Vision Research 51 (2011) 1778–1780

Contents lists available at ScienceDirect

Vision Research

journal homepage: www.elsevier.com/locate/visres

Psychophysical measures of visual acuity in autism spectrum conditions

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ARTICLE INFO

Article history:
Received 6 January 2011
Received in revised form 1 June 2011
Available online 16 June 2011

Keywords:
Autism
Visual acuity
Freiburg Visual Acuity and Contrast Test

ABSTRACT

Previously reported superior visual acuity (VA) in autism spectrum conditions (ASC) may have resulted from methodological settings used (Ashwin, Ashwin, Rhydderch, Howells, & Baron-Cohen, 2009). The current study re-tested whether participants with ($N = 20$) and without ($N = 20$) ASC differ on psychophysical measures of VA. Participants' vision was corrected before acuity measurement, minimising refractive blur. VA was assessed with an ETDRS chart as well as the Freiburg Visual Acuity and Contrast Test (FrACT). FrACT testing was undertaken at 4 m (avoiding limitations of pixel-size), using 36 trials (avoiding fatigue). Best corrected VA was significantly better than the initial habitual acuity in both groups, but adults with and without ASC did not differ on ETDRS or FrACT binocular VA. Future research should examine at which level of visual processing sensory differences emerge.

1. Introduction

Autism spectrum conditions (ASC) are characterized by difficulties in social interaction and communication, alongside unusually narrow interests and highly repetitive behaviour (A.P.A., 1994). In addition, anecdotal reports (Chamak, Bonniau, Jaunay, & Cohen, 2008; Grandin, 1996) and questionnaire studies indicate consistent perceptual differences in ASC (Kern, Grannemann, & Carmody, 2007; Kern et al., 2006; Kern, Trivedi, et al., 2007; Kientz & Dunn, 1997; Leekam, Nieto, Libby, Wing, & Gould, 2007; Tomchek & Dunn, 2007).

There is however mixed evidence as to whether adults with ASC show superior performance on "low-level" visual tasks (Bertone, Mottron, Jelenic, & Faubert 2005; Koldewyn, Whitney, & Rivera, 2006; Simmons et al., 2009; Spencer et al., 2000).

Inconsistent findings have been published regarding visual acuity (VA) in ASC. Milne, Griffiths, Buckley, and Scope (2009) used the Crowded LogMAR test and reported that children and adolescents with ASC show poorer VA compared to typically developing control participants (Milne et al., 2009). Keita, Mottron, and Bertone (2010) have reported similar distance VA in adults with ASC and without measured with Landolt-C optotypes (Keita et al., 2010). Bölte et al. (2011), while not exploring the high acuity domain, also report no difference in VA between adolescents and young adults with and without ASC. In contrast, Ashwin, Ashwin, Rhydderch, Howells, and Baron-Cohen (2009) showed markedly superior VA in adults with ASC using the Freiburg Visual Acuity and Contrast Test (FrACT) (Ashwin et al., 2009). However such "eagle-eyed visual acuity" has proved contentious and two methodological issues were raised (Bach & Dakin, 2009; Crewther & Sutherland, 2009) which inspired us to conduct the current study. First, the Ashwin et al. (2009) study used a viewing distance of 60 cm, a procedure that – given the pixel resolution of the visual display – likely elicited too few errors to allow the FrACT to precisely estimate VA. The present study addresses this issue by testing at a viewing distance of 4 m (where pixel size will not limit acuity measurement). Second, the Ashwin et al. (2009) study used 150 trials, which commentators argued may have caused group-differential fatigue and led to stimulus-unrelated "keypress" errors, which could disproportionately inflate threshold estimates given the low (near-zero) error-rates that result under short viewing distances. Superior VA in ASC could then simply reflect attentional rather than sensory group differences. To test this we again employed the FrACT, but used a reduced number of 36 trials. Finally, uncorrected refractive error may have contributed to the erroneous findings. In the present study participants were refracted prior to assessment to minimise refractive blur.

