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The Autism-Spectrum Quotient (AQ): evidence from Asperger Syndrome/high-functioning autism, males and females, scientists and mathematicians.

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Abstract

Currently there are no brief, self-administered instruments for measuring the degree to which an adult with normal intelligence has the traits associated with the autistic spectrum. In this paper, we report on a new instrument to assess this: the **Autism-Spectrum Quotient** (AQ). Individuals score in the range 0-50. Four groups of subjects were assessed: Group 1: n = 58 adults with Asperger Syndrome (AS) or high-functioning autism (HFA); Group 2: n = 174 randomly selected controls. Group 3: n = 840 students in Cambridge University; and Group 4: n = 16 winners of the UK Mathematics Olympiad. The adults with AS/HFA had a mean AQ score of 35.8 (sd = 6.5), significantly higher than Group 2 controls (x = 16.4, sd = 6.3). 80% of the adults with AS/HFA scored 32+, vs 2% of controls. Among the controls, males scored slightly but significantly higher than women. No females scored extremely highly (AQ score 34+) whereas 4% of males did so. Twice as many males (40%) as females (21%) scored at intermediate levels (AQ score 20+). Among the AS/HFA group, males and female scores did not differ significantly. The students in Cambridge University did not differ from the randomly selected control group, but scientists (including mathematicians) scored significantly higher than both humanities and social sciences students, confirming an earlier study that autistic conditions are associated with scientific skills. Within the sciences, mathematicians scored highest. This was replicated in Group 4, the Mathematics Olympiad winners scoring significantly higher than the male Cambridge humanities students. 6% of the student sample scored 32+ on the AQ. On interview, 11 out of 11 of these met 3 or more DSM-IV criteria for AS/HFA, and all were studying sciences/mathematics, and 7 of the 11 met threshold on these criteria. Test-retest and inter-rater reliability of the AQ was good. The AQ is thus a valuable instrument for rapidly quantifying where any given individual is situated on the continuum from autism to normality. Its potential for screening for autism spectrum conditions in adults of normal intelligence remains to be fully explored.

Autism is defined in terms of abnormalities in social and communication development, in the presence of marked repetitive behaviour and limited imagination (APA, 1994). Asperger Syndrome (AS) is defined in terms of the individual meeting the same criteria for autism but with no history of cognitive or language delay, and not meeting the criteria for PDD (ICD-10, 1994). Language delay itself is defined as not using single words by two years of age, and/or phrase speech by three years of age. There is growing evidence that autism and Asperger Syndrome (AS) are of genetic origin. The evidence is strongest for autism, and comes from twin and behavioural genetic family studies (Bailey et al., 1995; Bolton & Rutter, 1990; Folstein & Rutter, 1977; Folstein & Rutter, 1988). Family pedigrees of AS also implicate heritability (Gillberg, 1991). There is also an assumption, still under debate, that autism and AS lie on a *continuum* of social-communication disability, with AS as the 'bridge' between autism and normality (Baron-Cohen, 1995; Frith, 1991; Wing, 1981; Wing, 1988). The continuum view shifts us away from categorical diagnosis and towards a *quantitative* approach.

Currently there are no *brief, self-administered* instruments available for measuring where any given individual adult, with normal intelligence, lies on this continuum. Existing instruments, such as the ADI-R (Autism Diagnostic Interview) (Le Couteur et al., 1989; Lord, Rutter & Le Couteur, 1994), the ADOS-G (Autism Diagnostic Observation Schedule) are fairly time-consuming to administer, and the CARS (Childhood Autism Rating Scale) which can be brief, is not self-administered (Schopler, Reichler & Renner, 1986). What is needed is a short, self-administered scale for identifying the degree to which any individual adult of normal IQ may have 'autistic traits', or what has been called 'the broader phenotype' (Bailey et al., 1995). This would be useful for both scientific reasons (e.g., establishing who is "affected" and who is not, or the degree of

'caseness' of an individual, in scientific comparisons), and potentially for applied reasons (e.g., screening for possibly "affected" individuals to assist in making referrals for a full diagnostic assessment). For both of these reasons, we developed the Autism-Spectrum Quotient (AQ). The instrument's name was chosen because of the assumption, mentioned above, that there is an autism spectrum (Wing, 1988)[1].

Design of the AQ

The AQ was designed to be short, easy to use, and easy to score. It is shown in Appendix 1. It comprises 50 questions, made up of 10 questions assessing 5 different areas: *social skill* (items 1,11,13,15,22,36,44,45,47,48); *attention switching* (items 2,4,10,16,25,32,34,37,43,46); *attention to detail* (items 5,6,9,12,19,23,28,29,30,49); *communication* (items 7,17,18,26,27,31,33,35,38,39); *imagination* (items 3,8,14,20,21,24,40,41,42,50). Each of the items listed above scores 1 point if the respondent records the abnormal or autistic-like behaviour either mildly or strongly (see below for scoring each item; Abnormality = poor social skill, poor communication skill, poor imagination, exceptional attention to detail, poor attention-switching/strong focus of attention). Approximately half the items were worded to produce a 'disagree' response, and half an 'agree' response, in a high scoring person with AS/HFA. This was to avoid a response bias either way. Following this, items were randomized with respect to both the expected response from a high-scorer, and with respect to their domain.

