CHAT may have missed some cases.

In the current study we undertook a major revision of the CHAT, with the aim of creating a screening instrument that could identify toddlers at risk for ASC with improved sensitivity, for both clinical and research purposes. The original CHAT study showed that parent-report alone had equal sensitivity to parent + health professional report combined (Baird et al. 2000). We therefore opted for parent-report alone. This reduces the burden on primary health care workers and is a cost and time-effective method of screening large populations (the Q-CHAT takes approximately 5–10 min to complete). Second, we designed the Q-CHAT in the form of a questionnaire that enables a range of response categories. Thus, the original CHAT was converted to a rating scale, quantifying autistic traits at 18–24 months of age, rather than having a binary scoring system for each item (Yes/No). This Likert scale response allows for the possibility that children at risk of ASC show a *reduced* rate of key behaviours, and takes into account the proposed ASC continuum (Constantino et al. 2006). Such a quantitative approach has been successful in the development of screening instruments such as the Autism Spectrum Quotient (AQ) in adult, adolescent and child populations (Auyeung et al. in press; Baron-Cohen et al. 2006; Baron-Cohen et al. 2001; Hoekstra et al. 2007; Wakabayashi et al. 2006; Wheelwright et al. 2006), though the AQ does not extend as young as 18 months old (the Child AQ can be used from 4 to 11 years old).

The Q-CHAT retains the three key items from the original CHAT (from the domains of joint attention and pretend play) but includes additional items from other important domains: language development, repetitive behaviours, and other aspects of social communication. The additional items were chosen based on the ICD-10 (World Health Organisation 1993) and DSM-IV (American Psychiatric Association 1994) core features of ASC, as well as searching the literature for target behaviours that are expressed during toddlerhood. Question 9 on the Q-CHAT relates to the pretend play item from the original CHAT. Questions 5 and 6 on the Q-CHAT relates to the pointing items from the original CHAT. Some items on the Q-CHAT (e.g. items 20, 21, 24 and 25) are similar in wording to items from the M-CHAT (Robins et al. 2001). Questions were constructed to allow parents to report the relative frequency of each behaviour, and the wording of the questions was piloted and refined on a group of parents who have a child already diagnosed with an ASC. As with the original CHAT, the Q-CHAT remains quick to administer but dimensionalises each item, a higher score indicating more autistic traits.

The aims of the present study were (1) To examine the distribution of Q-CHAT scores in an unselected sample of toddlers and in a sample of toddlers and preschool children already diagnosed with an ASC; and (2) To assess the test-retest reliability and internal consistency of the Q-CHAT. The present report constitutes preliminary research using this revised instrument, and it is not possible to report the full range of test properties at this stage.

## Methods

### Participants

Cambridge Local Research Ethics Committee gave approval for this study and informed consent was obtained from parents/guardians. We collected data on 2 groups of participants using the Q-CHAT (see Appendix) as follows:

#### *Unselected Group*

2,360 Q-CHAT questionnaires were sent to all parents of toddlers who were between 18 and 24 months on the date of mailing, selected from the Cambridgeshire Child Health Surveillance Database in two health districts in Cambridgeshire. Data were also collected on socio-economic status, to check how representative the sample was in relation to the general population. We included questions from the Office of National Statistics (ONS) to derive the National Statistics Socio-Economic Classification (NS-SEC) (Office for National Statistics 2002). Parental educational attainment was assessed by collecting information on the age at which each parent left full time education. Data were also collected on whether parents or health professionals had ever expressed concerns about the child's development.

#### *ASC Group*

This comprised $n = 160$ (136 male, 24 female) toddlers and preschool children with a diagnosis of ASC, diagnosed either in the UK or abroad. The children's families had all volunteered to take part in research at the Cambridge University Autism Research Centre and completed the Q-CHAT either online, or a paper version was posted to them. An advertisement was placed on the website at the Autism Research Centre asking for parents who had a child who was diagnosed at an early age to complete the questionnaire.

### Test-retest Reliability

500 Q-CHAT forms were sent to a subsample of parents from the Unselected Group in order to examine test-retest reliability. Information on who completed each questionnaire was collected to verify that the same parent completed both questionnaires. 500 respondents to the first Q-CHAT were sent a second questionnaire direct to their home approximately 1 month after the first. The second mailing was identical to the first with the exception of the covering letter. Data were also collected on the exact time interval between the two questionnaires' completion.

### Scoring the Q-CHAT

All 25 items on the Q-CHAT are scored using a 5-point scale of frequency, with scores ranging from 0 to 4. Half the items are reverse-scored. The scores from all items are summed to obtain a total Q-CHAT score, higher scores indicative of more autistic traits. On item 4, there is a sixth option for cases were the child does not have any language, and this also scores 4 points. Items that were not completed, or where the checked answer was ambiguous, score 0.

## Results

### The Unselected Group

779 questionnaires were returned (382 male, 372 female) which represents 33% of the total mailed. Scores on the Q-CHAT showed a near-normal distribution. A total of 25 questionnaires were excluded from the analyses. Exclusions were for the following reasons: the child was not in the specified age band ($n = 22$); there was a whole page missing from the questionnaire ($n = 1$); the questionnaire was returned blank ($n = 2$). The overall response rate for the Q-CHAT, after exclusions, was 32% ($n = 754$). Of the 754 included Q-CHAT questionnaires, 660 had complete data. The items with the most missing data were items 3, 10, 15, 22 and 23. We adopted a conservative approach and scored missing items as zero. The majority of Q-CHAT questionnaires with missing items had only 1 item missing ($n = 71$), and 2 questionnaires had 6 missing items but were retained in the analyses. Questionnaires with 7 or more missing items were excluded ($n = 8$). The mean age of the Unselected Group (after all these exclusions) was 21.2 months (range 17–26 months, SD 2.1 months).

