ORIGINAL ARTICLE

The Influence of Subclinical Autistic Traits on Binocular Functions

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ABSTRACT

Introduction: Autistic trait is autistic-like behaviour that presents in individuals without autism diagnosis (subclinical), which can be quantified using the Autism Spectrum-Quotient questionnaire (AQ). Individuals with high autistic traits have been reported to show altered visual perception similar to that found in autistic people. However, it is unknown whether a similar pattern will be observed in clinical measures of vision. Therefore, this study aimed to investigate whether binocular functions are affected by the level of autistic traits in the subclinical population. **Methods:** A cross-sectional study was conducted at a single eye centre to compare binocular functions between low AQ (scores below 15) and high AQ groups (scores above 20). 30 participants were recruited for each group via purposive sampling. Five binocular functions were evaluated: amplitude, lag, facility, and relative accommodation as well as near-point-of-convergence. **Results:** TPositive relative accommodation (PRA) was significantly higher in the high AQ group (Mdn = -3.50DS) compared with low AQ group (Mdn = -3.00DS) (U = 234, z-score = -3.313, p = 0.001). However, other binocular functions tested did not differ significantly between the groups (p>0.05) despite a trend towards slightly remote near-point-of-convergence observed high AQ group. **Conclusion:** The binocular functions tested in this study do not seem to be affected by the level of autistic traits, except PRA. Findings in this study may have implications towards the understanding of autistic traits and also benefit the clinicians when testing people with high autistic traits.

Keywords: Autistic traits, Accommodation, Autism Spectrum-Quotient (AQ), Binocular vision, Convergence

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INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by problems in social interaction and communication together with the presence of repetitive and stereotyped behaviours. The neurodevelopmental problem in autism does not only affect their social ability but also their senses as their brain processes sensory stimuli differently. This has resulted in sensory symptoms that are commonly reported in autism such as hyperstimulation or hypostimulation by the environment; for example, a light that is bearable to a typically developing individual will seem to be too bright to them.

Autistic traits are suggested to exist in a continuum and expand into the general population, with autistic people laying on the upper range of the scores which can be assessed using a self-administered questionnaire such as the Autism Spectrum Quotient (AQ) (1). Although the average score in the non-clinical population has been suggested as 16.40 (2) while the autistic people are typically at the upper end of the range, there is some overlapping in the scores between the groups; non-clinical population who do not have autism diagnosis may obtain high scores suggesting high autistic traits (subclinical autistic traits) (3). High subclinical autistic traits are not restricted to only family members of autism, but can also be found in the general population; though more common in the former (4,5).

Research has shown that individuals with high autistic traits (thereafter referred to as high AQ) have been reported to exhibit autistic-like characteristics in visual processing compared with individuals with lower autistic traits (low AQ). This includes reduced sensitivity in recognizing emotion (6,7), abnormal sensory

experiences (8,9), superior visual search ability(10–12) as well as atypical biological motion processing (13). These atypical visual perceptions have been suggested to result from local processing bias and a relative reduction in global percept similar to autism, perhaps to a lesser degree (10,14).

In addition to atypical visual perception, a higher prevalence of ocular conditions such strabismus (15), refractive errors (16) and reduced binocular functions (17) have also been reported in individuals with autism. Binocular functions are the ability of the two eyes to work together when performing near tasks such as reading. This can be divided into two components which are accommodation and vergence functions. A recent study by Ankatell et al. (18) had compared accommodative functions between autistic and typically developing children. They reported that the autistic children showed a higher lag of accommodation and a slight reduced in near point of convergence (NPC) with habitual corrections. These indicate that their eyes were under focussed when looking at near targets, therefore reducing the quality of near vision.

Although individuals with subclinical autistic traits have been reported to inherit the atypical visual perception seen in autism, it is unknown whether a similar pattern will be seen in the clinical measures of vision too. Therefore, this study aimed to investigate whether binocular functions, one of the important clinical measures of vision, is affected by the level of autistic traits. To answer this, this study compared four accommodation functions and NPC between individuals with low and high AQ scores without an autism diagnosis (subclinical group). It was hypothesized that accommodation function and NPC might be affected in high AQ individuals when compared with low AQ; similar to perceptual tasks findings reported in earlier studies.