Instrument development

[1] The term 'quotient' is not used in the arithmetic sense (the result of dividing one quantity by another) but

Items were selected from the domains in the "triad" of autistic symptoms (APA, 1994; Rutter, 1978; Wing & Gould, 1979), and from demonstrated areas of cognitive abnormality in autism. The AQ as shown in Appendix 1 is the outcome of piloting multiple versions, over several years. The instrument was piloted on adults with AS or high functioning autism (HFA), and age matched controls. An early version was also interview-based, and required the coding of responses. Following piloting, items which controls scored on as often, or more often, than did people with autism/AS were omitted.

Due to the concern over whether a condition like HFA or AS might impair one's ability to understand the items in the questionnaire, we checked comprehension with the patients in our pilot study. We did this by calling some patients into our lab, selected at random, where we had the opportunity to ask them about their responses. Comprehension of wording might be a greater problem in a less able population, but this instrument is designed for high functioning individuals who are perfectly able to read or discuss issues. For caution, however, parents independently completed an AQ for their child with AS/HFA. A related issue is whether a condition like AS or HFA might impair the subject's ability to judge their own social or communicative behaviour, due to subtle mind-reading problems (Baron-Cohen, 1995; Baron-Cohen, Jolliffe, Mortimore & Robertson, 1997). If this occurred, this would lead a person to score lower on the AQ, rating their own behaviour as more appropriate than it might really be. Any inaccuracies of this kind would therefore, if anything, lead to a conservative estimate of the person's true 'AQ' score. However, to guard against false negatives, we included questions in both the social and communication domains that ask about the person's *preferences*, rather

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as derived from the Latin root *quotiens* (how much or how many).

than only asking them to judge their own behaviour. Piloting revealed that such able subjects were certainly able to report on their own preferences and what they find easy or difficult. Equally, items in the other domains ask about their attentional preferences or focus of attention (e.g., to dates, numbers, small sounds, etc.,). There is no reason to expect that a high functioning person with autism or AS would be at all impaired in being able to report faithfully on such items. The final version of the AQ has a forced choice format, can be self-administered, and is straight forward to score since it does not depend on any interpretation in the scoring.

Subjects

Four groups of subjects were tested: Group 1 comprised n = 58 adults with AS/HFA (45 males, 13 females). This sex ratio of 3.5:1 (m:f) is similar to that found in other samples (Klin, Volkmar, Sparrow, Cicchetti & Rourke, 1995). All subjects in this group had been diagnosed by psychiatrists using established criteria for autism or AS (APA, 1994). They were recruited via several sources, including the National Autistic Society (UK), specialist clinics carrying out diagnostic assessments, and adverts in newsletters/web-pages for adults with AS/HFA. Their mean age was 31.6 yrs (sd = 11.8, range 16.5-58.3). They had all attended mainstream schooling and were reported to have an IQ in the normal range. See below for a check of this. Their mean number of years in education was 14.2 (sd = 2.41). 32 had higher educational qualifications (university degrees). Their occupations reflected their mixed socio-economic status (SES). Because we could not confirm age of onset of language with any reliability (due to the considerable passage of time), these individuals are grouped together, rather than attempting to separate them into AS vs HFA. The final sample of 58 were those who responded from a larger sample of

63. Group 2 comprised 174 adults selected at random (n = 76 males and 98 females). They were drawn from 500 adults sent the AQ by post, giving a return rate of 34.8%. They were all living in the East Anglia area. Their mean age was 37.0 yrs (sd = 7.7, range 18.1-60.0). Their mean number of years in education was 13.9 (sd = 2.34). 89 had university degrees, and their mix of occupations was similar to that of Group 1. In Groups 1 and 2, 15 individuals were randomly selected from the individuals who had returned an AQ and invited into the lab to check pro-rated IQ, using 4 subtests of the WAIS-R (see below). Group 3 comprised n = 840 students in Cambridge University (n = 454 males, n = 386 females). Their mean age was 21.0 yrs (sd = 2.9, range = 17.6-51.1). They were drawn from 4175 students sent an AQ, giving a return rate of 20.1%. The return rates from the different disciplines did not differ significantly. Group 3 was included to test if they showed a similar profile to the randomly selected controls (Group 2, above), despite the difference in both IQ and educational level of the two groups. Group 3 also allowed us to test if scientists differed from students in the humanities, given earlier reports (Baron-Cohen et al., 1998) suggesting that autism is more common in families of physicists, engineers, and mathematicians. Finally, Group 4 comprised n = 16 winners of the UK Mathematics Olympiad (15 males, 1 female). They were included as a re-test of this same association. Their mean age was 17.4 yrs (sd = 1.0, range = 15.3 - 18.7).