The mean age of mothers at the child's birth was 30.0 years (SD 5.5, range 16–46) and for fathers it was 32.7 years (SD 5.8, range 16–63). For mothers, mean age when leaving full time education was 18.2 years (SD 2.5, range 11–29) and for fathers it was 18.0 years (SD 2.9, range 11–33). A Chi Square analysis was performed to compare the NS-SEC status of the Q-CHAT sample to the 2001 census (Office for National Statistics 2001a, b) for Cambridgeshire, and there was a significant difference between this sample and national levels in both men (Pearson Chi-Square = 69.5, df = 4, $p = <.0001$) and women (Pearson Chi-Square = 79.9, df = 4, $p = <.0001$). A residual analysis indicated that for men, Classes 1

(managerial and professional occupations) and 4 (lower supervisory and technical occupations) were over-represented in our sample, and Classes 2 (intermediate occupations) and 5 (semi-routine and routine occupations) were under-represented. For women, a residual analysis indicated that Classes 1 and 2 were over-represented in our sample, and Class 5 (semi-routine and routine occupations) was under-represented. We note this but have not excluded anyone on the basis of socioeconomic status from further analysis.

The mean score on the Q-CHAT was 26.7 (SD 7.8 range: 7–57). The mean score for boys of 27.5 ($n = 382$, SD 7.8, range 11–57) was significantly higher than the mean score for girls of 25.8 ($n = 372$, SD 7.7, range 7–51)($t(752) = 2.96$, $p = 0.03$, equal variances assumed). The effect size according to Cohen's d calculation was 0.2. There was no significant correlation between age and score. See Table 1 for the distribution of scores for each scored item (i.e. 0–4). All but 1 item (Q22) had responses from at least 98% of respondents. Internal consistency was adequate (Cronbach's alpha = 0.67). Scores from all items, except for item 18 were significantly correlated with total Q-CHAT score.

**Table 1** The unselected group item-score distribution ($n = 754$)

| Question | Score % | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| 1. Look when call name | 45.0 | 51.7 | 3.1 | 0.3 | 0 |
| 2. Eye contact | 65.5 | 32.4 | 1.7 | 0.3 | 0 |
| 3. Line objects up[a] | 15.8 | 24.5 | 42.3 | 13.0 | 3.1 |
| 4. Understand child's speech | 9.2 | 49.9 | 27.7 | 4.5 | 8.2 |
| 5. Protoimperative pointing | 67.6 | 24.1 | 4.8 | 2.1 | 1.1 |
| 6. Protodeclarative pointing | 59.3 | 31.2 | 6.5 | 1.6 | 1.3 |
| 7. Interest maintained by spinning object[a] | 32.0 | 46.2 | 14.5 | 5.2 | 1.1 |
| 8. Number of words[a] | 13.5 | 19.5 | 42.7 | 19.8 | 3.8 |
| 9. Pretend play | 57.0 | 32.5 | 7.4 | 1.3 | 1.3 |
| 10. Follow a look | 47.6 | 40.6 | 7.6 | 1.7 | 1.2 |
| 11. Sniff/lick unusual objects[a] | 31.7 | 25.1 | 21.8 | 12.3 | 8.5 |
| 12. Use of hand as tool[a] | 22.7 | 13.3 | 16.6 | 25.2 | 21.8 |
| 13. Walk on tiptoes[a] | 27.7 | 28.4 | 38.6 | 3.4 | 1.1 |
| 14. Adapt to change in routine | 35.5 | 56.1 | 6.8 | 0.9 | 0.5 |
| 15. Offer comfort | 24.5 | 34.9 | 25.7 | 9.2 | 4.4 |
| 16. Do same thing over and over again[a] | 22.5 | 20.3 | 25.5 | 17.8 | 13.5 |
| 17. Typicality of first words | 65.9 | 27.7 | 1.9 | 0.4 | 3.4 |
| 18. Echolalia[a] | 5.0 | 5.0 | 13.4 | 33.0 | 42.6 |
| 19. Gestures | 80.4 | 16.7 | 2.1 | 0.3 | 0.5 |
| 20. Unusual finger movements[a] | 77.5 | 10.7 | 5.0 | 3.2 | 2.4 |
| 21. Check reaction | 18.3 | 39.5 | 29.2 | 8.2 | 4.0 |
| 22. Maintenance of interest[a] | 19.2 | 39.0 | 30.5 | 7.3 | 1.9 |
| 23. Twiddle objects repetitively[a] | 54.2 | 23.9 | 8.4 | 8.8 | 3.2 |
| 24. Oversensitive to noise[a] | 33.2 | 41.1 | 20.6 | 3.3 | 1.6 |
| 25. Stare at nothing with no purpose[a] | 59.7 | 26.8 | 9.3 | 2.8 | 0.5 |