MATERIALS AND METHODS

Study design and sample

This study was a cross-sectional study, conducted at the eye centre of a private university in Selangor, Malaysia. Data were collected between January to December 2019 by two final year optometry students, under the supervision of clinical optometrists at the eye centre. N.A measured convergence function, while A.S. measured accommodation function on all participants to ensure the examinations carried out were consistent for all participants for a particular test.

One hundred AQ questionnaires were distributed to the patients attending the eye centre to screen and find individuals with the desired AQ scores for the study. To minimize bias, the study was conducted double-blind, where the questionnaire was administered online and the scores were only accessible to S.S. Based on the scores, S.S. filtered patients with AQ score of below 15 and above 20 and informed the examiners the shortlisted patients to enrol in the study for further examination. This was to ensure that the scores were unknown to the examiners at the time of the data collection.

Participants were recruited via purposive sampling with specific inclusion criteria; obtain AQ scores within the specific range set for each group (2), have a minimum of 6/6 visual acuity, have no history of ocular trauma and surgery, and no active ocular disease. These criteria were decided to exclude other possible causes of abnormal binocular vision findings.

Of one hundred samples answering the AQ questionnaire, thirty participants who met the inclusion criteria were recruited for each low and high AQ groups. The study was conducted according to the Declaration of Helsinki and was approved by the ethical committee of the university where the data collection was carried out (ethical approval number: MSU-RMC-02/FR01/02/L1/042).

Autistic Traits

The level of autistic traits of the participants was measured using an online version of Autism-Spectrum Quotient (AQ) (1) in the form of Google Form to ease the recording process. The questionnaire comprised of five different skills which include social skills, attention switching, attention to details, communication and imagination. The questionnaire was administered according to the authors' recommendations; the participants were asked to choose between four options ranging from strongly agree to strongly disagree for all 50 questions, which was then scored in binary form; two of the answer options will receive 1 point indicating autistic-like characteristics and the other two will receive 0 point. Participants with total scores of below 15 and above 20 were then grouped into low and high AQ groups respectively. These were decided as the cut-off scores for each group which were deemed achievable in order to get enough samples considering the mean score of 16.94 reported among subclinical population (2).

Clinical Measures of Vision

The clinical measures of vision compared in this study were binocular functions. Five tests were performed to evaluate accommodation and vergence functions; amplitude of accommodation, lag of accommodation, facility of accommodation, relative accommodation and NPC. All procedures were conducted with participants' habitual correction and performed according to the standard optometric testing procedures. These were repeated three times and the average values were taken for data analysis.

Accommodation Function

The amplitude of accommodation (AA) was tested to measure the nearest point at which the participants can accommodate (focus) to see things. This indicates the

maximum ability of the crystalline lens to increase in size and focus at near. AA was tested with the Royal Air Force (RAF) Rule (Haag Streit, Essex, United Kingdom) with a word at N5 line as the target. Participants were asked to look at the word and try to keep it clear while the examiner pushed the target towards their nose. The point (in diopter) at which the participants reported first sustained blur was recorded as the AA. The measurement was taken for each right and left eye, as well as binocular (both eyes open).

The second accommodation test conducted was the facility of accommodation to measure the flexibility of the crystalline lens in changing focus. This was tested using a flipper lens that has a pair of convex (+2.00D) and concave (-2.00D) lenses. With the flipper lens placed in front of the eyes, participants were asked to read a reading chart and flip the flipper lens (to change the lens) whenever the words became clear. The number of flips made per minute was taken as the reading. This was tested monocularly on each eye (while the other been occluded) as well as binocularly.

The third accommodation test conducted was the lag of accommodation which indicate the accommodative accuracy during the near task. This was tested using a standard optometric technique called Monocular Estimation Method (MEM) using a retinoscopy to evaluate the reflex during a near task. Participants were asked to read the words written on a MEM card which was attached to the examiner's retinoscopy placed at 40cm away. The examiner neutralized the retinal reflex separately for each eye while the participants were reading the words. The power required to neutralize the reflex was taken as the amount of lag of accommodation of the person.

