J Autism Dev Disord (2009) 39:670–677
DOI 10.1007/s10803-008-0658-3

BRIEF REPORT

# Brief Report: Visuospatial Analysis and Self-Rated Autistic-Like Traits

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Published online: 24 October 2008


**Abstract** Although there is good evidence that the behavioral traits of autism extend in lesser form to the general population, there has been limited investigation of whether cognitive features of the disorder also accompany these milder traits. This study investigated whether the superiority in visuospatial analysis established for individuals with autism also extends to individuals in the general population who self-report autistic-like traits. In an initial study, students scoring high on the Autism-spectrum Quotient (AQ) were faster and more accurate on the Embedded Figures Test (EFT) and the Block Design subscale of the Wechsler Intelligence Scale III compared to those scoring low on the AQ. A second study showed that high AQ scorers were faster to complete the EFT compared to low AQ scorers irrespective of IQ. Results are discussed with reference to weak central coherence theory and the autism spectrum.

**Keywords** Autism · Autistic-like traits · Embedded figures task · Visuospatial analysis · Weak central coherence

It is now commonly accepted that the genetic variants that put a child at risk for autism may also lead to a broader autism phenotype (Folstein and Rutter 1977; Szatmari et al. 2007). This expression of milder symptoms of the disorder has an elevated rate of incidence for the first-degree relatives of individuals with autism (see Bailey et al. 1998, for a review). Thus, the siblings and parents of those affected by autism are reported to show mild impairments in the three domains used to diagnose the disorder: restricted or odd social behavior, limited communication skills and unusual or highly specialized interests (e.g., Bishop et al. 2004; Briskman et al. 2001; Constantino et al. 2006; Pickles et al. 2000). While not required for a diagnosis, certain cognitive features are commonly associated with autism spectrum disorders (for reviews, see Hill 2004; Rajendran and Mitchell 2007). Significantly, there is evidence that the broader phenotype is expressed at this cognitive level as well as at the behavioral level. For instance, first-degree relatives have been reported to show executive-function deficits (e.g., Hughes et al. 1997), weak central coherence (e.g., Happé et al. 2001) and limitations in identifying mental states (e.g., Baron-Cohen and Hammer 1997) that are similar to those shown by individuals with autism themselves.

An extension of the concept of a broader autism phenotype is to argue for a continuum of severity of autistic traits in the broader population (Baron-Cohen et al. 2001; Frith 1991), such that individuals can report mild autistic-like traits without themselves or their immediate relatives having an autism spectrum disorder. Support for the continuum has been gathered using questionnaires such as the Autism-spectrum Quotient (AQ), the Social Responsiveness Scale, the Broad Autism Phenotype Questionnaire and the Childhood Asperger Syndrome Test, which assess preferences and behaviors consistent with milder autistic traits. Demonstrated to be both reliable and valid (Baron-Cohen et al. 2001; Constantino et al. 2003; Hurley et al. 2007; Scott et al. 2002; Woodbury-Smith et al. 2005) these self-report measures tap behavioral traits that are approximately normally distributed in the general population

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(Baron-Cohen et al. 2001) and substantially heritable (Constantino and Todd 2003). Illustrating the validity of these instruments, the AQ has been shown to discriminate individuals with an autism spectrum disorder from unaffected individuals, with a score of 32 recommended as a useful cut-off for distinguishing individuals who have clinically significant levels of autistic traits (Baron-Cohen et al. 2001; Woodbury-Smith et al. 2005).

Although there is good evidence of continuity in the severity of the behavioral symptoms of autism, there has been limited investigation of whether cognitive characteristics of the disorder extend into the general population. One intriguing cognitive feature of autism is a preserved or perhaps even superior capacity to engage in detailed visuospatial analysis. There are now several reports of individuals with an autism spectrum disorder either matching (Kaland et al. 2007; Ropar and Mitchell 2001) or outperforming (Morgan et al. 2003; Pellicano et al. 2006; Shah and Frith 1993) comparison groups on the Block Design subtest of the Weschler Intelligence Scales or the closely related Pattern Construction subtest of the Differential Ability Scales. Similarly, there are multiple reports that, relative to controls, participants with an autism spectrum disorder show equivalent (Brian and Bryson 1996; Kaland et al. 2007; Ozonoff et al. 1991; Ropar and Mitchell 2001) or advanced (Edgin and Pennington 2005; Jarrold et al. 2005; Jolliffe and Baron-Cohen 1997; Morgan et al. 2003; Pellicano et al. 2005, 2006; Shah and Frith 1983) capabilities in disembedding simple shapes from complex backgrounds on the Embedded Figures Test (EFT).