[a] indicates item is reverse scored

## The ASC Group

The mean age of this group was 44.5 months (SD 10.2 months, range 19–63 months,), 41 of whom were 36 months or less. Twenty seven children had a parent reported diagnosis of High Functioning Autism (HFA), 10 had a diagnosis of Asperger Syndrome (AS), 106 had a diagnosis of autistic disorder, 2 had a diagnosis of atypical autism, 14 had a diagnosis of Pervasive Developmental Disorder (PDD) and 1 had a diagnosis of Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS). No data were available regarding any intervention programmes the children had, or were participating in. Scores on the Q-CHAT showed a normal distribution (Kolmogorov-Smirnoff $Z = .70$, $p = .71$). The mean score was 51.8 (SD = 14.3, range 21–88). When examining boys and girls separately, the mean score for boys was 51.3 ($n = 136$, SD = 14.1, range 21–83) and for girls was 54.6 ($n = 24$, SD = 14.9, range 26–88) which was not significantly different from each other ($t(158) = -1.05$, $p = 0.3$, equal variances assumed). There was a small significant negative correlation between age and score (Pearson's $r = -0.16$, $p = < 0.05$), indicating that Q-CHAT score slightly decreased with age. Every question had at least a 99% response. Internal consistency was good (Cronbach's alpha = 0.83). All items were significantly correlated with Q-CHAT score, although question 22 was only correlated at the $p < 0.05$ level. In order to get closer to the age group at which the Q-CHAT is aimed, we conducted a second analysis using just those children who were the youngest in the sample: below 37 months at the time the Q-CHAT was completed ($n = 41$; 31 boys, 10 girls). The mean age of this group was 31 months (SD = 4.8, range 19–36). Whilst this is not as young as the unselected sample, it would be almost impossible to identify an ASC group as young as 18–24 months without a specialized form of screening. This younger subgroup thus represents the youngest ASC group available. See Table 2 for the distribution of scores for each item within this selected sample. The data remained normally distributed, and the mean score was significantly higher in this younger group than in the whole ASC Group ($t(158) = 2.78$, $p = .006$, equal variances assumed). As before, there was no difference in scores between boys ($M = 58.0$, SD = 11.5) and girls ($M = 54.0$, SD = 17.5) ($t(39) = 0.84$, $p = 0.41$, equal variances assumed). Unsurprisingly, within this younger group there was no significant correlation between age and score, presumably reflecting their narrower age range. Cronbach's alpha was

**Table 2** The ASC group item-score distribution ($n = 41$)

| Question | Score % | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| 1. Look when call name | 2.4 | 22.0 | 46.3 | 24.4 | 4.9 |
| 2. Eye contact | 0.0 | 41.5 | 31.7 | 22 | 4.9 |
| 3. Line objects up[a] | 22.0 | 17.1 | 29.3 | 12.2 | 19.5 |
| 4. Understand child's speech | 0.0 | 7.3 | 12.2 | 26.8 | 53.7 |
| 5. Protoimperative pointing | 7.3 | 17.1 | 17.1 | 9.8 | 48.8 |
| 6. Protodeclarative pointing | 4.9 | 4.9 | 17.1 | 17.1 | 56.1 |
| 7. Interest maintained by spinning object[a] | 14.6 | 36.6 | 22 | 19.5 | 7.3 |
| 8. Number of words[a] | 4.9 | 14.6 | 17.1 | 36.6 | 26.8 |
| 9. Pretend play | 4.9 | 12.2 | 17.1 | 24.4 | 41.5 |
| 10. Follow a look | 4.9 | 9.8 | 17.1 | 26.8 | 41.5 |
| 11. Sniff/lick unusual objects[a] | 31.7 | 12.2 | 19.5 | 24.4 | 12.2 |
| 12. Use of hand as tool[a] | 17.1 | 9.8 | 7.3 | 24.4 | 41.5 |
| 13. Walk on tiptoes[a] | 29.2 | 14.6 | 39.0 | 12.2 | 4.9 |
| 14. Adapt to change in routine | 4.9 | 34.1 | 41.5 | 17.1 | 2.4 |
| 15. Offer comfort | 2.4 | 4.9 | 19.5 | 14.6 | 58.5 |
| 16. Do same thing over and over again[a] | 9.8 | 0 | 7.3 | 29.3 | 53.7 |
| 17. Typicality of first words | 17.1 | 19.5 | 14.6 | 12.2 | 36.6 |
| 18. Echolalia[a] | 39.0 | 9.8 | 14.6 | 9.8 | 26.8 |
| 19. Gestures | 4.9 | 19.5 | 14.6 | 34.1 | 26.8 |
| 20. Unusual finger movements[a] | 36.6 | 9.8 | 19.5 | 19.5 | 14.6 |
| 21. Check reaction | 0.0 | 9.8 | 43.9 | 29.3 | 17.1 |
| 22. Maintenance of interest[a] | 41.5 | 17.1 | 29.3 | 4.9 | 7.3 |
| 23. Twiddle objects repetitively[a] | 34.1 | 14.6 | 9.8 | 22.0 | 19.5 |
| 24. Oversensitive to noise[a] | 9.8 | 26.8 | 24.4 | 24.4 | 14.6 |
| 25. Stare at nothing with no purpose[a] | 26.8 | 9.8 | 22.0 | 22.0 | 19.5 |

[a] indicates item is reverse scored

still high (0.81), and 4 items did not correlate significantly with total score (items 11, 12, 20 and 24).

### Group Differences

See Table 3 for a comparison of the percentage of individuals scoring at each point on the Q-CHAT from the Typical and all the ASC Group ($n = 160$). There was a between groups difference in total score both when all of the ASC Group were included, ($t(912) = -31.1$, $p = < .0001$, equal variances assumed), and this remained significant when only the 41 early diagnosed children with ASC were included ($t(793) = -23.2$, $p = < .0001$, equal variances assumed), indicating that the ASC Group scored significantly higher than the Unselected Group. See Fig. 1 for a comparison of the distribution of scores.

### Test-Retest Reliability

388 pairs of Q-CHAT questionnaires were received from the unselected sample (69% response rate). 58 pairs of questionnaires were excluded for the following reasons: they were either not completed by the same parent, or this information was missing ($n = 45$); the age at completion of the first or second Q-CHAT was not within the correct age-range ($n = 7$); the second Q-CHAT was returned blank or a whole page of either Q-CHAT was missing ($n = 6$). The response to the Q-CHAT retest after exclusions was 59% ($n = 330$). This is a moderate response, reflecting that these parents had already opted into the Q-CHAT study. There were no significant differences between participants who responded or did not respond to the Q-CHAT retest in terms of the child's age (Mann-Whitney U test, $p = 0.92$) or sex ($\chi^2$, $p = 0.85$), or whether previous concerns had been expressed over the child's development ($\chi^2$, $p = 0.54$). However, those responding to the Q-CHAT retest had significantly lower scores on the first Q-CHAT ($M = 26.04$; SD: 7.73; $n = 330$) than non-responders to the Q-CHAT retest ($M = 28.70$; SD: 8.38; $n = 171$) ($t(499) = 3.55$, $p = < 0.0001$, equal variances assumed). The time interval between the two tests on each individual had a mean of 38 days (SD = 12, range 15–109). The score distributions at time 1 ($M = 26.04$, SD = 7.73) and time 2 ($M = 25.71$, SD = 7.71) were very similar and the intraclass correlation coefficient between the two test scores was 0.82 for single measures ($p < 0.0001$). A Paired-Samples T test showed no significant difference between test pairs ($p = 0.19$). The difference between the pairs of test scores had a mean of −.33 (SD=4.66; range −16–13).