The fourth accommodation test conducted was relative of accommodation test which includes Negative Relative Accommodation (NRA) and Positive Relative Accommodation (PRA) measurements. In both measurements, participants were instructed to hold a near chart at 40cm and look at a target on a near chart. For NRA measurement, while participants were looking at the target, the examiner added plus lenses binocularly in +0.25D increments until the first sustained blur or diplopia was reported. On the other hand, for PRA measurement, minus lenses were added instead until first sustained blur or diplopia was reported.

Near point of convergence (NPC)

NPC was tested to measure the nearest point the participants can converge with the two eyes while performing near tasks. This was tested with the RAF Rule (Haag Streit, Essex, United Kingdom) using the line and dot targets. Participants were asked to look at the dot and maintain fusion while the examiner pushed the target towards their nose. Point (in cm) at which the participants reported double or one of the eyes deviated out was recorded as the break point.

Statistical Analysis

Data analysis was conducted using IBM SPSS version 27.0. The participants were grouped into different AQ groups based on the AQ score before the data been analysed. This was done by one of the authors who did not involve in the data collection to reduce bias. Demographic characteristics of the participants in each group, including the AQ scores were summarized using descriptive statistics.

Shapiro-wilk test was used to determine whether the variables were normally distributed. AQ score between the groups was compared using an independent t-test to ensure that the two groups had significantly different level of subclinical autistic traits. All measurements were compared between the two groups using the Mann-Whitney U test since the variables were not normally distributed. All analysis conducted were two-tailed, with an alpha level set at 0.05 significance level.

RESULTS

All participants were between 21-26 years old, with no significant difference found in age between the groups ($t(58) = -1.844$, $p = 0.071$). Independent t-test showed that the AQ score was significantly higher in the high AQ compared with low AQ group ($t(58) = -16.713$, $p<0.001$). Demographic data including the AQ scores for each group are summarized in Table I.

Table I: Demographic data of the participants for each AQ group

	Low AQ group (n = 30)	High AQ group (n = 30)
Age	M= 22.20 (SD=0.93)	M=22.77 (SD=1.41)
AQ score*	M= 12.80 (SD=2.07)	M=26.87 (SD=4.12)
Gender		
Female	23	20
Male	7	10
Race		
Indian	6	4
Malay	24	26
Education	Health-science undergraduate students	

AQ = Autism Spectrum Quotient; Low AQ group = Participants with total AQ score of below 15; High AQ group = Participants with total AQ score of above 20. M and SD represent mean and standard deviation of the samples respectively. Asterisk (*) indicates that the AQ score was significantly different between the groups ($p<0.001$).

Results showed AA was not significantly different between the groups for right eye ($U = 298$, z-score = -2.281, $p = 0.230$), left eye ($U = 478$, z-score = 0.419, $p = 0.675$) as well as binocular AA ($U = 390$, z-score = -0.907, $p = 0.364$). In addition, no group difference

Table II: The amplitude of accommodation and facility of accommodation in low and high AQ groups

		Low AQ group (n = 30)	High AQ group (n = 30)
Amplitude of accommodation	Right eye	Mdn = 12.00 D (IQR=4)	Mdn = 11.33 D (IQR=2)
	Left eye	Mdn = 11.00 D (IQR=4.50)	Mdn = 10.00 D (IQR=2)
	Binocular	Mdn = 12.00 D (IQR=6)	Mdn = 11.00 D (IQR=3)
Facility of accommodation	Right eye	Mdn = 11.00 D (IQR=4)	Mdn = 11.00 D (IQR=5)
	Left eye	Mdn = 13D (IQR=6)	Mdn = 11.00 D (IQR=3)
	Binocular	Mdn = 10.00 D (IQR=4)	Mdn = 10.00 D (IQR=3)