The major aim of the present research was to investigate whether this advanced capability in detailed visual analysis reported for groups with an autism spectrum disorder also characterizes groups from the broader population who endorse high levels of autistic-like traits on the AQ. There are several reasons for investigating whether there is continuity in this visuospatial skill across these groups. First, evidence of continuity at the cognitive level would support the position that there is a continuum from severe autism through to typical development in respect of underlying cognitive mechanisms as well as in preferences and behavior. Second, we have argued elsewhere (Grinter et al. 2008) that an advanced capability for visuospatial analysis may be a unique marker for autism, given that such a facility has not been found for other developmental disorders. This argument would be strengthened if the present investigation were to demonstrate an association between higher levels of mild autistic traits and superior visuospatial analytic ability in the general population.

We investigated, in two studies, whether groups of students selected for their extreme scores on the AQ were differentiated in Block Design and EFT performance. In the only previous study of this kind, Kunihira et al. (2006) reported a non-significant difference between low and high AQ groups on EFT reaction times. However, the population from which these authors drew their groups—Japanese university students—had much higher AQ means (men: 22.83; women: 21.00) than those reported by Baron-Cohen et al. (2001) for a British university sample (men: 18.6; women: 16.4), resulting in relatively high cutoffs for the low AQ group in the Kunihira et al. study (men: 18.5; women 16.75). Our research used a student population comparable in AQ distribution to the British sample, and from which more extreme AQ groups could be selected than those used by Kunihira et al. In addition, we broadened the scope of the investigation of visuospatial analytic abilities by investigating Block Design as well as EFT performance, collected error as well as reaction-time data for the EFT, and (in Study 2) evaluated whether group differences were independent of IQ.

## Study 1

The first study compared high and low AQ groups on the EFT (Witkin et al. 1971) and also the Block Design subscale of the Wechsler Adult Intelligence Scales-III (WAIS-III; Wechsler 1997). It was hypothesised that, similar to individuals with autism (Edgin and Pennington 2005; Jarrold et al. 2005; Jolliffe and Baron-Cohen 1997; Morgan et al. 2003; Pellicano et al. 2005, 2006; Shah and Frith 1983) and their family members (Baron-Cohen and Hammer 1997; Bölte and Poustka 2006; Happé et al. 2001), high AQ scorers would outperform low AQ scorers on both tasks.

### Method

#### *Participants*

Initially, 548 students at the University of Western Australia completed the AQ (mean [*M*] score $= 17.28$; standard deviation [*SD*] $= 5.46$). Next, students from the upper and lower quintiles of the AQ distribution (using cutoff scores of 12 or less and 23 or more) were invited to complete further testing. The characteristics of the resulting high and low AQ groups are outlined in Table 1. The groups did not differ significantly in age distribution, $t(37) = .78$, $p > .05 = .44$. Numerically, there was a higher proportion of females in the low AQ group than in the high AQ group. While this difference was not statistically significant, $\chi^2(1) = 3.143$, $p = .08$, and had a small effect size (8% of variance based on $\phi = .28$),

**Table 1** Male–female ratio, and means (and SDs) for AQ score, age, Block Design scaled score, EFT response time and EFT errors for Study 1

| | Low AQ ($N = 20$) | High AQ ($N = 19$) |
|---|---|---|
| Male:Female | 5:15 | 10:9 |
| AQ score | 8.55 (1.89) | 25.89 (2.92) |
| Age (years) | 17.75 (.79) | 18.05 (1.54) |
| Block Design scaled score | 12.65 (1.63) | 15.00 (1.97) |
| EFT response time (s) | 40.53 (17.48) | 22.20 (10.33) |
| EFT errors | 5.00 (2.36) | 2.53 (1.81) |

gender has been included as an additional factor in the analyses.

*Materials and Procedure*

The AQ is a 50-item self-report questionnaire, measuring tendency towards autistic traits (Baron-Cohen et al. 2001). Scores range from 0 to 50. Form A of the EFT was used. Following the EFT manual (Witkin et al. 1971), the reaction-time score was the mean time taken to locate the simple figure over the 12 trials, while the error score was the number of times the simple form was incorrectly traced. The Block Design subscale was administered according to the WAIS-III manual.