Method

Subjects were sent the AQ by post, and the subject was instructed to complete it as quickly as possible (to avoid thinking about responses too long), and to complete it on

their own. Subjects in Group 2 had the option to complete this anonymously or not. To confirm the diagnosis of adults in Group 1 being high-functioning, 15 of them were randomly selected and invited into the lab for intellectual assessment using 4 subtests of the WAIS-R (Wechsler, 1958). The 4 subtests of the WAIS-R were Vocabulary, Similarities, Block Design, and Picture Completion. On this basis, all of these had a prorated IQ of at least 85, that is, in the normal range (mean=106.5, sd-8.0), and did not differ significantly from the subsample (n=15) selected from Group 1 (t test, $p > 0.5$), (mean=105.8, sd=6.3).

Scoring the AQ

'Definitely agree' or 'slightly agree' responses scored 1 point, on the following items: 2, 4, 5, 6, 7, 9, 12, 13, 16, 18, 19, 20, 21, 22, 23, 26, 33, 35, 39, 41, 42, 43, 45, 46. 'Definitely disagree' or 'slightly disagree' responses scored 1 point, on the following items: 1, 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36,37, 38, 40, 44, 47, 48, 49, 50.

Results

AS/HFA vs. controls, and sex differences

Mean total and sub-category AQ scores from each group are displayed in Table 1. Comparing Groups 1 and 2 using an ANOVA of total AQ score by Group and Sex, we found, as predicted, that there was a main effect of Group [$F(1, 228) = 328.9$, $p = 0.0001$], the AS/HFA group scoring higher than the controls, and a two-way interaction of Group by Sex ($F(1, 228) = 6.01$, $p = 0.015$) the control males scoring significantly

higher than the control females ($t = 2.56$, df = x, $p < 0.01$). There was no difference between mean AQ scores of males and females with AS/HFA. Group means on each subscore are also shown in Table 1. See also Figures 1 and 2 for graphic displays of the Group and Sex differences. The AS/HFA group differed from Group 2 on all subscores (t tests, $p < 0.0001$). Comparing the students (Group 3) to the randomly selected controls (Group 2), there was no main effect of Group ($F(1, 1010) = 3.2$, $p = 0.07$) and no Group by Sex interaction ($F(1, 1010) = 0.042$, $p = 0.84$), but there was a significant effect of Sex ($F(1, 1010) = 19.4$, $p = 0.0001$), males scoring higher than females. This means that on the AQ the students do not differ from the general population sample, despite the differences in IQ and educational level between the two groups. Combining Groups 2 and 3, males and females differed on all subscales except local details (t tests, all $p < 0.0001$).

insert Table 1 and Figures 1-2 here

Scientists vs non-scientists

Table 2 shows the AQ scores for subjects in Group 3, broken down according to their Degree/area of study. We compared students studying Science (i.e., physical sciences[2], biological sciences[3], mathematics, computer science, engineering, medicine[4], and non-specific science[5]), vs Humanities (i.e., classics, languages, law, architecture, philosophy, English, theology, history, or music), vs the Social Sciences (i.e., geography, economics,

[2] Physical sciences included physics, physical natural sciences, chemistry, geology, communications, chemical engineering, mineral science, material science, and geophysics.
[3] Biological sciences included experimental psychology, neurophysiology, biological natural sciences, biology, bioanthroplogy, neuroscience, and molecular ecology.
[4] Medicine included both medicine and veterinary science.
[5] This last category included those subjects who simply listed their Degree as natural sciences, which could have been any of the sciences.

social and political sciences, archaeology and anthropology, land economy, or management). There was a main effect of Degree ($F(2, 834) = 5.8$, $p = 0.003$), scientists scoring higher than both humanities and social scientists, who did not differ from each other. This confirms an earlier report of an association between science/maths skills, and autistic conditions (Baron-Cohen et al., 1998). There was also a main effect of Sex ($F(1, 834) = 11.4$, $p = 0.001$), males scoring higher than females over all, replicating the sex difference found in Group 2 above. Scientists differed from non-scientists on two subscales (social and imagination, t tests, $p < 0.0001$). There was no significant interaction of Sex by Degree ($F(2, 834) = 0.32$, $p = 0.73$).

insert Table 2 here

Differences between types of science

We then tested if there were differences between the different types of scientists, or between male and female scientists, in Group 3. The 6 types of sciences (i.e., excluding the non-specific category), by Sex, were compared in one ANOVA. There was a main effect of type of science ($F(5, 331) = 7.8$, $p < 0.0001$), but no main effect of Sex ($F(1,331) = 3.0$, $p = 0.08$), and no Sex by Science-Type interaction ($F(5,331) = 27.3$, $p = 0.62$). The mean AQ's and subscale scores (and sd's) for each type of science are shown in Table 3. Student Neuman Keuls tests showed that mathematicians scored higher than engineers, physical and computer sciences, who scored higher than medicine and biology. Analysed differently, mathematicians scored significantly higher than the non-mathematician scientists ($F(1,450) = 16.9$, $p = 0.0001$). Subscale differences were not compared within the science types in order to avoid multiple statistical testing. In order to retest the finding from Group 3 that mathematicians score significantly higher than controls, the final analysis compared Group 4 (Maths Olympiad) vs male humanities students from Group 3. Group 4 scored significantly higher than the male humanities students ($t = -4.42$, df 133, $p = 0.0001$). There were no differences between Group 4 and mathematicians from Group 3 ($t = -1.7$, $df = 99$, $p = 0.09$). Mean AQ and subscale scores from Group 4 are shown in Table 1.