## Discussion

This study reports the preliminary development of a quantitative version of the CHecklist For Autism in Toddlers (Q-CHAT). Results reported here are promising, but the data represent initial psychometric work with this revised instrument. Scores on the Q-CHAT followed a near-normal distribution in an unselected general population sample. As far as we know, this is the first ASC screening instrument for use with toddlers to have been shown to have a range of scores that approximates to a normal distribution, which makes it potentially useful not just for population screening for ASC but also as a trait measure of individual differences in the population, for genetic or other types of research into the continuum nature of autistic traits.

As expected, children with an existing diagnosis of ASC scored significantly higher on the Q-CHAT than did the

**Table 3** Percentage of each group scoring at each point

| Score | The unselected group | The ASC group | Score | The unselected group | The ASC group |
|---|---|---|---|---|---|
| 1 | 100.0 | 100.0 | 51 | 0.7 | 51.9 |
| 2 | 100.0 | 100.0 | 52 | 0.4 | 50.6 |
| 3 | 100.0 | 100.0 | 53 | 0.3 | 48.8 |
| 4 | 100.0 | 100.0 | 54 | 0.1 | 47.5 |
| 5 | 100.0 | 100.0 | 55 | 0.1 | 45.6 |
| 6 | 100.0 | 100.0 | 56 | 0.1 | 42.5 |
| 7 | 100.0 | 100.0 | 57 | 0.1 | 40.6 |
| 8 | 99.9 | 100.0 | 58 | 0.0 | 38.8 |
| 9 | 99.9 | 100.0 | 59 | 0.0 | 35.6 |
| 10 | 99.7 | 100.0 | 60 | 0.0 | 33.1 |
| 11 | 99.6 | 100.0 | 61 | 0.0 | 30.6 |
| 12 | 99.2 | 100.0 | 62 | 0.0 | 26.9 |
| 13 | 98.4 | 100.0 | 63 | 0.0 | 23.8 |
| 14 | 97.6 | 100.0 | 64 | 0.0 | 21.9 |
| 15 | 95.6 | 100.0 | 65 | 0.0 | 18.8 |
| 16 | 94.2 | 100.0 | 66 | 0.0 | 16.9 |
| 17 | 92.0 | 100.0 | 67 | 0.0 | 13.8 |
| 18 | 89.5 | 100.0 | 68 | 0.0 | 11.9 |
| 19 | 87.0 | 100.0 | 69 | 0.0 | 10.6 |
| 20 | 83.3 | 100.0 | 70 | 0.0 | 8.8 |
| 21 | 78.4 | 100.0 | 71 | 0.0 | 8.8 |
| 22 | 72.9 | 99.4 | 72 | 0.0 | 8.8 |
| 23 | 67.0 | 98.8 | 73 | 0.0 | 8.1 |
| 24 | 63.0 | 98.8 | 74 | 0.0 | 6.9 |
| 25 | 56.8 | 98.1 | 75 | 0.0 | 6.3 |
| 26 | 51.9 | 98.1 | 76 | 0.0 | 4.4 |
| 27 | 45.5 | 97.5 | 77 | 0.0 | 4.4 |
| 28 | 42.0 | 96.9 | 78 | 0.0 | 3.8 |
| 29 | 37.3 | 94.4 | 79 | 0.0 | 3.1 |
| 30 | 33.6 | 94.4 | 80 | 0.0 | 2.5 |
| 31 | 29.4 | 91.3 | 81 | 0.0 | 1.9 |
| 32 | 25.6 | 91.3 | 82 | 0.0 | 1.9 |
| 33 | 22.7 | 90.0 | 83 | 0.0 | 1.3 |
| 34 | 18.7 | 88.1 | 84 | 0.0 | 0.6 |
| 35 | 15.9 | 87.5 | 85 | 0.0 | 0.6 |
| 36 | 13.7 | 85.0 | 86 | 0.0 | 0.6 |
| 37 | 11.1 | 83.8 | 87 | 0.0 | 0.6 |
| 38 | 8.9 | 81.3 | 88 | 0.0 | 0.6 |
| 39 | 7.2 | 78.8 | 89 | 0.0 | 0.0 |
| 40 | 6.6 | 76.9 | 90 | 0.0 | 0.0 |
| 41 | 5.0 | 75.6 | 91 | 0.0 | 0.0 |
| 42 | 4.2 | 75.0 | 92 | 0.0 | 0.0 |
| 43 | 3.2 | 71.9 | 93 | 0.0 | 0.0 |
| 44 | 2.5 | 71.9 | 94 | 0.0 | 0.0 |
| 45 | 1.9 | 70.0 | 95 | 0.0 | 0.0 |
| 46 | 1.6 | 66.3 | 96 | 0.0 | 0.0 |
| 47 | 1.6 | 62.5 | 97 | 0.0 | 0.0 |
| 48 | 1.2 | 60.0 | 98 | 0.0 | 0.0 |
| 49 | 0.9 | 58.8 | 99 | 0.0 | 0.0 |
| 50 | 0.8 | 56.3 | 100 | 0.0 | 0.0 |

control sample. This held true when only those with an ASC diagnosis who were age 3 or below were selected. This demonstrates that the Q-CHAT has good face validity, since the questionnaire aims to dimensionalize autistic traits in toddlers, and those with a diagnosis of ASC score higher than a population sample. Future studies will test if those scoring above a cut-off are at risk for a diagnosis of ASC, but such a test was beyond the scope of this initial study as it involves extensive follow-up assessments. Figure 1 shows that the distribution of the two groups diverge to a marked extent.