Results

The means and standard deviations for the Block Design scaled scores and EFT measures are presented in Table 1. The high AQ group demonstrated higher Block Design scaled scores compared to the low AQ group, $F(1, 35) = 31.47$, $p < .01$, $\eta_p^2 = .23$, indicating that they completed the task faster and/or more accurately than the low AQ group (see Fig. 1a). Males had higher Block Design scaled scores than females, $F(1, 35) = 14.03$, $p < .05$, $\eta_p^2 = .12$, but there was no interaction between AQ group and gender, $F(1, 35) = .16$, $p = .70$, $\eta_p^2 = .00$, on this variable.

The high AQ group was also faster to identify embedded figures than the low AQ group, $F(1, 35) = 10.7$, $p < .01$, $\eta_p^2 = .23$ (see Fig. 1b). Further, the high AQ group completed the EFT with fewer errors than the low AQ group, $F(1, 35) = 11.46$, $p < .01$, $\eta_p^2 = .25$ (see Fig. 1c). There were no main effects or interaction with gender for either EFT variable (largest $F(1, 35) = .13$, $p = .72$, $\eta_p^2 = .00$). The superior performance of the high AQ group on both the EFT and Block Design tasks when compared to the low AQ group is consistent with the pattern of performance seen in individuals with autism and their family members. These AQ differences are independent of gender differences.

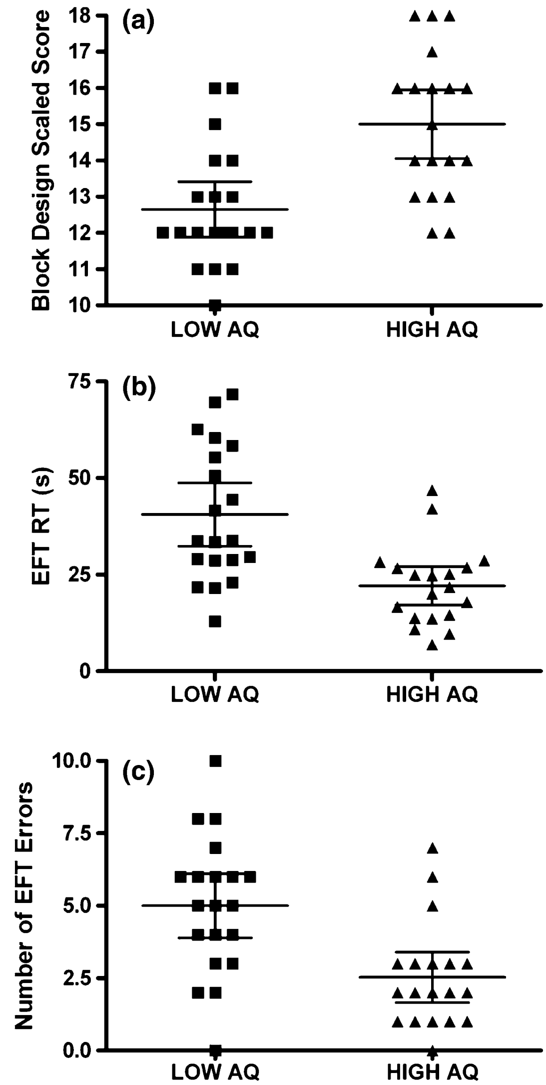


**Fig. 1** Block Design scaled scores (**a**), reaction times on the EFT (**b**), and EFT errors (**c**) for the low and high AQ groups of Study 1 (with horizontal lines depicting the means and 95% confidence intervals)

## Study 2

Given the contrast in results for Kunihira et al. (2006), who found no difference in EFT performance between low and high AQ groups, and Study 1, which did find significant differences in EFT performance between such groups, Study 2 re-examined EFT performance in new samples. Further, since IQ was not assessed in Study 1 or in Kunihira et al. (2006), Verbal and Performance subscales of the WAIS-III were used to investigate whether any group differences in EFT performance were dependent on these facets of general ability. It was predicted that the high AQ group would outperform the low AQ group on the EFT even when IQ was taken into account, since superior EFT performance has been reported for children with autism compared to typically developing children when the groups have been matched on both verbal and nonverbal ability (Pellicano et al. 2006).

## Method

### Participants

A 25-item short version of the AQ[1] (see below) was administered to 571 students, and participants from the top and bottom deciles were invited to participate in further testing, which included administering the full AQ. Table 2 shows characteristics of the high and low AQ groups (which conformed to full-scale AQ scores of 22 or more, and 13 or less, respectively). The groups did not differ significantly in age, $t(33) = .35$, $p = .73$, or gender distribution, $\chi^2(1) = .16$, $p = .69$.