insert Table 3 here

Test-retest reliability, and self vs parent report

To establish test-retest reliability, 17 students from Group 3 were asked to complete a second AQ two weeks after the first administration. Scores from the first and second AQ's did not differ statistically ($t = 0.3$, $df = 16$, $p = 0.75$) and were strongly correlated ($r = 0.7$, $p = 0.002$). To test if self-report by adults with AS/HFA was leading to inflated scores, all subjects in Group 1 were asked if a parent could also compete an AQ on them. Twenty-two of these families agreed to do this. The parent version of the AQ omitted 10 items out of 50 (items 3, 5, 6, 8, 12, 20, 23, 27, 36, and 42), since these could only be answered subjectively. The mean difference in AQ score between self-report and parent-report for the 40-item AQ was 2.8 points (sd = -0.6), parents scoring their child more highly than their child's self-report. This shows that scores in Group 1 are if anything more conservative than would be estimated by another judge.

Item analysis and internal consistency

An item analysis (percentage of each group scoring on each item) is shown in Table 4. On only 2 items out of 50 (items 29, and 30) did controls score more than adults with AS/HFA, strongly confirming the value of these items for discriminating HFA/AS vs controls established at the pilot phase. These two items were conservatively retained in the analysis since, if anything, they served to reduce the size of group differences. The internal consistency of items in each of the 5 domains was also calculated, and Cronbach's Alpha Coefficients were all moderate to high (Communication = 0.65; Social, = 0.77; Imagination = 0.65; Local Details = 0.63; Attention Switching = 0.67). Regarding the decision to score "slightly agree" and "definitely agree" responses using one point only, a re-analysis differentiating these in terms of 1 vs 2 points led to the same pattern of results overall.

insert Table 4 here

Determining a useful cut-off

Percentage of each group scoring at or above each AQ score is shown in Table 5, and the same analysis for science vs non-science students in Group 3, in Table 6. Considering Table 5, and using the rule that a useful cut-off would discriminate the groups with as many true positives and as few false positives as possible, an AQ score of 32+ was chosen, since 79.3% of the AS/HFA group scored at this level, whilst only 2% of controls did so. 32+ also seems to be a useful cut-off for distinguishing females with AS/HFA (92.3% scoring at this point or above) vs. control females (1% of whom score at this point or above).

insert Tables 5 and 6 here

Normal sex differences on the AQ

Table 5 also shows that control females never score as high as 34+, whereas 3.9% of control males do. Note also that at AQ score 20+, there are twice as many males (40%) as females (21%) in the control group scoring at this intermediate point on the scale. This suggests that there is not only a sex difference on the AQ overall (as reflected in the male mean AQ being higher than the female mean), and a sex difference at high levels on the

AQ (reflected in the sex ratio in Group 1 being 3.5:1), but that significantly more males than females in the general population show moderate levels of "autistic traits"[6].

Validation of the AQ among controls

We cannot determine the rate of false negatives in Group 2 (general population controls), as the majority of these completed the AQ anonymously. To validate the AQ in Group 3, we called in for clinical interview all subjects scoring 32+, of whom 11 agreed to be interviewed. Using DSM-IV[7] criteria for autistic disorder, an experienced clinician (SBC) sought to establish the number of criteria each subject met. The clinician remained blind to the AQ score of the subject being interviewed. Of the 11 subjects scoring 32+, 7 of these met criteria for HFA or AS. No diagnoses were actually made for two reasons: No parent was present to provide independent developmental data, and because none of those meeting criteria complained of any current unhappiness. Indeed, many of them reported that within a University setting their desire not to be sociable, together with their desire to pursue their narrow or repetitive interests (typically mathematics and computing) was not considered odd, and was even valued. Of the other 4, all met at least 3 criteria. In all 11 cases however, there was evidence from self-report of significant impairment in functioning during the school years (social isolation, being bullied, and difficulty in making friendships).

Discussion

In this paper we have described a new self-assessment screening instrument, the Autism-Spectrum Quotient (AQ), for measuring the degree to which an individual of normal

[6] ie. those traits which people with AS or HFA tend to endorse on the AQ.
[7] Only DSM-IV criteria were applied, as for individuals of this age it was not appropriate to also use instruments such as the ADI-R or the ADOS (Lord et al., 1994).

