CORRESPONDENCE

Regarding "Eagle-Eyed Visual Acuity: An Experimental Investigation of Enhanced Perception in Autism"

To the Editor:

Low-level perceptual abnormalities are increasingly seen to play an important role in some features of autistic spectrum disorder (ASD) (review [1]) by contributing to impairments of social communication through limiting higher-level visual processing of faces, for example. Arguably the most interesting findings are that individuals with ASD can sometimes perform better than matched control subjects when the task involves attention to detail (e.g., in visual search [2], finding hidden figures [3], or resisting the influence of context within illusions [4]), suggesting that ASD might be associated with enhanced processing of local information (2). A recent article by Ashwin *et al.* (5) has suggested that enhanced perceptual processing in ASD might include superior visual acuity (VA), a measure of individuals' ability to identify symbols of a set size (5 arc min width) presented foveally at standardized viewing distances. Specifically, Ashwin *et al.* report mean decimal visual acuities of 2.79 in their group of observers with ASD and 1.44 in an age-matched control group (VA is typically expressed as a fraction with the numerator referring to the distance at which the subject can just identify the letter, and the denominator the distance at which an observer with standard VA could identify the same letter; although, by definition, "normal" acuity must be 1.0 [or 20/20 = 6/6 in Snellen notation], when measured with good psychometric procedures [6], young adults have a median acuity of 1.6 [7]) If true, Ashwin *et al.*'s finding would be very important for two reasons. First, as far as we are aware, this is the first report of consistently superior VA in any clinical population (neuropsychological or otherwise). Second, VA is generally considered limited by the earliest stages of the visual system (i.e., optical properties of the eye, photoreceptor density) so that this result would suggest either that: 1) this is not true, acuity is limited by other (higher level) factors; or 2) there are structural differences in the eyes of observers with ASD. The authors consider both possibilities by suggesting that either higher number of foveal cone cells or higher numbers of dopamine receptors at the retinal or neural level could contribute to their findings.

Prompted by the highly counterintuitive nature of both these conclusions and the finding that inspired them, we have investigated the procedure employed by the authors of this study (one of us—MB—developed the computerized acuity test [Freiburg Visual Acuity & Contrast Test (FrACT)] used by Ashwin *et al.*). We report that although there are real behavioral differences between ASD and control groups, technical limitations in the procedure used to measure acuity call into question the conclusion that people with ASD have higher acuity compared with unaffected individuals without the context of the experiment.

We begin by considering the technical details and limitations of the acuity testing system employed and then describe the specific chain of events in the experiments reported that led to estimates of VA that—we contend—are gross overestimates of performance in the ASD group. We conclude by offering a hypothesis as to why, if observers with ASD do not have superior acuity, they might have outperformed control subjects on this task.

The Freiburg Visual Acuity (and Contrast) Test and Its Limitations. Ashwin *et al.* used the "Freiburg Visual Acuity (and Contrast) Test", which is well-suited to formal studies, because it reduces subjective influences compared with routine clinical tests. The test was first described in 1996 (8) and has subsequently been evaluated under a wide range of conditions. It was programmed with the "Flash" development environment (Adobe Systems, San Jose, California) and is available free of charge online at http://www.michaelbach.de/fract/ (9) for the Linux, Macintosh, and Windows platforms.

Acuity measurement with the FrACT involves subjects identifying the orientation (up, down, right, left) of a Landolt-C of various sizes. The size of the letter is controlled by an adaptive psychophysical staircase (Best PEST [10]), and acuity is defined at a size where a performance criterion is reached (62.5% for a 25% guessing rate). The minimum size of the Landolt-C is typically expressed in terms of the gap width of the letter, expressed as a visual angle (measured in minutes of arc). Because the standard letter-size for acuity is 5 arc min width and because the gap within a Landolt C is one-fifth the width, a decimal acuity of 1.0 corresponds to a threshold gap size of 1 min of arc.

When rendering the letter on a computer screen, the discrete pixel raster limits what can be displayed (11). The FrACT is calibrated by entering: 1) the viewing distance of the observer (Ashwin *et al.* selected 60 cm; the default is 400 cm); and 2) the length in millimeters of a 700 pixel-long on-screen ruler (Ashwin *et al.*'s measurement was 170 mm; private communication, December 2008). Thus, the size of a pixel was 170/700 = .243 mm (typical for current monitors) or, in minutes of arc of visual angle:

$$60 \times 2 \times \arctan(\text{pixel width}/[2 \times \text{distance}])$$

$$= 120 \times \arctan(.243/1200) = 1.39 \text{ arc min}$$

If the gap size were 1 pixel (a reasonable minimum to allow a C to be rendered on a 5 × 5 pixel grid), this would correspond to a decimal acuity of 1/1.39 = .72. To put it another way, if one sets 1 pixel as the minimum displayable gap, the best acuity one could estimate viewing the screen at 60 cm would be .72. This limitation is clearly displayed in the preferences screen of FrACT when entering the distance or the ruler length.