2. Materials and methods

2.1. Participants

Twenty adults with ASC (11 male, 9 female) and 22 adult controls (14 male, 8 female) with no history of psychiatric conditions

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doi:10.1016/j.visres.2011.06.004

took part. All ASC participants had been previously diagnosed by a qualified clinician using DSM-IV criteria (A.P.A., 1980, 1994). To screen control participants for autistic traits we used the Autism Spectrum Quotient (AQ) questionnaire (Woodbury-Smith, Robinson, & Baron-Cohen, 2005), a short questionnaire measuring autistic traits, with five subscales (social skills, attention switching, attention to detail, imagination and communication) (Baron-Cohen, Hoekstra, Knickmeyer, & Wheelwright, 2006; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). A cut-off AQ score of below 26 was used for the control group (Woodbury-Smith et al., 2005). Two participants in the control group scored above 26 and were therefore excluded from further analysis. In the end 20 adult participants with ASC (11 male, 9 female) were compared to 20 controls (13 male, 7 female). All participants completed the Wechsler Abbreviated Scale of Intelligence (WASI) (see Table 1).

2.2. Visual acuity

Visual acuity (VA) was assessed by a qualified optometrist (KL). Habitual binocular VA was initially assessed with the participant wearing their usual spectacles or contact lenses (if any) for distance vision. VA was assessed using the standard ETDRS eye-chart (Ferris & Sperduto, 1982), at a 3 m distance with VA scored on a letter by letter basis (Hazel & Elliott, 2002). Each participant was refracted and best-corrected visual acuity (BCVA) was then assessed with an alternative ETDRS chart.

VA was then measured using the FrACT (version 3.4.3, <http://michaelbach.de/fract/>) (Bach, 1996) with participants wearing the best correction as determined by refraction. A Dell Precision 690-Intel Xeon 5050 computer with an Nvidia Quadro FX3500 graphic card was used for stimulus presentation. The observer distance was set at 4 m. Threshold was determined by the "Best Probability Estimation of Sensory Threshold" (PEST) staircase routine, with threshold set to DIN/ISO corrected (67% correct) for comparison to other acuity measures. The number of trials was set to 36, with an "easy trial" every 6th item. Thirty trials correspond to the default number of trials of the FrACT. The time-out duration was set to 10 s. Auditory feedback was not used.

The Cambridge University Psychology Research Ethics Committee approved the study and all participants gave written informed consent before taking part in the study.

3. Results

3.1. Descriptive statistics

SPSS 16 was used to analyse the data. As expected, the AQ scores differed significantly between the two groups ($t(37) = 8.54$, $p < .01$). Sex ratios (Pearson Chi-Square (1) = .41, $p = .51$), age ($p = .60$) and IQ ($p = .51$) were not significantly different between groups. Lastly, tests of normality (Kolmogorov–Smirnov test; KS) showed that VA values were normally distributed and thus parametric tests were used ($p = .20$).

Table 1
Descriptive characteristics of the groups.

Participant characteristics	ASC group	Control group
N	20	20
Sex ratio (f:m)	9:11	13:7
Mean age in years (SD)	30.4 (10.0)	30.7 (10.1)
WASI-IQ (SD)	109.2 (18.1)	112.5 (10.6)
AQ (SD) (range from 0 to 50)	36.8 (9.1)	17.2 (4.5)

Abbreviations: AQ = Autism Spectrum Quotient, ASC = Autism Spectrum Condition, f = female, m = male, *N* = number of participants, WASI = Wechsler Abbreviated Scale of Intelligence, IQ = Intelligence Quotient, SD = standard deviation.

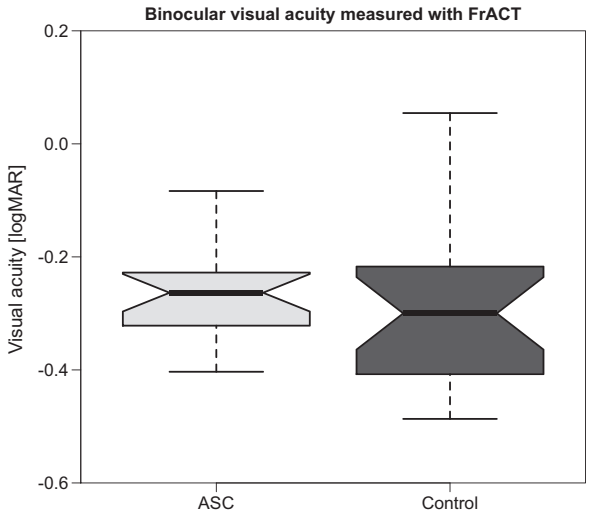

Fig. 1. The bars represent the experimentally measured visual acuity using the Freiburg Visual Acuity and Contrast Test (FrACT). Visual acuity is expressed in logMAR. The antennas are the standard error of the mean (SEM, calculated from logarithmised VA). There was no significant differences between the two groups ($p > .05$).