intelligence shows 'autistic traits'. As predicted, adults with AS/HFA scored significantly higher on the AQ than matched controls. 80% scored above a critical minimum of 32+, whereas only 2% of controls did so. This demonstrates that the AQ has reasonable face validity, since the questionnaire purports to measure autistic spectrum traits, and people with a diagnosis involving these traits score highly on it. AQ scores from a general population sample and a Cambridge student sample were not significantly different, implying that IQ and SES do not appear to influence AQ. The AQ can also be said to have reasonable construct validity, in that items purporting to measure each of the 5 domains of interest (social, communication, imagination, attention to detail, and attention switching) show moderate to high alpha coefficients. Future work needs to test the false negative rate by carrying out diagnostic assessments on a larger number of subjects in the control group than was possible here. The AQ has excellent test-retest reliability. The group differences between the AS/HFA group vs controls are if anything conservative, given that parents score their child with AS/HFA higher than they score by self-report. Within the control group, males score slightly but significantly higher than females, both overall, and at intermediate and high levels of autistic traits. This is consistent with the extreme male brain theory of autism (Asperger, 1944; Baron-Cohen & Hammer, 1997) and may have implications for the marked sex ratio in AS (Wing, 1981). Finally, scientists score higher than non-scientists, and within the sciences, mathematics, physical scientists, computer scientists, and engineers score higher than the more human or life-centred sciences of medicine (including veterinary science) and biology. This latter finding replicates our earlier studies finding a link between autism spectrum conditions and occupations/skills in maths, physics, and engineering. Our recent single case studies of very high achieving mathematicians, physicists, and computer scientists with AS show that this condition need not be any obstacle to achieving the highest levels in these fields. Converging evidence for a link between AS and talent in physics has recently been reported in an unselected sample of children with AS (Baron-Cohen et al., 1998).

We wish to underline that the AQ is not diagnostic, but may serve as a useful instrument in identifying the extent of autistic traits shown by an adult of normal intelligence. A score of 32+ appears to be a useful cut-off for distinguishing individuals who have clinically significant levels of autistic traits. Such a high score on the AQ however does not mean an individual has AS or HFA, since a diagnosis is only merited if the individual is suffering a clinical level of distress as a result of their autistic traits. As shown in the subsample of students in Group 3 above, 80% of those scoring 32+ met DSM-IV criteria for HFA, but did not merit a diagnosis as they were not suffering any significant distress. If an adult scores above 32 on the AQ, and is suffering some distress, we suggest this would then merit a referral to an expert clinician for a full diagnostic assessment. A limitation of this instrument is that it may not be appropriate for patients with low IQ, since the AQ assumes reading comprehension skills. Future work could include administering the AQ to other psychiatric control groups, in order to further determine its specificity, and to replicate the current results from Group 1 with patients diagnosed using standardised instruments. We suggest the AQ fills a gap for a brief assessment instrument for HFA/AS in adults of normal intelligence.

Appendix 1: The AQ

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

16. I tend to have very strong interests, which I get upset about if I can't pursue.	definitely agree	slightly agree	slightly disagree	definitely disagree

17. I enjoy social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
18. When I talk, it isn't always easy for others to get a word in edgeways.	definitely agree	slightly agree	slightly disagree	definitely disagree
19. I am fascinated by numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
20. When I'm reading a story, I find it difficult to work out the characters' intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
21. I don't particularly enjoy reading fiction.	definitely agree	slightly agree	slightly disagree	definitely disagree
22. I find it hard to make new friends.	definitely agree	slightly agree	slightly disagree	definitely disagree
23. I notice patterns in things all the time.	definitely agree	slightly agree	slightly disagree	definitely disagree
24. I would rather go to the theatre than a museum.	definitely agree	slightly agree	slightly disagree	definitely disagree
25. It does not upset me if my daily routine is disturbed.	definitely agree	slightly agree	slightly disagree	definitely disagree
26. I frequently find that I don't know how to keep a conversation going.	definitely agree	slightly agree	slightly disagree	definitely disagree
27. I find it easy to "read between the lines" when someone is talking to me.	definitely agree	slightly agree	slightly disagree	definitely disagree
28. I usually concentrate more on the whole picture, rather than the small details.	definitely agree	slightly agree	slightly disagree	definitely disagree
29. I am not very good at remembering phone numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
30. I don't usually notice small changes in a situation, or a person's appearance.	definitely agree	slightly agree	slightly disagree	definitely disagree
31. I know how to tell if someone listening to me is getting bored.	definitely agree	slightly agree	slightly disagree	definitely disagree

32. I find it easy to do more than one thing at once.	definitely agree	slightly agree	slightly disagree	definitely disagree
33. When I talk on the phone, I'm not sure when it's my turn to speak.	definitely agree	slightly agree	slightly disagree	definitely disagree

34. I enjoy doing things spontaneously.	definitely agree	slightly agree	slightly disagree	definitely disagree
35. I am often the last to understand the point of a joke.	definitely agree	slightly agree	slightly disagree	definitely disagree
36. I find it easy to work out what someone is thinking or feeling just by looking at their face.	definitely agree	slightly agree	slightly disagree	definitely disagree
37. If there is an interruption, I can switch back to what I was doing very quickly.	definitely agree	slightly agree	slightly disagree	definitely disagree
38. I am good at social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
39. People often tell me that I keep going on and on about the same thing.	definitely agree	slightly agree	slightly disagree	definitely disagree
40. When I was young, I used to enjoy playing games involving pretending with other children.	definitely agree	slightly agree	slightly disagree	definitely disagree
41. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	definitely agree	slightly agree	slightly disagree	definitely disagree
42. I find it difficult to imagine what it would be like to be someone else.	definitely agree	slightly agree	slightly disagree	definitely disagree
43. I like to plan any activities I participate in carefully.	definitely agree	slightly agree	slightly disagree	definitely disagree
44. I enjoy social occasions.	definitely agree	slightly agree	slightly disagree	definitely disagree
45. I find it difficult to work out people's intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree

