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Young adults with autism spectrum disorder show normal attention to eye-gaze information: Evidence from a new change blindness paradigm

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Running head: Autism and Social Change Detection

## Abstract

Other people's eye gaze is a powerful social stimulus that captures and directs visual attention. There is evidence that this is not the case for children with autism spectrum disorder (ASD), although less is known about attention to eye gaze in adults. We investigated whether young adults would detect a change to the direction of eye-gaze in another's face more efficiently than a control change (presence/absence of spectacles). A change blindness method was used in which images showing faces formed part of a complex, naturalistic scene. Results showed that adults with ASD, like typically developing controls, were faster and more accurate at detecting eye-gaze than control changes. Results are considered in terms of a developmental account of the relationship between social attention and other skills.

Key words: social attention; change blindness; eye-gaze direction; autism

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The social aspects of a visual scene rapidly attract our attention. People typically show enhanced visual attention to social elements of their environment such as human figures, (Buswell, 1935) and are rapidly able to identify social elements of a scene from peripheral vision (Fletcher-Watson, Findlay, Leekam, & Benson, in press). In addition, the social cue of eye-gaze direction can direct attention reflexively (Friesen & Kingstone, 1998), while other perceptually similar stimuli do not have the same influence over our attention (Ristic & Kingstone, 2005).

Research with children with autism spectrum disorder (ASD), however, suggests that they are less likely than typically-developed children to direct their attention to social stimuli in the environment (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Dawson *et al.*, 2004; Klin, 1991) and fail to direct their attention according to the eye-gaze direction of another (Leekam, Lopez, & Moore, 2000; Loveland & Landry, 1986; Mundy, Sigman, Ungerer, & Sherman, 1986). This evidence has led to the proposal that atypical social attentional biases in infancy and childhood may be a central early cause of ASD (Klin, Jones, Schultz, & Volkmar, 2003; Mundy & Neal, 2001; Schultz, 2005). There has been little work on the manifestation of social attention difficulties in adults with ASD, though there is research to show that they are less likely to direct their attention to social stimuli, especially people's eyes (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). However, conclusions from this work may be compromised by the complex stimulus processing requirements also placed upon participants (Kemner & van Engeland 2003).

The current study uses a novel change blindness method to examine evidence for an attentional bias for eye-gaze information in adolescents and adults with and

without ASD. Change blindness is the phenomenon whereby an individual finds it very difficult to spot the change between two near-identical scenes presented one after the other, but separated by a blank screen or other interruption (Simons & Levin, 1997). Though differing explanations of change blindness are available (Henderson & Castelhano, 2005), most theorists suggest that changes can be detected to only those objects which have been subject to focused attention (Rensink O'Regan & Clark, 1997). This method permits the use of naturalistic stimuli without complex stimulus processing requirements.

We compared changes to eye-gaze direction and a control set of changes to spectacles. A previous study (Fletcher-Watson, Leekam, Turner & Moxon, 2006) of non-social change blindness showed that ASD individuals detected such changes as effectively as typically developing (TD) controls, thus no main effect of group was predicted. Instead, it was predicted that the TD group would show reduced response times when detecting changes to eye-gaze direction, compared to changes to spectacles, due to an attentional bias towards social information. This bias for eye-gaze information was not expected in the ASD group.

## Method

### *Participants*

The TD group comprised 36 young adults (6 female, 30 male) aged 17-32 years, from mainstream high schools and further education colleges in the Durham area.

The ASD group comprised 36 young adults (6 female, 30 male) aged 17-25 years, with high-functioning autism or Asperger's syndrome (AS). All these participants attended a specialist college in the Sunderland area for which a diagnosis of autism or Asperger's

syndrome was a criterion of admission. All had been diagnosed by experienced clinicians (a psychiatrist or clinical psychologist employed by the National Health Service) working in specialised centres, as meeting DSM-IV criteria for either high-functioning autism or AS (American Psychiatric Association, 1994). These diagnoses were confirmed, upon each participant's admission to the college, by a second clinical psychologist.

The groups had equal gender distributions and were group-wise matched on age, full-scale IQ, verbal IQ and performance IQ (Wechsler abbreviated Scales of Intelligence [WASI]: Wechsler, 1999) as shown in Table 1.

[Table 1 about here]

### *Design*

Participants were shown pairs of images separated by a blank screen. These image pairs were realistic scenes which were either identical, or different in one single detail. The participants' task was to view the images and then decide whether a change was present or not. The study used a mixed-design with type of change (eye-gaze versus spectacles) as a within-subjects factor and group (ASD versus TD) as a between-subjects factor.