### Materials and Procedure

A short form of the AQ was created for screening purposes based on item information reported in Baron-Cohen et al. (2001): the 25 items showing the largest separation in scores between their autism spectrum disorder and control samples were selected. The AQ data from Study 1 ($N = 548$) showed an acceptable correlation of .86 between full-scale and short-form scores.

Participants selected for the low and high AQ groups completed two verbal (vocabulary and similarities) and two performance (matrix reasoning and symbol search) subscales of the WAIS-III (Wechsler 1997) from which WAIS-Verbal and WAIS-Performance indices were derived. They were also administered the full AQ and the EFT using the procedure described for Study 1.

## Results

Whilst the two AQ groups did not differ in WAIS-Verbal scores, $F(1, 31) = 2.55$, $p = .12$, $\eta_p^2 = .07$, the high AQ group demonstrated superior WAIS-Performance scores relative to the low AQ group, $F(1, 31) = 7.21$, $p = .01$, $\eta_p^2 = .20$. There were no main effects or interaction with gender on the IQ measures (largest $F(1, 31) = 2.35$, $p = .14$, $\eta_p^2 = .07$). Given the significant difference in WAIS Performance reported above for the high and low AQ groups, a median split (cut-off = 24) was used to form high and low groups on WAIS Performance, which was then used in conjunction with the AQ and gender group factors in ANOVAs conducted on the EFT RT and error scores. The means and standard deviations for the EFT measures are presented in Table 2. The analysis of EFT RTs revealed a main effect of AQ group, $F(1, 27) = 7.55$, $p = .01$, $\eta_p^2 = .22$, with high AQ scorers locating the embedded shapes faster than the low AQ scorers (see Fig. 2a). While there was a trend for males ($M = 23.24$ s, $SD = 8.07$ s) to be faster than females ($M = 28.82$ s, $SD = 10.81$ s), $F(1, 27) = 3.30$, $p = .08$, $\eta_p^2 = .11$, there was no significant interaction between AQ group and gender, $F(1, 27) = .18$, $p = .68$, $\eta_p^2 = .00$. No other effects from the ANOVA were significant (largest $F(1, 27) = 1.54$, $p = .22$, $\eta_p^2 = .05$).

**Table 2** Male–female ratio, and means (and SDs) for AQ score, age, WAIS subscale scores, EFT response time and EFT errors for Study 2

| | Low AQ ($N = 20$) | High AQ ($N = 15$) |
|---|---|---|
| Male:Female | 8:12 | 7:8 |
| AQ score | 10.60 (2.26) | 25.80 (4.16) |
| Age (years) | 18.45 (1.64) | 18.27 (1.39) |
| WAIS verbal | 24.35 (4.4) | 26.73 (3.28) |
| WAIS performance | 22.10 (3.45) | 25.47 (3.54) |
| EFT response time (s) | 30.12 (9.17) | 21.52 (9.13) |
| EFT errors | 3.60 (2.84) | 1.80 (1.26) |

With EFT errors, there was a trend for the high AQ group to make fewer errors than the low AQ group, $F(1, 27) = 4.00$, $p = .07$, $\eta_p^2 = .13$, but this effect was subsumed by an interaction between AQ group and WAIS-Performance group, $F(1, 27) = 7.56$, $p = .01$, $\eta_p^2 = .22$. Simple effects t tests indicated that for the high WAIS-Performance group there was no significant difference in EFT errors between high and low AQ scorers (see Fig. 2b). However, for the low WAIS-Performance group, the high AQ scorers made fewer errors ($M = 1.4$; $SD = 1.67$) than the low AQ scorers ($M = 4.77$; $SD = 2.77$), $t(16) = 2.52$, $p < .05$ (see Fig. 2c), while no other effects from the ANOVA were significant (largest $F(1, 27) = 1.21$, $p = .28$, $\eta_p^2 = .04$).

The AQ contains items designed to tap five facets of ASD, including social skills, attention switching, attention to detail, communication abilities and imagination (Baron-Cohen et al. 2001). Therefore, the relationship between EFT RT and each subscale of the AQ was examined. EFT performance was most strongly related to the attention to detail subscale, $r(34) = -.43$, $p < .01$, but also correlated negatively with the communication subscale, $r(34) = -.42$, $p < .01$, and the social skills subscale $r(34) = -.37$, $p < .05$.