46. New situations make me anxious.	definitely agree	slightly agree	slightly disagree	definitely disagree
47. I enjoy meeting new people.	definitely agree	slightly agree	slightly disagree	definitely disagree
48. I am a good diplomat.	definitely agree	slightly agree	slightly disagree	definitely disagree
49. I am not very good at remembering people's date of birth.	definitely agree	slightly agree	slightly disagree	definitely disagree
50. I find it very easy to play games with children that involve pretending.	definitely agree	slightly agree	slightly disagree	definitely disagree

Table 1: Mean AQ and subscale scores (and sds) by group

		Communication	Social	Imagination	Local Details	Attention Switching	Total AQ
Group 1							
AS/HFA	x	7.2	7.5	6.4	6.7	8.0	35.8
(n=58)	sd	2.0	1.9	2.1	2.3	1.8	6.5
AS/HFA males	x	7.2	7.4	6.2	6.6	7.7	35.1
(n=45)	sd	2.0	2.0	2.2	2.3	1.9	6.9
AS/HFA females	x	7.3	7.9	7.0	6.9	8.9	38.1
(n=13)	sd	2.1	1.4	1.5	2.1	1.0	4.4
Group 2							
Controls	x	2.4	2.6	2.3	5.3	3.9	16.4
(n=174)	sd	1.9	2.3	1.7	2.3	1.9	6.3
Control males	x	2.8	2.8	2.7	5.2	4.3	17.8
(n=76)	sd	2.0	2.5	1.9	2.3	1.9	6.8
Control females	x	2.1	2.3	1.9	5.4	3.6	15.4
(n=98)	sd	1.8	2.2	1.5	2.3	1.8	5.7
Group 3							
Students	x	2.9	2.3	2.5	5.3	4.5	17.6
(n=840)	sd	2.0	2.2	1.9	2.2	2.0	6.4
Student males	x	3.2	2.6	2.9	5.3	4.7	18.6
(n=454)	sd	2.0	2.3	2.0	2.1	2.0	6.6
Student females	x	2.7	2.0	2.0	5.4	4.3	16.4
(n=386)	sd	1.8	2.0	1.7	2.3	2.0	6.1
Group 4							
Olympiad	x	3.0	5.1	4.9	6.6	4.9	24.5
(n=16)	sd	2.3	3.2	2.5	2.3	1.9	5.7

Table 2: Mean AQ and subscale scores (and sds) for students (group 3) studying different degrees

		Communication	Social	Imagination	Local Details	Attention Switching	Total AQ
Sciences							
All	x	3.1	2.6	2.7	5.5	4.6	18.5
(n=454)	sd	2.0	2.3	2.0	2.2	2.0	6.8
Males	x	3.2	2.9	3.1	5.4	4.7	19.3
(n=284)	sd	2.1	2.5	2.1	2.1	2.0	6.8
Females	x	2.8	2.1	2.1	5.6	4.4	17.1
(n=170)	sd	1.8	2.1	1.7	2.5	2.0	6.5
Humanities							
All	x	2.8	2.0	2.1	5.2	4.5	16.7
(n=276)	sd	1.9	2.0	1.8	2.2	2.1	5.9
Males	x	3.3	2.1	2.4	5.2	4.7	17.7
(n=119)	sd	1.9	2.0	1.8	2.0	2.2	5.8
Females	x	2.5	2.0	1.9	5.2	4.3	15.9
(n=157)	sd	1.9	2.0	1.8	2.3	2.0	5.8
Social Sciences							
All	x	2.7	1.8	2.4	5.2	4.3	16.4
(n=110)	sd	1.7	1.9	1.9	2.1	1.9	5.8
Males	x	2.8	1.8	2.8	5.2	4.5	17.1
(n=51)	sd	1.8	1.8	2.0	2.3	1.8	6.1
Females	x	2.6	1.9	1.9	5.2	4.2	15.8
(n=59)	sd	1.7	2.0	1.7	2.0	2.0	5.5

Table 3: Mean AQ and subscale scores (and sds) for student scientists (group 3) studying different subjects

		Communication	Social	Imagination	Local Details	Attention Switching	Total AQ
Biological sciences	x	2.7	1.5	1.7	4.7	4.2	14.9
(n=31)	sd	2.0	1.5	1.4	2.4	2.1	5.7
Computer science	x	3.4	3.7	3.4	5.7	4.8	21.1
(n=23)	sd	2.4	3.0	1.9	1.8	1.9	7.7
Engineering	x	2.9	2.3	3.0	5.4	4.3	17.9
(n=77)	sd	1.8	2.1	2.5	2.2	1.7	5.6
Mathematics	x	3.8	3.6	3.3	5.8	5.1	21.5
(n=85)	sd	2.0	2.5	1.8	1.9	2.0	6.4
Medicine	x	2.5	1.4	2.0	5.2	4.2	15.4
(n=69)	sd	1.6	1.6	1.6	2.4	1.9	5.0
Physical sciences	x	3.0	3.4	3.1	5.4	4.6	19.6
(n=47)	sd	2.3	2.8	1.9	2.2	2.3	7.8
Non-specific science	x	3.0	2.6	2.6	5.6	4.7	18.5
(n=122)	sd	2.0	2.1	1.9	2.4	2.1	7.2