### *Materials*

Experimental images were photographs taken on a digital camera by the first author and filler images were sourced from the Internet. Both Experimental and Filler images depicted people in naturalistic settings. Experimental changes were either to eye-gaze direction or to the presence/absence of a pair of spectacles. Filler changes were to objects or clothing: for example, a badge on a coat lapel appearing and disappearing. Stimuli featuring experimental changes (to eye-gaze direction and to spectacles) were matched for

characteristics including scene content, change location, contrast and luminance at the site of the change, and image size and orientation.<sup>i</sup>

A total of 104 trials included 26 experimental trials (13 eye-gaze changes and 13 spectacles changes), 38 filler change trials and 40 no change trials. No change trials were created by presenting filler and experimental images without a change.

### *Program*

The images were incorporated into a specially-designed program and run on a Sony Vaio laptop with a 15-inch LCD screen. This program was based on the flicker paradigm (Rensink et al, 1997) and all responses were made by the participant using a button box attached to the computer and containing two buttons (labelled YES and NO). Within each trial the program ran as illustrated in Figure 1. Participants could make a decision about the presence or absence of a change at any point during the cycle of alternations or wait for the response screen prompt if needed.

[Insert Figure 1 about here]

Participants were given instructions, and then had the opportunity to complete five practice trials (two with no change, three with a change to an object) before beginning the experiment. All participants responded correctly on at least three of the five practice trials before beginning the experiment. The experimental trials were presented in two reversed orders, counter-balanced between participants. Images were ordered semi-randomly with the exception that no two eye-gaze images or spectacles images were allowed to follow each other in succession. Also, no two trials using the same image could be within five places of each other.

### *Procedure*

Participants were tested in a quiet room in their college or school. They were given an information sheet and were then asked to fill in a consent form. The WASI (Wechsler, 1999) was administered and then participants were introduced to the computer program by a set of instructions on the screen. The instructions were read out and explained if necessary by the investigator. Following the five practice trials was a brief reminder of the keys to use. Each participant then completed all 104 trials of the experimental task. Participants were debriefed and paid £5 for their participation.

## Results

### *Preparing the data*

Data from ten experimental trials (six from the ASD group and four from the TD group) were removed from the analysis due to participants' premature responding. In addition, data from one eye-gaze change was excluded from subsequent analysis because it elicited outlying responses. The remaining item-wise data were normally distributed.

Participants undertook the task in one of two reversed orders: a t-test found no main effects of order nor were there any interactions between image type (eye-gaze versus spectacles) and order.

Analysis of the distribution of participant-wise responses revealed kurtosis in the distribution of accuracy scores for both eye-gaze and spectacles trials ( $k = 6.79$ ,  $k = 2.15$  respectively). A transformation in which all data were squared reduced the kurtosis to an acceptable level ( $k = .80$ ,  $k = -.50$  respectively).

### *Group Comparison*

All participant-wise analyses were performed using ANCOVAs (type I sums of squares) with full-scale IQ included, to account for the dependence created by matching groups.

For accuracy data (% correct responses, squared) a main effect of image was found,  $F(1, 69) = 33.71, p < .001, \eta^2 = .328$ , reflecting reduced accuracy to spectacles compared with eye-gaze images (see Figure 2). In addition there was a main effect of group,  $F(1, 69) = 9.58, p = .003, \eta^2 = .122$ , reflecting reduced accuracy overall for the ASD group compared to the TD group (see Figure 2). There was no interaction between group and image type, nor any effects of full-scale IQ. Reanalysis with VIQ entered as a covariate did not change this result.

[Insert Figure 2 and 3 about here]

For response times, a main effect of image was found,  $F(1, 69) = 16.35, p < .001, \eta^2 = .192$ , reflecting reduced response times to eye-gaze over spectacles images across both groups (see Figure 3). There was no main effect of group nor any group by image-type interaction, indicating that both participant groups were responding at a similar rate across all images.

A weak full-scale IQ by image-type interaction was revealed,  $F(1, 69) = 4.23, p = .044, \eta^2 = .058$ , reflecting a slight negative correlation between full-scale IQ and response time in the eye-gaze condition, Pearson's  $r = -.251, p = .033$ , such that higher IQ was linked with faster response times. No such correlation was present for response time to spectacles images, and there was no correlation when verbal IQ was entered into the analysis.