AQ = Autism Spectrum Quotient; Low AQ group = Participants with total AQ score of below 15; High AQ group = Participants with total AQ score of above 20. Mdn and IQR represent median and interquartile ranges of the samples respectively.

was also observed in facility of accommodation on right eye (U = 350, z-score = -1.507, p = 0.132), left eye (U = 360, z-score = -1.345, p = 0.179) and binocular facility (U = 470, z-score = 0.300, p = 0.764) (Table II). Similarly, Mann-Whitney test showed no difference in lag of accommodation between the groups, although high AQ group showed a slightly lesser lag of accommodation in both eyes (right eye: U = 382, z-score = -1.018, p = 0.309; left eye: U = 352, z-score = -1.463, p = 0.143) (Figure 1).

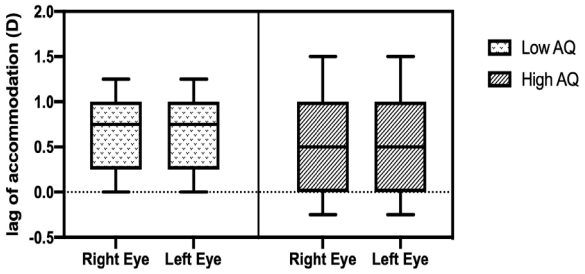

Fig. 1: Box plot of the lag of accommodation in low and high AQ groups for each eye.
Group difference was not significant for lag of accommodation for both eyes. AQ = Autism Spectrum Quotient; Low AQ group = Participants with total AQ score of below 15; High AQ group = Participants with total AQ score of above 20.

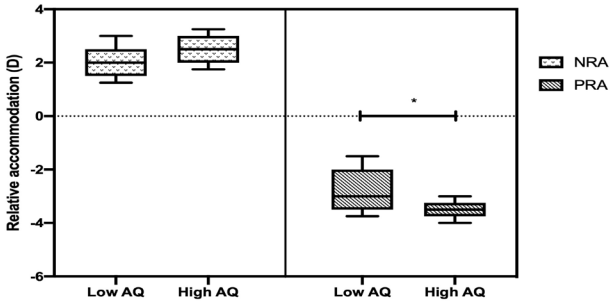

Fig. 2: Box plot of the relative of accommodation in low and high AQ groups.
The group difference was significant for positive relative accommodation (PRA)* (p<0.05). AQ = Autism Spectrum Quotient; Low AQ group = Participants with total AQ score of below 15; High AQ group = Participants with total AQ score of above 20.

In contrast, relative accommodation was slightly lesser in low AQ compared with high AQ group (Figure 2). However, the group difference was only significant for PRA (U = 234, z-score = -3.313, p = 0.001), and not for NRA (U = 552, z-score = 1.573, p = 0.116).

On the other hand, NPC results showed a trend towards reduced convergence in high AQ (M=7.23, SD=1.54) where the point was more remote compared with low AQ groups (M=5.67, SD=3.27); this difference was however not statistically significant in our study (U = 470, z-score = 0.308, p = 0.758).

DISCUSSION

This study aimed to investigate whether autistic traits influence binocular functions by comparing binocular functions between low and high AQ groups. We hypothesized that high AQ group might show reduced binocular functions compared with low AQ group, similar to that reported in autism studies. However, of all the binocular functions tested, significant group difference was only observed in PRA, where high AQ group showed a higher PRA value than low AQ group. Although other clinical measures did not differ significantly between the groups, a similar trend to that of the autistic group was also observed with NPC in high AQ group.

A high PRA value indicates that the person is able to tolerate more negative lenses introduced by the examiner, by exerting more accommodation to maintain a clear vision. Although high values of relative accommodation are usually less worrying for the clinicians compared to low values, a high PRA value may partly indicate adaptive response to convergence weakness (19, 20). Despite no studies have previously investigated relative accommodation in autism, a study investigating vergence function in this group had reported that base-out prism fusion (convergence) was significantly lower in autistic children; which was not found with a base-in prism (divergence) (17). These are indicative of a rather weaker convergence ability, which also accords with our findings of high PRA value. Even though this study did not measure fusional vergence, relative accommodation findings serve as an indirect evaluation of the vergence system, suggesting that high AQ individuals may inherent convergence weakness similar to that found in autism.