There was a significant sex difference, with boys scoring higher than girls in the Unselected Group. While the effect size was small (0.2) this is not unexpected for a sex difference in an unselected population. This finding suggests that boys may exhibit more difficulties in social, communication and rigid and repetitive behaviours than girls in early development (Leekam et al. 2007). This finding is consistent with a number of previous screening instruments: males score higher on the Childhood Autism Spectrum Test[1] (CAST) (Williams et al. submitted); the Social Reciprocity Scale (SRS (Constantino et al. 2003)); and on the child, adolescent and adult versions of the Autism Spectrum Quotient (AQ), a screening instrument for high functioning autism or AS in adolescents or adults of average IQ or above (Baron-Cohen et al. 2006; Baron-Cohen et al. 2001). This sex difference is consistent with the higher prevalence of ASC in males (Chakrabarti and Fombonne 2005) and with the Extreme Male Brain theory of autism (Baron-Cohen 2002). When individuals in the ASC Group were separated into those above or below 3 years old, results were very similar. However, when comparing older with younger diagnosed groups, the mean score was higher in the younger age group, and in the whole ASC group there was a small but significant negative correlation between Q-CHAT score and age.

In our assessment of test-retest reliability, we found a strong correlation between Q-CHAT scores across two administrations, indicating good test-retest reliability. Those who did not return the Q-CHAT retest had significantly higher scores on the first Q-CHAT than those who completed the Q-CHAT retest. This may reflect that parents who had mild concerns about their child's behaviour whilst completing the first Q-CHAT were more reluctant to complete the second administration. It remains possible that re-test sampling bias was introduced as the response to the first Q-CHAT was 33% but at the second Q-CHAT had increased to 59%.

[1] The CAST was formerly known as the Childhood Asperger Syndrome Test, but was renamed in recognition that it is relevant for the whole autistic spectrum, not just Asperger Syndrome (Baron-Cohen et al. in preparation).

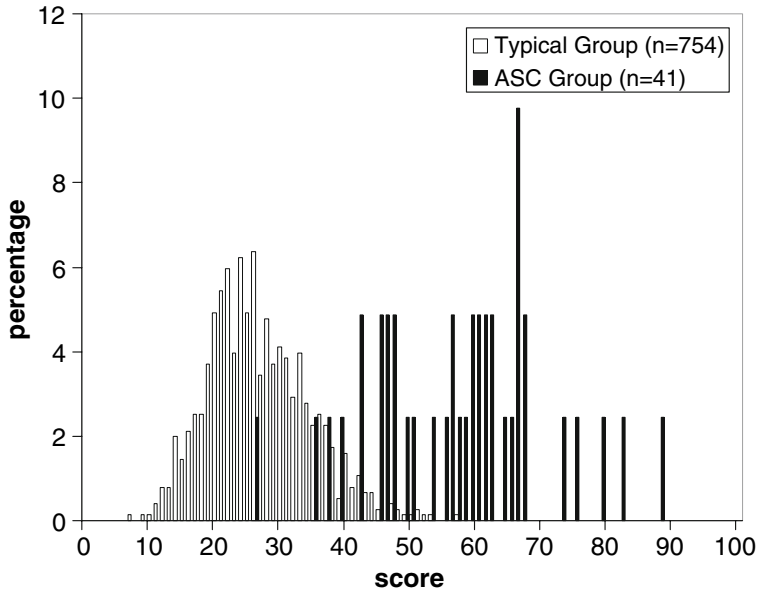


**Fig. 1** Comparison of score distributions for the Unselected Group ($n = 754$) and the ASC Group ($n = 41$)

## Limitations

There are a number of limitations with this study. First, independent verification of diagnostic status in the ASC Group was not possible, and nor was any IQ data available. The majority of participants in this group (79%) were children whose parents had volunteered on the Autism Research Centre website as volunteers and who had stated that their child had been diagnosed either by a psychologist, psychiatrist or paediatrician at a named clinic either in the UK or abroad. The rest of this group were children whose parents had volunteered previously at the Autism Research Centre, and had been diagnosed by recognised and experienced clinicians from local services. This study was a postal survey and we did not have the resources independently to obtain IQ and diagnostic data. Second, the mean age of the children in the ASC Group was significantly older than those for whom the Q-CHAT is intended. This was unavoidable because we were limited to the youngest age at which children are currently diagnosed. However, even when the older diagnosed children were excluded from the analyses, the ASC Group still scored significantly higher than the Unselected Group, suggesting that the Q-CHAT is able to discriminate between typically developing toddlers and those who have a clear ASC diagnosis. However direct testing of its ability to discriminate between toddlers with and without ASC will await future studies of referred or general population samples at 18–24 months. Third, while the response rate of 32% is typical for unsolicited postal questionnaires, this low response brings into question how representative the Unselected Group is of the general population. We cannot know how the non-responder section of the population would have replied. One study found significantly more high scorers in non-responders using an ASC screening measure for older children (the Autism Spectrum Screening Questionnaire (Ehlers et al. 1999; Posserud et al. 2006). Further, there was a fair amount of missing data (117 out of 779 returned Q-CHAT questionnaires had incomplete data), although the majority ($n = 71$) had only 1 missing item.

Analysis of the socio-economic status (SES) of the responding families in the Unselected Group revealed that some SES groups were significantly different in our sample compared to the Cambridgeshire population as a whole. The women in our sample were over-represented in groups 1 and 2, and under-represented in group 5. In terms of population screening, this could have implications concerning access to services if only the high SES group complete the screening questionnaire. In a recent prevalence study, Baird et al. (2006) found that previously diagnosed cases of ASC were more common in families with well-educated parents. Lastly, parents in the ASC Group completed the Q-CHAT after their child had been diagnosed, which may have led to over-reporting of symptoms, since parents who have already received a diagnosis and information about autism might be more aware of autistic symptoms than parents of an undiagnosed child.