*Expectation versus Social Advantage*

The design led to two ways in which participants might have performed well on experimental trials. First, they might have used an expectation of repeated spectacles and eye-gaze changes to direct their search for these changes, resulting in rapid performance on all experimental trials. Second, they may have shown a specific social advantage in attending to social information. This would aid detection of eye-gaze changes, but not changes to spectacles. To compare the two possibilities, two difference scores were constructed from response time on correct trials only. The first difference score was baseline response time (to changes in filler images) minus response time to images depicting spectacles changes, indicating 'expectation-advantage'. The second was calculated as response time to spectacles changes minus response time to eye-gaze changes, indicating social advantage.

T-tests revealed no significant differences between groups on these difference scores for response time. Both groups showed an advantage for an expectation-based approach to the task, such that spectacles response times were faster than baseline response times (TD mean difference = 300ms, SD = 463ms; ASD mean difference = 253ms, SD = 450ms). Both groups also showed an advantage for using social information to complete the task (TD mean difference = 387ms, SD = 600ms; ASD mean difference = 172 ms, SD = 600ms). The variability in these difference scores was large and so a regression analysis was carried out to discover what underlying characteristics underpinned these advantages. However, none of group membership, gender, age, full-scale IQ, performance IQ or verbal IQ were significant predictors of either difference score.

#### *Accuracy for Filler Changes*

The accuracy data revealed reduced change detection ability across all experimental trials for the ASD group. Both eye-gaze and spectacles changes occur on the face and so it

is possible that the reduced accuracy reflects less looking to faces overall. Therefore, accuracy scores for filler changes were assessed. A between-groups t-test revealed a significant difference in percentage correct responses to all filler changes,  $t(70) = 4.61$ ,  $p < .001$ , such that the ASD group were less accurate than the TD group. There was no group difference in correctly identifying trials where no change occurred,  $p = .312$ , indicating that the ASD group were not simply more conservative in their responses.

### Discussion

The goal of the study was to investigate attention to eye-gaze in a group of young adults with ASD and a group of typically developing young adults. Both groups showed a change detection advantage for eye-gaze over spectacles changes in both response time and accuracy. This result is striking since these two change types were virtually indistinguishable on a low-level visual basis (e.g. contrast and luminance at the site of change). The finding demonstrates that eye-gaze direction is a powerful social signal that is detected rapidly and independently when presented as a component of a complex scene. This result also supports recent findings which suggest that visual attention can be directed by the high-level properties of a stimulus, such as semantic role and informativeness, as well as its low-level characteristics (Fletcher-Watson *et al.*, in press; Smilek, Birmingham, Cameron, Bischof, & Kingstone, 2006).

Contrary to expectations, participants with ASD showed a very similar advantage in detecting eye gaze changes as the TD controls. There are a number of reasons why the ASD data may have followed a pattern similar to that of the typical group. The relationship between social attention and social skills is likely to be a continuous one (Mundy & Neal, 2001; Schultz, 2005), which varies with age, developmental level and degree of autism (Leekam *et al.*, 1998; Leekam *et al.*, 2000). It is possible that the higher ability and age of

the participants with ASD in this study facilitated their success on this task. Secondly, the milder forms of autism present in this group may be the developmental outcome of an ability to attend to and learn about social information across development, not present in those more severely affected by the disorder. Finally, the stimuli used were uni-modal, static images of people, presented for just under four seconds in total. In contrast, social information in the real world is presented across multiple modalities, by moving stimuli who may only present a social cue very fleetingly. It is possible that the relative simplicity of the task at hand allowed participants with ASD to exhibit a social attention bias not present in real life.

Although a social attention bias was present in both groups, the data also revealed reduced accuracy to all experimental changes for the ASD group. We considered the possibility that this reflected reduced attention and looking to faces in general, since both eye-gaze and spectacles changes occurred on the face. However the fact that the ASD group were also less accurate in detecting filler changes, such as to objects and clothing, refutes this suggestion. In addition, the ASD group were no more likely to make false positives than the TD group, saying they thought there had been a change in cases where no change was present. Therefore the ASD group were also not merely more conservative in their responses than the TD group. This difference in accuracy may reflect the fact that the ASD group found the task more challenging than their TD peers, perhaps as a result of difficulty co-ordinating the visuo-motor responses necessary.