[1] Screening could not be conducted with the full-scale AQ because of time restrictions. Nevertheless, the high and low AQ groups selected for Study 2 based on the short-form AQ were comparable to the corresponding groups selected for Study 1 based on the full-scale AQ, since a 2 (Study: 1 vs. 2) × 2 (AQ group: high vs. low) ANOVA conducted on full-scale AQ scores did not show any significant effects involving Study.

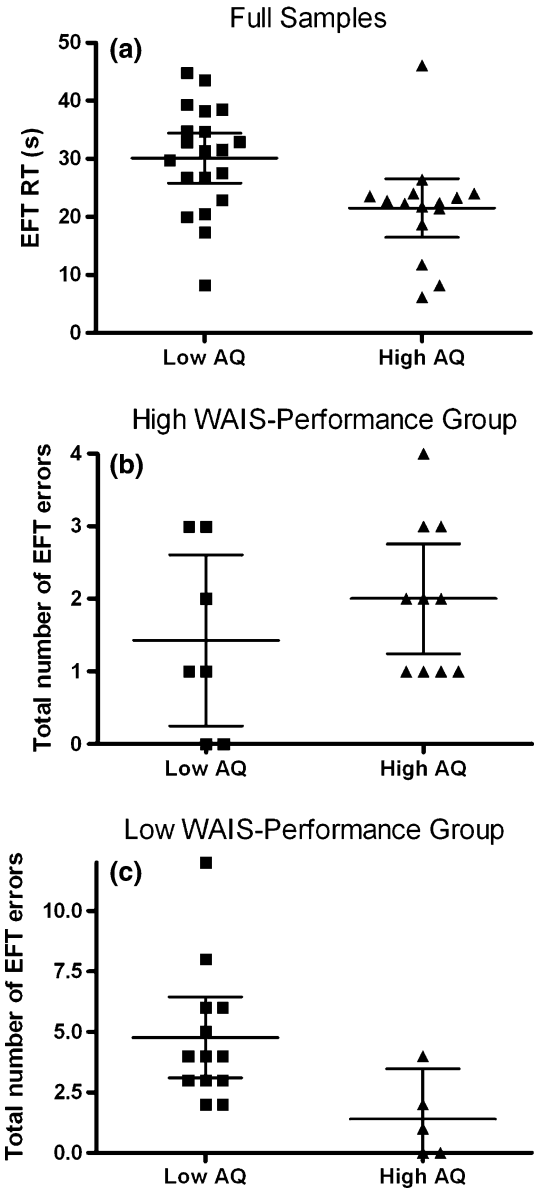


**Fig. 2** Data for the high and low AQ scorers of Study 2, comprising **a** reaction times on the EFT, **b** EFT errors for the high WAIS-Performance group, and **c** EFT errors for the low WAIS-Performance group (with horizontal lines depicting the means and 95% confidence intervals)

## General Discussion

In Study 1, individuals self-reporting more mild autistic traits on the AQ exhibited shorter RTs and fewer errors for the EFT, and also superior scores for the Block Design subscale, relative to individuals reporting fewer such traits. Study 2 replicated the advantage in RT on the EFT for high AQ scorers compared to low AQ scorers, and showed that this difference was independent of both verbal and nonverbal ability. However it was only among those of lower nonverbal ability that fewer errors on the EFT were found for a high AQ subgroup relative to a low AQ subgroup. One interpretation of this final result might be that higher performance-IQ may enable those scoring low on the AQ to be better able to inhibit making an incorrect response to items that partially match the target shape on the EFT (see Gray et al. 2003, for an illustration of the relationship between fluid intelligence and response inhibition). Nevertheless, the RT data demonstrate that the low AQ scorers are still disadvantaged on EFT performance relative to the high AQ group.

The consistent evidence from our studies of an association between higher AQ scores and superior EFT performance contrasts with the report by Kunihira et al. (2006) of the absence of such a relationship. As noted earlier, the Japanese sample used by Kunihira et al. yielded higher AQ scores than both the British sample reported by Baron-Cohen et al. (2001) and the Australian samples used in the present investigation. A consequence of this is that the low AQ group used by Kunihira et al. had substantially higher AQ scores compared to our low AQ groups. Thus, one way to reconcile the conflicting results would be to argue that the differences reported in our studies may reflect especially poor EFT performance in our (more extreme) low AQ groups rather than especially good EFT performance in the high AQ groups. However, when the mean EFT reaction times of our sample are compared to the norms published by Witkin et al. (1971), it seems that this is not the case as the low AQ males and females in the present study performed at levels comparable to these norms, whereas the high AQ groups were faster than the reported norms. Additionally, the aforementioned argument is difficult to sustain given the frequent reports of superior EFT performance for individuals with an autism spectrum disorder compared to individuals of typical development selected from the general population (Edgin and Pennington 2005; Jarrold et al. 2005; Jolliffe and Baron-Cohen 1997; Morgan et al. 2003; Pellicano et al. 2005, 2006; Shah and Frith 1983), since in these studies the control groups were not selected to be especially low in autistic traits. An alternative explanation of the different results is that the nonsignificant outcome reported by Kunihira et al. reflects a Type II error because of low power resulting from the modest magnitude of difference in AQ scores between their high and low AQ groups.[2] Collapsed across males and females, the separation in cutoffs for the two groups was 6.5 AQ units for Kunihira et al. whereas the separation for Study 1 (which also used the full AQ) was 11 units. However there are other differences in methodology for the two investigations and so