The gap in a Landolt-C can be smaller than 1 pixel through the use of anti-aliasing, which trades luminance resolution for spatial resolution (12); this technique is used in FrACT by means of the built-in graphics renderer of Flash. In the version of FrACT used by Ashwin *et al.* (v1.3), the smallest pixel size was limited to .5, corresponding at 60-cm distance to a decimal acuity of 1.44; stimuli smaller than this were never presented to subjects in the Ashwin *et al.* study simply because rendering a "C" on < a 2.5 × 2.5 pixel array is not realistic. To have challenged subjects who really had acuities approximately 2.8 (the mean reported value for the ASD group), one would have needed to display the entire C with a 1.2 × 1.2 pixel grid (!).

Clearly, given an insufficiently long viewing distance, the use of FrACT to measure acuities above 1.0 is not ideal (e.g., 1.44 in the control group), and above 1.44 (2.79 in the ASD group) will give estimates that are determined by factors unrelated to VA. Why would FrACT report high VAs, given the technical limitations described? With details of the program settings provided to one of us (MB) by the authors, the situation was reconstructed and a technical explanation was derived.

Chain of Events Causing Artifactual Acuity Results. The relevant setting parameters made by Ashwin *et al.* in FrACT were:

1. Observation distance: 60 cm.

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2. Threshold definition: not set to the default ("DIN/ISO corrected") that reduces acuity estimates by 10% to account for the difference between descending threshold procedures (widely used in an optometry/ophthalmology environment) but to a "psychometric" procedure that reports exactly the steepest point of the psychometric function. Consequently, acuities will be 10% higher than if obtained with standard procedures, (e.g., ETDRS [Early Treatment Diabetic Retinopathy Study]) (13).
3. The number of trials (default is 30) was increased to 200.
4. Permissible period subjects might fail to respond before being "timed-out". The default (30 sec) was reduced to 3 sec.
5. "Post hoc max. likelihood analysis" set to "on" ("off" by default). This procedure estimates not just the threshold but also the slope of the psychometric function. On average, this analysis has no effect on VA estimates under normal operating conditions (14), but in this instance something else happened. Because of the short viewing distance, FrACT operated at its ceiling (smallest possible gap; .5 pixels or .69 arc min). Assume a diligent subject achieved 200 correct trials at an acuity of 1/0.69 = 1.44. Now the post hoc analysis would extrapolate from these data, assuming a standard psychometric function, to the threshold estimate. This results in a higher estimate of acuity because, given error-free data that do not constrain the psychometric function properly, the more correct trials one achieves at the easy stimulus-level, the more confident the procedure becomes that this level is located further into the tails of the psychometric function (i.e., the threshold must be lower). Reactivating the FrACT version used by Ashwin *et al.*, we found that, with no error in 200 trials, FrACT would report 3.56 as VA estimate; with 1 error in 200 trials, this would drop to 1.84—with 2 errors to 1.65, and so forth.

Errors are what drive psychophysical estimates of performance; when subjects do not make errors, VA measures so derived (beyond the operating range of FrACT) are largely meaningless with respect to acuity (as a consequence, FrACT now includes stronger warnings when exceeding its operating range), and we propose that this is specifically why Ashwin *et al.* obtained results that were so high. Subjects with ASD were not able to identify smaller letters than the control group; they were less prone to make errors at categorizing letters presented near their acuity limit. Our analysis has shown that the results reported by Ashwin *et al.* are consistent with patients with ASD essentially making no random errors (i.e., errors unrelated to the stimulus) and control subjects making 1–2 random errors, in a run of 200 trials (the latter being consistent with typical lapse rates for psychophysical experiments). Thus, we suggest that Ashwin *et al.*'s results are attributable to patients with ASD exhibiting a slightly lower lapse rate and that this reflects a difference in strategy arising from any number of possible cognitive factors (e.g., that patients with ASD are less prone to distraction during the experiment). Alternatively, it is known that patients with ASD are less prone than unaffected subjects to alter a stereotypical response strategy when achieving consistently high levels of performance (15). We speculate that this more rigid adherence to a successful strategy might have contributed to the patients' success at performing the letter identification task, compared with unaffected observers who might have been more prone to testing new strategies, which risked failure on a few trials. This suggests interesting research opportunities for understanding perseverance in ASD.

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