In conclusion, the results of this study provide support for the importance of social information in directing typical attention within a naturalistic scene. The TD group displayed a powerful advantage in detecting eye-gaze changes quickly and accurately. This finding appears to argue strongly for a specific ability for eye-gaze direction changes to attract attention. That this ability seems to be intact in autism was unexpected, if it is

assumed that social attention difficulties in autism continue unchanged through life. The result could be explained by our use of a very able, adult sample, supporting the evidence that social attention skills develop over time. It also could be explained by the use of a uni-modal, static stimulus set, supporting the view that autistic social attention can operate effectively in controlled experimental settings. These results call for a more systematic analysis of the social attention literature in autism across the different tasks, such as interactive, dynamic joint attention tasks and computer-based gaze-following tasks, that until now have been equated. In addition, the development of social attention in both children and adults with ASD should be further researched, as well its relationship to the use of social cues in real life.

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Sue Fletcher-Watson has changed affiliation subsequent to the time of the study, and is now at Newcastle University, Institute of Health and Society, Newcastle upon Tyne, UK.

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Table One

*Demographic data and group matching for ASD and TD groups.*

	ASD		TD		t-test sig. level
	Mean	SD	Mean	SD	
Age	18.72	2.20	19.92	3.97	p = .12
Verbal IQ	93.92	15.47	94.61	13.92	p = .84
Performance IQ	95.94	14.91	100.64	12.76	p = .16
Full-scale IQ	94.72	13.96	97.22	13.02	p = .44

## Figure Captions

*Figure 1.* A schematic diagram illustrating the sequence of events within each experimental trial. Also an example of an eye-gaze change.

*Figure 2.* Accuracy of detection of changes to Eye-Gaze and Spectacles by Group. (error bars show the standard error of the mean)

*Figure 3.* Response time to detect changes to Eye-Gaze and Spectacles by Group. (error bars show the standard error of the mean)