Table 4: Item analysis for groups 1-3

	Group 1	Group 2	Group3
	AS/HFA	**Controls**	**Students**
Item	(n=58)	(n=174)	(n=840)
1	67.2	36.2	29.2
2	81.0	31.6	36.0
3	32.8	13.2	17.9
4	91.4	55.7	65.4
5	79.3	59.2	50.8
6	65.5	55.2	49.9
7	65.5	19.0	27.1
8	37.9	6.9	21.0
9	58.6	38.5	23.6
10	81.0	25.9	40.1
11	86.2	31.0	34.5
12	96.6	79.9	75.1
13	74.1	25.3	13.8
14	60.3	38.5	40.0
15	77.6	29.9	19.8
16	82.8	52.3	64.4
17	74.1	32.8	29.0
18	58.6	38.5	36.0
19	58.6	39.1	47.4
20	60.3	14.4	15.1
21	58.6	18.4	12.5
22	84.5	31.0	26.0
23	81.0	54.6	71.4
24	60.3	32.2	23.9
25	81.0	32.8	37.6
26	81.0	35.1	45.0
27	81.0	20.7	24.9
28	69.0	35.6	43.0
29	48.3	54.6	65.0
30	58.6	73.0	65.6
31	67.2	10.3	14.5
32	70.7	17.8	28.2
33	63.8	10.9	12.7
34	65.5	22.4	17.6
35	60.3	19.0	29.0
36	74.1	19.0	27.3
37	69.0	16.1	38.9
38	87.9	33.9	38.7
39	81.0	23.6	36.2
40	77.6	20.7	23.8
41	81.0	25.3	18.3
42	84.5	32.2	36.2
43	81.0	61.5	65.4
44	75.9	14.9	9.9
45	84.5	27.6	35.2
46	93.1	69.5	59.0
47	56.9	19.5	11.0
48	72.4	20.7	25.1
49	50.0	40.8	43.0
50	87.9	25.9	41.0

Table 5: Percent of subjects in groups 1 and 2 scoring at or above each AQ score

AQ Score	AS/HFA (n=58)	AS/HFA males (n=45)	AS/HFA females (n=13)	Controls (n=174)	Control males (n=76)	Control females (n=98)
0	100	100	100	100	100	100
1	100	100	100	100	100	100
2	100	100	100	100	100	100
3	100	100	100	100	100	100
4	100	100	100	100	100	100
5	100	100	100	98.3	97.4	99.0
6	100	100	100	96.6	97.4	95.9
7	100	100	100	96.0	97.4	94.9
8	100	100	100	93.7	96.1	91.8
9	100	100	100	90.2	93.4	87.8
10	100	100	100	85.1	89.5	81.6
11	100	100	100	81.6	85.5	78.6
12	100	100	100	77.0	78.9	75.5
13	100	100	100	71.8	73.7	70.4
14	100	100	100	65.5	69.7	62.2
15	100	100	100	60.9	68.4	55.1
16	100	100	100	54.0	63.2	46.9
17	100	100	100	47.1	57.9	38.8
18	100	100	100	40.8	51.3	32.7
19	98.3	97.8	100	36.8	48.7	27.6
20	96.6	95.6	100	29.3	39.5	21.4
21	96.6	95.6	100	24.7	32.9	18.4
22	96.6	95.6	100	19.0	25.0	14.3
23	96.6	95.6	100	16.7	22.4	12.2
24	94.8	93.3	100	13.8	18.4	10.2
25	94.8	93.3	100	9.8	14.5	6.1
26	94.8	93.3	100	8.0	13.2	4.1
27	89.7	86.7	100	4.0	6.6	2.0
28	89.7	86.7	100	4.0	6.6	2.0
29	86.2	82.2	100	4.0	6.6	2.0
30	84.5	80.0	100	2.9	5.3	1.0
31	82.8	77.8	100	2.9	5.3	1.0
32	79.3	75.6	92.3	2.3	3.9	1.0
33	70.7	66.7	84.6	2.3	3.9	1.0
34	63.8	60.0	76.9	1.7	3.9	0
35	62.1	57.8	76.9	0.6	1.3	0
36	53.4	46.7	76.9	0.6	1.3	0
37	50.0	46.7	61.5	0.6	1.3	0
38	43.1	37.8	61.5	0	0	0
39	36.2	33.3	46.2	0	0	0
40	27.6	24.4	38.5	0	0	0
41	22.4	22.2	23.1	0	0	0
42	22.4	22.2	23.1	0	0	0
43	19.0	17.8	23.1	0	0	0
44	13.8	13.3	15.4	0	0	0
45	5.2	4.4	7.7	0	0	0
46	1.7	2.2	0	0	0	0
47	1.7	2.2	0	0	0	0
48	1.7	2.2	0	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0