[2] It is unlikely that our results reflect Type I errors since two further studies recently conducted by our research group also show superior EFT performance for high AQ scorers compared to low AQ scores.

resolution of the contrasting results would be assisted by a cross-cultural investigation in which multiple AQ samples are tested in each culture, errors as well as RTs are collected for the EFT (note that Kunihira et al. did not report error data), and IQ scores are also obtained.

According to Shah and Frith (1983), individuals with autism show facilitated performance in locating embedded figures owing to a preference for processing parts accompanied by a failure to extract global form, a theory known as weak central coherence (Frith 1989). This cognitive style assumes a lack of distraction by holistic configurations and relative facilitation in dealing with piecemeal components, resulting in a double advantage when locating shapes immersed in a surrounding context. While there is empirical support for this theory at a number of levels (see Happé 1999, for a review), there is considerable debate as to whether autism is characterized by both an advantage in lower-level processing of detail and a limitation in higher-level processing of global form (Happé and Frith 2006; Happé and Booth 2007; Mottron et al. 2006; Plaisted et al. 2003). Since superior EFT performance associated with autism could reflect either enhanced processing of detail or limited processing of global form, our current work is attempting to isolate just which levels of processing in the ventral visual stream are implicated in this exceptional performance in the broader autism phenotype (Grinter et al. 2007, 2008). In Study 2, EFT RT was found to correlate with not just the attention to detail subscale of the AQ—as might be expected if autistic-like traits are best explained by an advantage in processing of detail—but also with the social skills and communication subscales. Of note, the two subscales that did not correlate with EFT RT—attention switching and imagination—were those that were not well supported in a recent factor analysis of the AQ (Austin 2005).This set of correlations suggests some support for a single dimension underlying these three sets of self-reported traits, but some caution is warranted since our method of recruitment did not favor differentiation of scores on the attention to detail, social skills and communication subscales AQ.

Although we are currently unable to specify the precise nature of differences in visual cognition, the results from the present study are consistent with the notion that the phenotype for autism may be broader than the diagnostic symptoms for the condition (Baron-Cohen and Hammer 1997). Establishing whether the profile of strengths and weaknesses in cognition identified for individuals with a diagnosis of an autism spectrum disorder also extends to individuals who report high levels of autistic-like traits is important for several reasons. First, such continuity in cognitive profile would provide another line of support for the concept of an autism spectrum that spans from autism through lesser variants to low levels of autistic traits (Baron-Cohen 2000; Baron-Cohen et al. 2001; Frith 1991). Continuity would also reinforce the view that atypical cognition is a core feature of autism (Morton 2004). Finally, if a cognitive profile characteristic of autism was found to apply to individuals from the general population who report high levels of autistic-like traits, the availability of this latter group would facilitate cognitive and neuropsychological research aimed at better articulating this common cognitive profile and identifying its neural basis.

To conclude, the present research has focused on the suggestion that members of the general population scoring high on measures of autistic-like traits may not have the condition itself, but rather a lesser variant of it, which may occur as a result of carrying or expressing some of the enabling genes (Constantino and Todd 2003). The present findings suggest that this genetic liability may contribute to a pattern of ability in visuospatial cognition that is shared by both individuals who meet diagnostic criteria for autism and healthy individuals who report high levels of autistic-like traits. The similarity in performance and thus cognitive style between high AQ scorers and individuals with autism highlights the potential value of using the AQ for analogue studies of autism in order to enhance our understanding of the autism spectrum.

**Acknowledgments** The authors would like to thank four anonymous reviewers for their comments on an earlier version of this manuscript. This research was supported by NH&MRC Project Grant 403942 to M. T. Maybery, D. R. Badcock, J. C. Badcock and E. Pellicano.

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