Figure 1 top

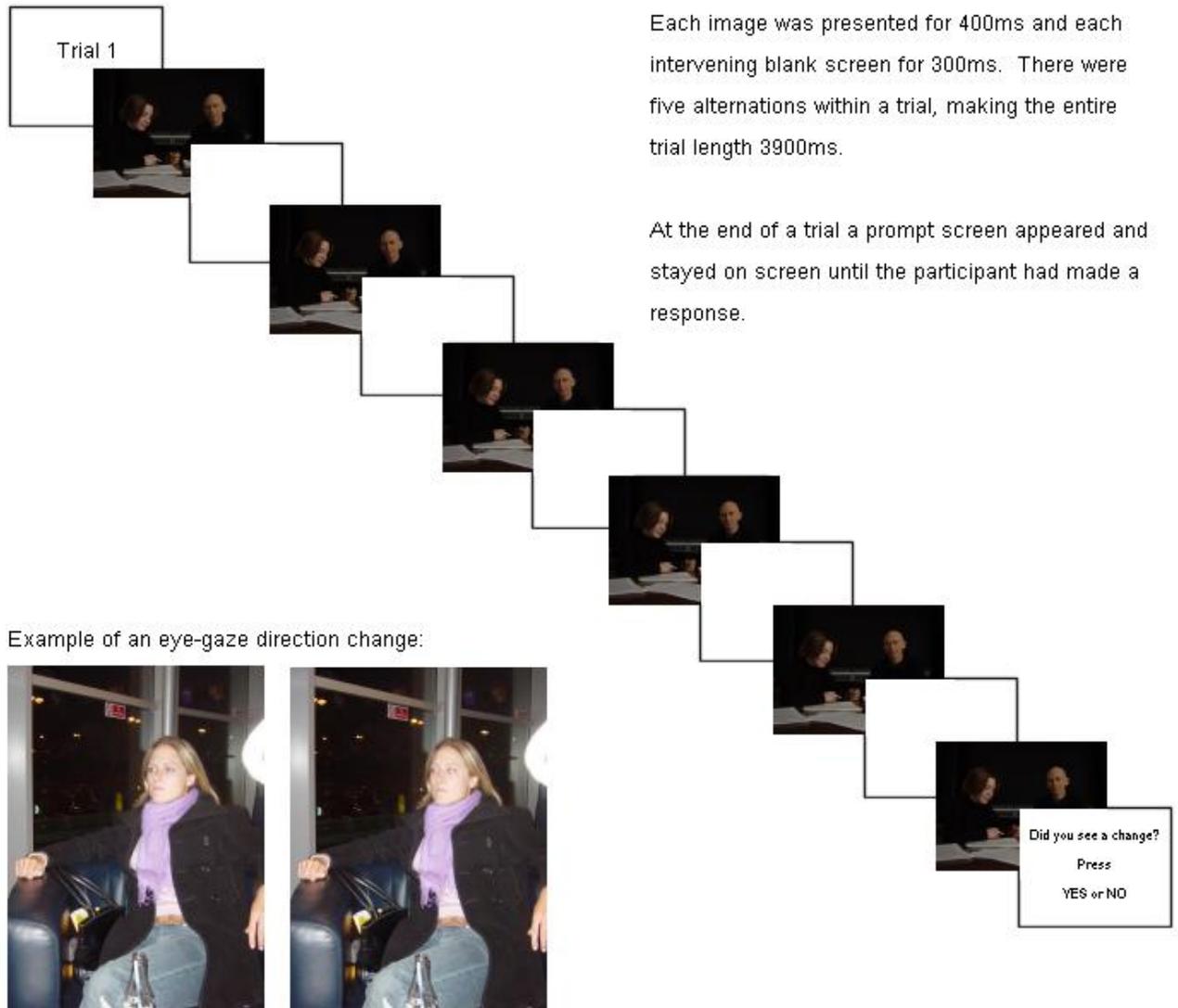


Figure 2 top

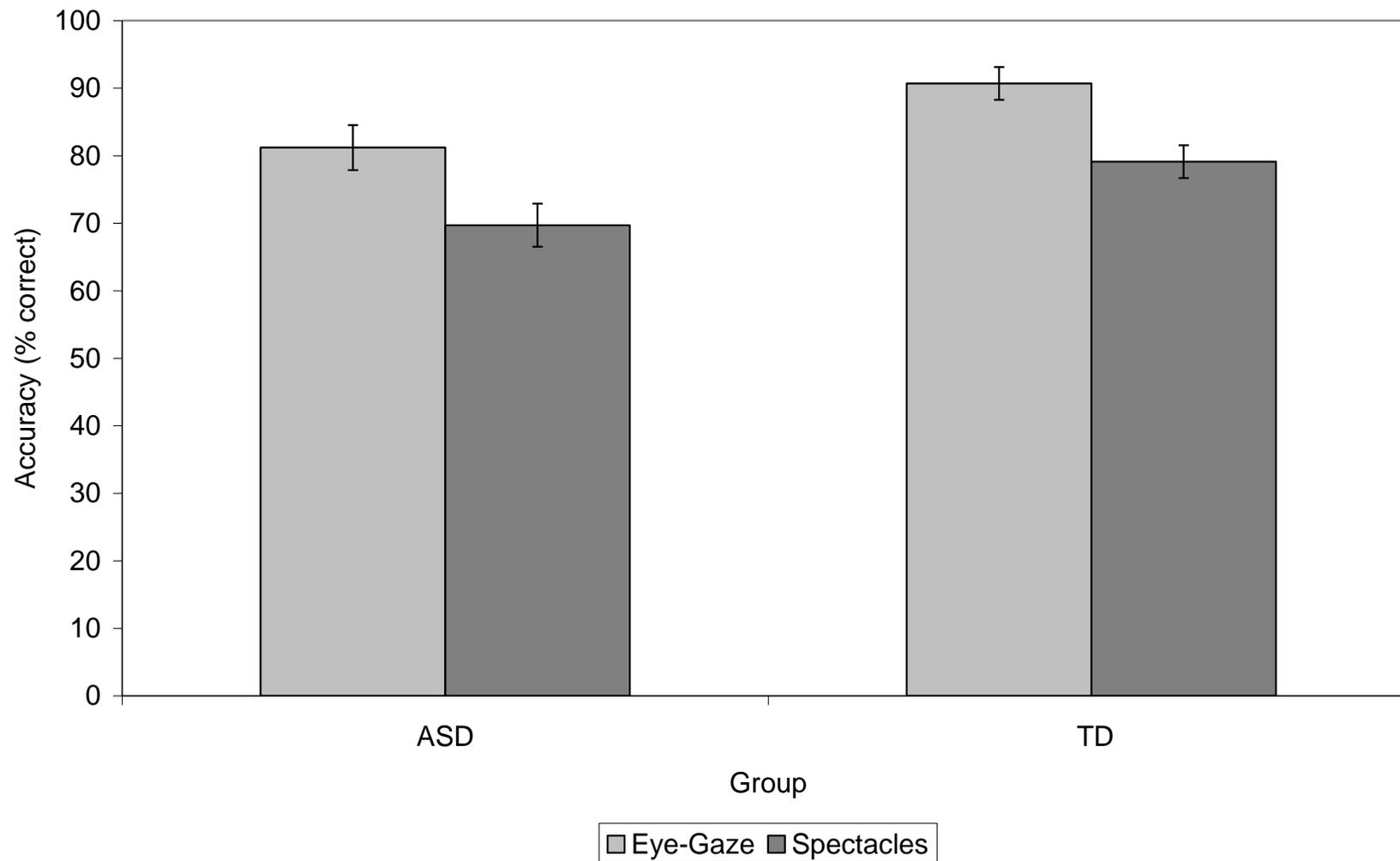
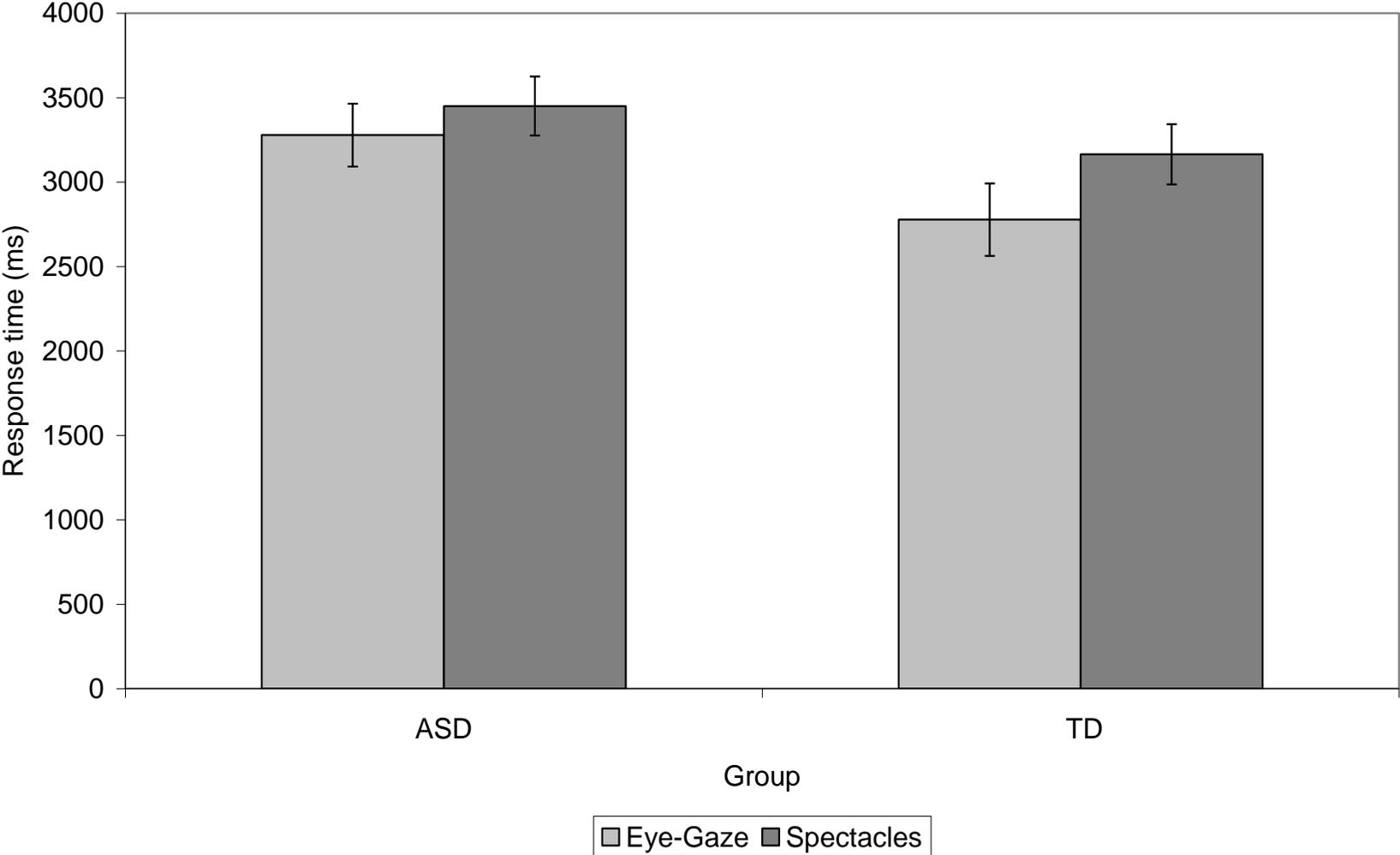


Figure 3 top



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<sup>i</sup> For more information about the selection of materials, matching procedures and instructions to participants please see <http://www.staff.ncl.ac.uk/sue.fletcher-watson>