Table 6: Percent of subjects in group 3 scoring or at above each AQ score

AQ Score	Science (n=454)	Non-science (n=386)
0	100	100
1	100	100
2	100	100
3	100	99.7
4	100	99.2
5	99.3	99.2
6	98.7	99.0
7	98.2	97.9
8	97.4	96.4
9	96.9	94.0
10	93.4	90.4
11	89.4	85.2
12	85.5	81.6
13	81.5	73.3
14	75.1	67.9
15	70.3	62.4
16	62.1	54.7
17	55.5	46.6
18	51.3	39.4
19	46.0	32.6
20	39.6	29.0
21	32.6	23.6
22	30.2	19.4
23	26.2	16.3
24	23.8	12.7
25	19.2	10.6
26	15.4	8.3
27	12.3	6.7
28	10.4	4.1
29	8.1	3.1
30	7.7	2.6
31	5.3	1.6
32	4.6	1.3
33	3.3	0.5
34	2.4	0.3
35	1.5	0.3
36	1.1	0
37	0.9	0
38	0.7	0
39	0.7	0
40	0.4	0
41	0.4	0
42	0.4	0
43	0.2	0
44	0.2	0
45	0	0
46	0	0
47	0	0
48	0	0
49	0	0
50	0	0

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Figure 1: AQ scores in AS/HFA group and controls (Groups 1 and 2)

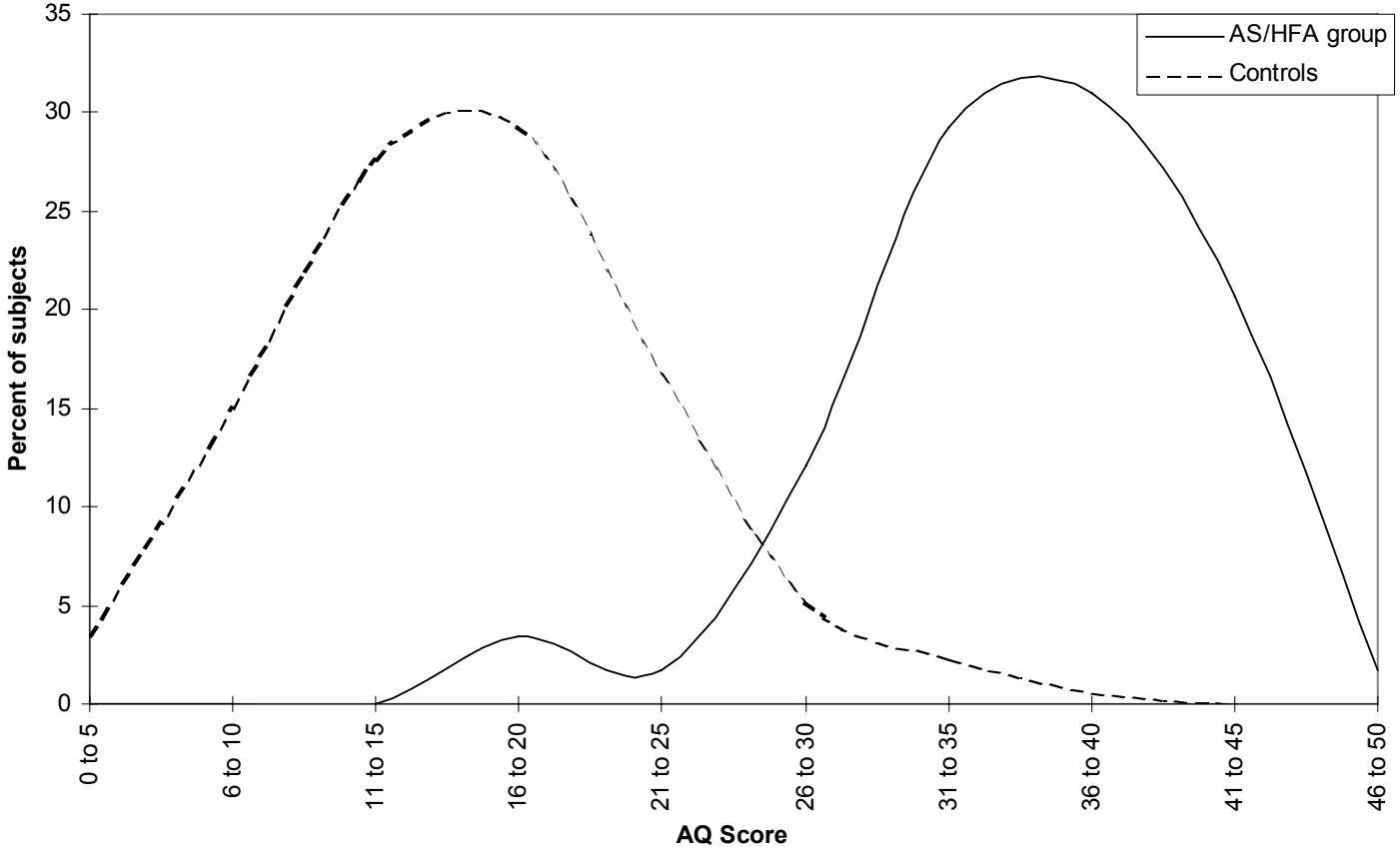

Figure 2: AQ scores in male and female controls (Group 2)