## Conclusion

A large scale epidemiological screening study is underway that aims to assess the utility of the Q-CHAT as a population screening instrument for ASC. Since such

comprehensive population-based studies take many years to complete, by virtue of the follow-up prospective design, the present paper represents the first report from this longitudinal research program. Future studies will include both clinical and unselected samples that will help to determine the full range of psychometric properties (sensitivity, specificity, positive and negative predictive value) of the Q-CHAT. Until such work is complete, the Q-CHAT cannot be recommended for use as a clinical screening instrument for ASC, though it clearly has potential.

In summary, the present study confirms that the Q-CHAT is easily completed by parents, provides normative data from an unselected sample of 18–24 month olds, and is able to discriminate between a group of unselected toddlers and those with a diagnosis of an ASC. This study lends weight to the proposed continuum notion of ASC in the general population (Baron-Cohen et al. 2001; Wing 1988) and supports Constantino and Todd's (2003) finding of continuously distributed autistic traits using the Social Responsiveness Scale (SRS) in a twin sample. It suggests that the Q-CHAT may be a useful measure in the early identification of threshold and sub-threshold autistic features. In contrast with other early screening instruments (M-CHAT, ESAT, FYI), the Q-CHAT is the first instrument to demonstrate that autistic traits may be normally distributed in toddlers as young as 18 months old. As such, it may have potential as a quantitative phenotypic measure in genetic studies. Overall, we have shown at the earliest age possible that ASC may represent the upper extreme of a dimension of traits that are continuously distributed in the general population.

**Acknowledgments** We are grateful to the Big Lottery Fund for their generosity in funding this study, to the UK Mental Health Research Network for supporting the study, to the parents/guardians who completed the questionnaires, and to Cambridgeshire and Peterborough Primary Care Trusts for facilitating the mailing of the questionnaires. These results were first reported at the International Meeting for Autism Research (IMFAR), Montreal, April 2006. The Q-CHAT Advisory Group gave valuable feedback. The development of the Q-CHAT was supported with funding from the MRC UK. We are grateful to Richard Mills and Sarah Chivers at the National Autistic Society UK, and to Bonnie Auyeung and Fiona Matthews for discussions of this work.

## Appendix: Q-CHAT items

Section 1. Please answer the following questions about your child. Try to answer every question if you can.

1. Does your child look at you when you call his/her name?
   - always
   - usually
   - sometimes
   - rarely
   - never
2. How easy is it for you to get eye contact with your child?
   - very easy
   - quite easy
   - quite difficult
   - very difficult
   - impossible
3. When your child is playing alone, does s/he line objects up?
   - always
   - usually
   - sometimes
   - rarely
   - never
4. Can other people easily understand your child's speech?
   - always
   - usually
   - sometimes
   - rarely
   - never
   - my child does not speak
5. Does your child point *to indicate that s/he wants something* (e.g. a toy that is out of reach)
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
6. Does your child point *to share interest with you* (e.g. pointing at an interesting sight)?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
7. How long can your child's interest be maintained by a spinning object (e.g. washing machine, electric fan, toy car wheels)?
   - several hours
   - half an hour
   - 10 min
   - a couple of minutes
   - less than a minute

8. How many words can your child say?
   - none—s/he has not started speaking yet
   - less than 10 words
   - 10–50 words
   - 51–100 words
   - over 100 words
9. Does your child pretend (e.g. care for dolls, talk on a toy phone)?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
10. Does your child follow where you're looking?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
11. How often does your child sniff or lick unusual objects?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
12. Does your child place your hand on an object when s/he wants you to use it (e.g. on a door handle when s/he wants you to open the door, on a toy when s/he wants you to activate it)?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
13. Does your child walk on tiptoe?
   - always
   - usually
   - sometimes
   - rarely
   - never
14. How easy is it for your child to adapt when his/her routine changes or when things are out of their usual place?
   - very easy
   - quite easy
   - quite difficult
   - very difficult
   - impossible
15. If you or someone else in the family is visibly upset, does your child show signs of wanting to comfort them? (e.g. stroking their hair, hugging them)?
   - always
   - usually
   - sometimes
   - rarely
   - never
16. Does your child do the same thing over and over again (e.g. running the tap, turning the light switch on and off, opening and closing doors)?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
17. Would you describe your child's first words as:
   - very typical
   - quite typical
   - slightly unusual
   - very unusual
   - my child doesn't speak
18. Does your child echo things s/he hears (e.g. things that you say, lines from songs or movies, sounds)?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
19. Does your child use simple gestures (e.g. wave goodbye)?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never
20. Does your child make unusual finger movements near his/her eyes?
   - many times a day
   - a few times a day
   - a few times a week
   - less than once a week
   - never

21. Does your child spontaneously look at your face to check your reaction when faced with something unfamiliar?
    - always
    - usually
    - sometimes
    - rarely
    - never
22. How long can your child's interest be maintained by just one or two objects?
    - most of the day
    - several hours
    - half an hour
    - ten minutes
    - a couple of minutes
23. Does your child twiddle objects repetitively (e.g. pieces of string)?
    - many times a day
    - a few times a day
    - a few times a week
    - less than once a week
    - never
24. Does your child seem oversensitive to noise?
    - always
    - usually
    - sometimes
    - rarely
    - never
25. Does your child stare at nothing with no apparent purpose?
    - many times a day
    - a few times a day
    - a few times a week
    - less than once a week
    - never

## References


American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders (DSM-IV)* (4th ed.). Washington, DC: APA.

Auyeung, B., Baron-Cohen, S., Wheelwright, S., & Allison, C. (in press). The autism spectrum quotient: Children's version (AQ-Child). *Journal of Autism and Developmental Disorders*.