3.2. Visual acuity

Repeated measure multivariate tests showed that best corrected visual acuity (−0.17 ± .09 logMAR, 20/13 Snellen) was statistically significantly better than the initial habitual acuity (−0.13 ± .1 logMAR, 20/15 Snellen) ($F(1, 37) = 23.33$, $p < .01$). The difference between habitual and corrected vision did not differ between groups ($F(1, 37) = 0.78$, $p = .38$). Clinical examination revealed that one control participant had strabismic amblyopia and two control and two ASC participants had anisometropic amblyopia (amblyopia defined as >2 lines difference in best-corrected VA between eyes and a VA in the poorer eye of worse than +0.20 logMAR). All other subjects were binocularly normal and refraction was achieved in all cases.

Multivariate tests showed that best corrected ETDRS and FrACT visual acuities did not differ between the groups ($F(2, 37) = .50$, $p = .60$). There was no significant difference between ASC (−0.15 ± .07 logMAR, 20/14 Snellen) and control (−0.18 ± .1 logMAR, 20/13 Snellen) groups' best corrected binocular ETDRS acuity ($F(1) = .46$, $p = .49$). The mean FrACT binocular acuity also did not differ between the ASC group (−0.27 ± .08 logMAR, 20/11 Snellen) and the control group (−0.28 ± .14 logMAR, 20/10 Snellen) ($F(1) = .85$, $p = .36$) = 0.27, $p = .79$) (see Fig. 1).

4. Discussion

We set out to resolve a debate over superior visual acuity (VA) in ASC by investigating psychophysical measures of VA in adults with and without autism spectrum conditions (ASC). Adults with and without ASC did not differ significantly in visual acuity in terms of either ETDRS or FrACT measures.

In the Ashwin et al. study (2009) the viewing distance of 60 cm was incompatible with the monitor resolution and could not allow for the accurate measurement of visual acuities due to pixel resolution limits. In the current study we used an ISO-norm compliant viewing distance of 4 m. Both groups in the present study had excellent VA, corresponding to 6/3 or 20/10 in Snellen notation. While these values appear high, they are typical if acuity is tested according to good psychophysical practice (Arditi & Cagenello,

1993), which is also prescribed by the international acuity norm EN ISO 8596.

Second, in the present experiment a qualified optometrist corrected each participant's vision before acuity measurement. The improvement in VA by refraction, whilst statistically significant, was small and not clinically relevant as test–retest reliability with ETDRS charts is ± 0.14 logMAR (Hazel & Elliott, 2002). Refraction, while a possible confound, is unlikely to have been a major factor in explaining Ashwin et al.'s findings (Ashwin et al., 2009).

Lastly, as the present study reduced the number of trials from 150 to 36 (including the six motivation trials), it is possible that the previous study finding superior VA in ASC is related to the ASC group making fewer errors under more fatiguing test conditions. Future research could examine the role of attention.

We conclude that there is no experimental evidence for superior visual acuity in ASC. However perceptual differences in ASC are a robust phenomenon as reported anecdotally and measured by questionnaires. Thus future research should examine at which level sensory differences in ASC emerge.

5. Financial disclosures

T.T. was supported by the Pinsent Darwin Trust and Autistica during the period of this work. S.B.C. was supported by the MRC UK. S.C.D. was supported by the Wellcome Trust. This work was conducted in association with the NIHR CLAHRC for Cambridgeshire and Peterborough NHS Foundation Trust. The authors of this paper report no biomedical financial interests or potential conflicts of interest.

Acknowledgments

We are grateful to the participants for their generous cooperation and to Bonnie Auyeung, Bhismadev Chakrabarti, Michael Lombardo, Caroline Robertson, Emma Ashwin and Chris Ashwin for valuable discussions.

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