In support of the association between a high PRA value with convergence insufficiency (21), a trend towards reduced NPC in high AQ group was also observed in this study; supporting a rather weaker convergence in this group. Previous work by Milne et al. (17) and Anketell et al. (18) had reported reduced NPC in autistic children. Besides, Milne et al. (17) also reported that the group difference found had missed significant when

they excluded children with low-functioning autism in a separate analysis; indicating that the autism severity may influence NPC. High AQ individuals without autism like participants in this study are expected to exhibit some autistic-like characteristics to some extent, yet, of a milder version than those with an autism diagnosis; hence not diagnosed with autism. This might explain the non-significant group difference found in this study, despite a similar trend observed to that of previous work; as high AQ individuals are milder than high-functioning autism participated in autism studies.

Findings in this study suggest that subclinical autistic traits do not only influence performance in perceptual tasks, but also certain clinical measures of vision (particularly convergence ability) perhaps to a lesser degree to that of autistic individuals. Both accommodation and convergence are crucial in near tasks to ensure comfortable and clear vision at near; however, this is expected to become weaker with age. Since all participants in both groups were young adults, they might still have a strong convergence, and therefore showed normal NPC (< 8cm). However, a trend towards a slightly remote NPC in high AQ group reported in our study might foresee that age-related reduction in convergence could happen sooner in this group as they age. This finding would be helpful to alert clinicians when examining someone with high AQ, such as relatives to individuals with autism.

Moreover, findings reported in this study may also have implications towards our understanding of the nature of autistic traits. A study examining autopsy of an autistic brain and rat embryos exposed to the autism-linked teratogen had reported anatomical changes to the brainstem (22). This has been suggested to underpin the reduction in accommodation and vergence functions in autism (18). In contrast, a study examining the brain of individuals with subclinical autistic traits found no association between the structure of the brain and AQ, suggesting the absence of anatomical difference in the subclinical group (23). Instead, atypical processing of the visual information has been reported in this group where aberrant visual evoked potentials (VEPs) responses were obtained when measured over ranges of luminance contrasts, indicative of functional differences with different levels of autistic traits (24). This perhaps explains the absence of group difference in most binocular functions measured in this study, as anatomical changes are more likely to cause this rather than functional changes.

Taken together, findings reported in this study have therefore shed some light on the nature of autistic traits. It is possible that in a milder version of autism such as individuals with subclinical autistic traits, the functional difference of the brain that drives the autistic-like behaviours, rather than the anatomical difference. It seems that individuals with high autistic traits may inherit the way the autistic brain processes information (functional aspect) to some extent, but without the anatomical changes to the brain; hence the high AQ score without an autism diagnosis. This may also explain the absence of group difference observed (in addition to other factors) in certain studies comparing perceptual tasks between different levels of autistic traits. It can be concluded that different tasks taping at different brain mechanisms might yield different results, depending on whether the mechanisms underlying the tasks are disturbed in individuals with high autistic traits.

One of the limitations of this study was the small size of the sample which was limited by the sampling area and duration of the study; within a single private university only. If a larger population can be screened, a larger number of participants meeting the criteria of low and high AQ may be obtained to increase the sample size. Besides, the AQ distribution of the participants in our low AQ group was not at the lowest end of the range, which possibly lessens the group differences found in this study. Since only young adults involved in this study, it is unknown if the group differences are more significant in older participants as binocular functions will reduce with age. Therefore, a future study examining older population would be useful to see whether high AQ groups will be more affected as they age.

CONCLUSIONS

In conclusion, this study reported that high AQ group does inherit a similar pattern to that observed in autistic individuals in only one binocular function measured in this study, particularly convergence ability, but to a lesser degree. This would be useful to alert clinicians on what to look for during vision testing, particularly when testing individuals that are likely to have high autistic traits such as family members of individuals with autism. Besides, our findings also support that functional instead of the anatomical difference of the brain may have driven the autistic-like characteristics in the subclinical population.

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