Baird, G., Charman, T., Baron-Cohen, S., Cox, A., Swettenham, J., Wheelwright, S., & Drew, A. (2000). A screening instrument for autism at 18 months of age: a 6-year follow-up study. *Journal of the American Academy of Child and Adolescent Psychiatry, 39*, 694–702.

Baird, G., Simonoff, E., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., & Charman, T. (2006). Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: The Special Needs and Autism Project (SNAP). *Lancet, 368,* 210–215.

Baron-Cohen, S. (2002). The extreme male brain theory of autism. *Trends in Cognitive Science, 6,* 248–254.

Baron-Cohen, S., Allen, J., & Gillberg, C. (1992). Can autism be detected at 18 months? The needle, the haystack, and the CHAT. *British Journal of Psychiatry, 161,* 839–843.

Baron-Cohen, S., Cox, A., Baird, G., Swettenham, J., Nightingale, N., Morgan, K., Drew, A., & Charman, T. (1996). Psychological markers in the detection of autism in infancy in a large population. *British Journal of Psychiatry, 168,* 158–163.

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,* 343–350.

Baron-Cohen, S., Scott, F., Allison, C., Williams, J., Bolton, P., Matthews, F., & Brayne, C. (in preparation). Estimating autism spectrum prevalence in the population: A school based study from the UK.

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.

Baron-Cohen, S., Wheelwright, S., Robinson, J., & Woodbury-Smith, M. (2005). The Adult Asperger Assessment (AAA): a diagnostic method. *Journal of Autism and Developmental Disorders, 35,* 807–819.

Bertrand, J., Mars, A., Boyle, C., Bove, F., Yeargin-Allsopp, M., & Decoufle, P. (2001). Prevalence of autism in a United States population: the Brick Township, New Jersey, investigation. *Pediatrics, 108,* 1155–1161.

Chakrabarti, S., & Fombonne, E. (2001). Pervasive developmental disorders in preschool children. *Journal of the American Medical Association, 285,* 3093–3099.

Chakrabarti, S., & Fombonne, E. (2005). Pervasive developmental disorders in preschool children: confirmation of high prevalence. *American Journal of Psychiatry, 162,* 1133–1141.

Charman, T., Taylor, E., Drew, A., Cockerill, H., Brown, J. A., & Baird, G. (2005). Outcome at 7 years of children diagnosed with autism at age 2: predictive validity of assessments conducted at 2 and 3 years of age and pattern of symptom change over time. *Journal of Child Psychology and Psychiatry, 46,* 500–513.

Constantino, J. N., Lajonchere, C., Lutz, M., Gray, T., Abbacchi, A., McKenna, K., Singh, D., & Todd, R. D. (2006). Autistic social impairment in the siblings of children with pervasive developmental disorders. *American Journal of Psychiatry, 163,* 294–296.

Constantino, J. N., Davis, S. A., Todd, R. D., Schindler, M. K., Gross, M. M., Brophy, S. L., Metzger, L. M., Shoushtari, C. S., Splinter, R., & Reich, W. (2003). Validation of a brief quantitative measure of autistic traits: comparison of the social responsiveness scale with the autism diagnostic interview-revised. *Journal of Autism and Developmental Disorders, 33,* 427–433.

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

Cox, A., Klein, K., Charman, T., Baird, G., Baron-Cohen, S., Swettenham, J., Drew, A., & Wheelwright, S. (1999). Autism spectrum disorders at 20 and 42 months of age: stability of clinical and ADI-R diagnosis. *Journal of Child Psychology and Psychiatry, 40,* 719–732.

De Giacomo, A., & Fombonne, E. (1998). Parental recognition of developmental abnormalities in autism. *European Child and Adolescent Psychiatry, 7,* 131–136.

Dietz, C., Swinkels, S., van Daalen, E., van Engeland, H., & Buitelaar, J. K. (2006). Screening for autistic spectrum disorder in children aged 14–15 months. II: Population screening with the Early Screening of Autistic Traits Questionnaire (ESAT). Design and general findings. *Journal of Autism and Developmental Disorders, 36,* 713–722.

Ehlers, S., Gillberg, C., & Wing, L. (1999). A screening questionnaire for Asperger syndrome and other high-functioning autism spectrum disorders in school age children. *Journal of Autism and Developmental Disorders, 29,* 129–141.

Gillberg, C., Nordin, V., & Ehlers, S. (1996). Early detection of autism. Diagnostic instruments for clinicians. *European Child and Adolescent Psychiatry, 5,* 67–74.

Glascoe, F. P. (1996). Developmental screening. In M. Wolraich (Ed.), *Disorders of development and learning: A practical guide to 20* (2nd ed.). St Louis: Mosby.

Gray, K. M., & Tonge, B. J. (2005). Screening for autism in infants and preschool children with developmental delay. *Australian and New Zealand Journal of Psychiatry, 39,* 378–386.

Hoekstra, R. A., Bartels, M., Verweij, C. J. H., & Boomsma, D. I. (2007). Heritability of autistic traits in the general population. *Archives of Pediatric & Adolescent Medicine, 161,* 372–377.

Howlin, P., & Asgharian, A. (1999). The diagnosis of autism and Asperger syndrome: Findings from a survey of 770 families. *Developmental Medicine and Child Neurology, 41,* 834–839.

Leekam, S., Tandos, J., McConachie, H., Meins, E., Parkinson, K., Wright, C., Turner, M., Arnott, B., Vittorini, L., & Couteur, A. L. (2007). Repetitive behaviours in typically developing 2-year-olds. *Journal of Child Psychology and Psychiatry, 48,* 1131–1138.

Lord, C. (1995). Follow-up of two-year-olds referred for possible autism. *Journal of Child Psychology and Psychiatry, 36,* 1365–1382.

Lord, C., Risi, S., DiLavore, P. S., Shulman, C., Thurm, A., & Pickles, A. (2006). Autism from 2 to 9 years of age. *Archives of General Psychiatry, 63,* 694–701.

Mawle, E., & Griffiths, P. (2006). Screening for autism in pre-school children in primary care: Systematic review of English Language tools. *International Journal of Nursing Studies, 43,* 623–636.

Myers, S. M., & Johnson, C. P. (2007). Management of children with autism spectrum disorders. *Pediatrics, 120,* 1162–1182.

National Screening Committee Child Health Subgroup (2005). National Screening Committee Policy on screening for autism. Retrieved 15/02/06, from http://libraries.nelh.nhs.uk/screening/viewResource.asp?categoryID=1330&uri=http%3A//libraries.nelh.nhs.uk/common/resources/%3Fid%3D60310.

Office for National Statistics (2001a). KS14b NS-SEC (National Statistics Socio-economic classification)—males: Census 2001, Key Statistics for Local Authorities. From http://www.statistics.gov.uk/statbase/expodata/spreadsheets/d6568.xls.

Office for National Statistics (2001b). KS14c NS-SEC (National Statistics Socio-economic classification)— females: Census 2001, Key Statistics for Local Authorities. From http://www.statistics.gov.uk/StatBase/Expodata/Spreadsheets/D6570.xls.

Office for National Statistics (2002). The National Statistics Socio-economic Classification. From http://www.statistics.gov.uk/nsbase/methods_quality/ns_sec/default.asp.

Posserud, M. B., Lundervold, A. J., & Gillberg, C. (2006). Autistic features in a total population of 7–9-year-old children assessed by the ASSQ (Autism Spectrum Screening Questionnaire). *Journal of Child Psychology and Psychiatry, 47,* 167–175.

Reznick, J. S., Baranek, G. T., Reavis, S., Watson, L. R., & Crais, E. R. (2007). A parent-report instrument for identifying one-year-olds at risk for an eventual diagnosis of autism: the first year inventory. *Journal of Autism and Developmental Disorders, 37,* 1691–1710.

Robins, D. L., Fein, D., Barton, M. L., & Green, J. A. (2001). The Modified Checklist for Autism in Toddlers: an initial study investigating the early detection of autism and pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 31,* 131–144.

Scott, F. J., Baron-Cohen, S., Bolton, P., & Brayne, C. (2002). Brief report: prevalence of autism spectrum conditions in children aged 5–11 years in Cambridgeshire, UK. *Autism, 6,* 231–237.

Siegel, B. (2004). *Pervasive Developmental Disorders Screening Test-II (PDDST-II)*. San Antonio: Harcourt.

Stone, W. L., Coonrod, E. E., Turner, L. M., & Pozdol, S. L. (2004). Psychometric properties of the STAT for early autism screening. *Journal of Autism and Developmental Disorders, 34,* 691–701.

Stone, W. L., Coonrod, E. E., & Ousley, O. Y. (2000). Brief report: Screening tool for autism in two-year-olds (STAT): Development and preliminary data. *Journal of Autism and Developmental Disorders, 30,* 607–612.

Swinkels, S. H., Dietz, C., van Daalen, E., Kerkhof, I. H., van Engeland, H., & Buitelaar, J. K. (2006). Screening for autistic spectrum in children aged 14–15 months. I: The development of the Early Screening of Autistic Traits Questionnaire (ESAT). *Journal of Autism and Developmental Disorders, 36,* 723–732.

Volkmar, F., & Klin, A. (2005). Issues in the classification of autism, related conditions. In F. Volkmar, R. Paul, A. Klin & D. Cohen (Eds.), Handbook of autism and pervasive developmental disorders (Vol. 1). New Jersey: Wiley & Sons.

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.

Watson, L. R., Baranek, G. T., Crais, E. R., Steven Reznick, J., Dykstra, J., & Perryman, T. (2007). The first year inventory: retrospective parent responses to a questionnaire designed to identify one-year-olds at risk for autism. *Journal of Autism and Developmental Disorders, 37,* 49–61.

Wetherby, A. M., Allen, L., Cleary, J., Kublin, K., & Goldstein, H. (2002). Validity and reliability of the communication and symbolic behavior scales developmental profile with very young children. *Journal of Speech Language and Hearing Research, 45,* 1202–1218.

Wetherby, A. M., & Woods, J. (2004). *Systematic observation of red flags for Autism Spectrum Disorders in young children*. Tallahassee: Florida State University Press.

Wetherby, A. M., Woods, J., Allen, L., Cleary, J., Dickinson, H., & Lord, C. (2004). Early indicators of autism spectrum disorders in the second year of life. *Journal of Autism and Developmental Disorders, 34,* 473–493.

Wheelwright, S., Baron-Cohen, S., Goldenfeld, N., Delaney, J., Fine, D., Smith, R., Weil, L., & Wakabayashi, A. (2006). Predicting Autism Spectrum Quotient (AQ) from the Systemizing Quotient-Revised (SQ-R) and Empathy Quotient (EQ). *Brain Research, 1079,* 47–56.

Williams, J. G., Allison, C., Scott, F., Bolton, P., Baron-Cohen, S., Matthews, F. E., & Brayne, C. (submitted). The Childhood Autism Spectrum Test (CAST): Sex differences.

Wing, L. (1988). The continuum of autistic disorders. In E. Schopler & G. B. Mesibov (Eds.), *Diagnosis and assessment IN AUTISM* (pp. 91–110). New York: Plenum.

Wing, L. (1997). *The autistic spectrum*. Oxford: Pergamon.

Wong, V., Hui, L. H., Lee, W. C., Leung, L. S., Ho, P. K., Lau, W. L., Fung, C. W., & Chung, B. (2004). A modified screening tool for autism (Checklist for Autism in Toddlers [CHAT-23]) for Chinese children. *Pediatrics, 114,* e166–e176.

World Health Organisation (1993). *The ICD-10 classification of mental and behavioural disorders: diagnostic criteria for research*. Geneva: WHO.