RESEARCH ARTICLE

Threatening Faces Fail to Guide Attention for Adults With Autistic-Like Traits

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Individuals diagnosed with autistic spectrum conditions often show deficits in processing emotional faces relative to neurotypical peers. However, little is known about whether similar deficits exist in neurotypical individuals who show high-levels of autistic-like traits. To address this question, we compared performance on an attentional blink task in a large sample of adults who showed low- or high-levels of autistic-like traits on the Autism Spectrum Quotient. We found that threatening faces inserted as the second target in a rapid serial visual presentation were identified more accurately among individuals with low- compared to high-levels of autistic-like traits. This is the first study to show that attentional blink abnormalities seen in autism extend to the neurotypical population with autistic-like traits, adding to the growing body of research suggesting that autistic-related patterns of behaviors extend into a subset of the neurotypical population. ***Autism Res** 2016, 00:0000–000*. © 2016 International Society for Autism Research, Wiley Periodicals, Inc.

Keywords: autistic-like traits; attentional blink; emotion; faces

Introduction

Because resource limitations prevent us from simultaneously processing all of the stimuli available to sensory systems, attention mechanisms must be employed to select a subset of information based on endogenous and exogenous factors. One particularly important exogenous factor in guiding attention is the level of emotional arousal (both positive and negative) elicited by incoming information. An abundance of evidence suggests arousing stimuli are responded to more quickly and accurately than neutral stimuli [e.g., Algom, Chajut, & Lev, 2004; Anderson, 2005; Mather & Nesmith, 2008; Mathews & MacLeod, 1985; Schimmack, 2005; Vogt, De Houwer, Koster, Van Damme, & Crombez, 2008], indicating they are more rapidly attended. Moreover, compared to neutral images, emotionally arousing visual images reliably increase activation in areas such as the amygdala, prefrontal cortex (PFC), and occipital regions [Costafreda, Brammer, David, & Fu, 2008; Fusar-Poli et al., 2009; Phan, Wager, Taylor, & Liberzon, 2002].

Faces are a common source of both positively and negatively valanced emotional arousal, and have been reliably shown to guide attention, most commonly illustrated by faster reaction times to identifying a target emotional face amongst neutral expression distractors [Frischen, Eastwood, & Smilek, 2008]. For example, in the well-known “anger superiority effect” [Hansen & Hansen, 1988], participants reliably identify the presence of an individual with an angry face within an array of individuals with neutral or happy expressions faster than they identify the presence of a happy face within an array of angry or neutral faces [Eastwood, Smilek, & Merikle, 2001; Fox et al., 2000; Hansen & Hansen, 1988; Hershler & Hochstein, 2005; Öhman, Lundqvist, & Esteves, 2001]. As angry or threatening faces are a critical signal of potential social conflicts, the ability to attend and respond to them swiftly is often theorized to benefit the observing individual in attempting to avoid the conflict [Öhman & Dimberg, 1984].

Individuals diagnosed with neurological disorders such as autism spectrum disorders (ASD) often exhibit relatively greater difficulty with facial and emotional recognition than their neurotypical counterparts [Adolphs, Sears, & Piven, 2001; Bölte & Poustka, 2003; Celani, Battacchi, & Arcidiacono, 1999; Farran, Branson, & King, 2011; Grossman, Klin, Carter, & Volkmar, 2000; Howard et al., 2000; Humphreys, Minshew, Leonard, & Behrmann, 2007; Pelphrey et al., 2002; see Uljarevic & Hamilton, 2013, for a review], which may in part stem from a failure to attend to the more socially meaningful aspects of the face, such as the eyes [Baron-Cohen, Wheelwright, & Jolliffe, 1997; Corden,

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Chilvers, & Skuse, 2008a; Dalton et al., 2005; Jones, Carr, & Klin, 2008; Kirchner, Hatri, Heekeren, & Dziobek, 2011; Kliemann, Dziobek, Hatri, Baudewig, & Heekeren, 2012; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Spezio, Adolphs, Hurley, & Piven, 2007]. This is not to say that individuals with ASD are universally impaired when processing facial information. Krysko and Rutherford [2009], for example, demonstrated that ASD individuals show a relatively intact anger superiority effect, detecting angry faces in a visual search paradigm as quickly as their neurotypical peers (although with less accuracy). That said, however, even when performance is similar between ASD and neurotypical samples, there is evidence to suggest that compensatory mechanisms and atypical perceptual processing strategies are present in ASD participants [see Harms, Martin, & Wallace, 2010, for a review].

It is possible that the diminished ability to attend to emotional stimuli also manifests itself in parts of the neurotypical population. An increasing body of research suggests that behavioral characteristics generally associated with ASD are also present in neurotypical individuals who demonstrate above-average scores on measures of autistic-like traits, such as the Autism Spectrum Quotient (AQ) [Almeida, Dickinson, Maybery, Badcock, & Badcock, 2010a,b,; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001; Grinter, Van Beek, Maybery, & Badcock, 2009; Grinter et al., 2009; Rhodes, Jeffery, Taylor, & Ewing, 2013; Russell-Smith, Maybery, & Bayliss, 2010; Sutherland & Crewther, 2010]. To date, however, relatively little research has examined whether similar overlap exists in the guidance of emotional attention. To our knowledge, the only autistic-trait based study to provide some suggestive results in this regard was conducted by Miu, Pană, and Avram [2012], who found that a fearful (compared to neutral) facial expression slowed the redirection of attention through gaze cueing in low-trait individuals, but had no differential effect in high-trait individuals. This finding parallels dissociations found in the processing of eye gaze cues in ASD and control groups [Uono, Sato, & Toichi, 2009]. However, it is not known whether differences in the ability of emotional faces to capture attention found in ASD relative to non-ASD groups [Ashwin, Wheelwright, & Baron-Cohen, 2006] are also generalizable to high-trait groups. It is also not known whether emotions other than fear, such as anger, guide attention in a similar manner across ASD and high-trait groups.

One way to examine how emotions guide attention is via a paradigm known as the attentional blink (AB). The AB refers to the reduced detection of the second of two targets presented within approximately 500 ms of each other in a rapid serial visual presentation (RSVP) [Broadbent & Broadbent, 1987; Raymond, Shapiro, & Arnell, 1992]. The AB is typically attributed, either directly or indirectly, to the requirement to process the initial target (T1), which limits the availability of attentional resources for the second target (T2) [Chun & Potter, 1995; Di Lollo, Kawahara, Ghorashi, & Enns, 2005; Jolicoeur & Dell'Acqua, 1998; Olivers & Meeter, 2008; Taatgen, Juvina, Schipper, Borst, & Martens, 2009; Visser, Merikle, & Di Lollo, 2005; Visser, 2007; Wyble, Bowman, & Nieuwenstein, 2009]. Notably, the AB is attenuated (higher T2 accuracy) when T2 is an emotionally arousing stimulus (e.g., the word "RAPE") relative to a non-arousing, neutral stimulus (e.g., the word "TABLE") [Anderson, 2005; Keil & Ihssen, 2004]. This has led to the suggestion that arousing stimuli have enhanced resistance to interference from competing, neutral stimuli, increasing the likelihood that the information will be consciously available [Anderson, 2005].

To date, evidence suggests that a similar AB occurs across both ASD and neurotypical individuals when neutral target stimuli are presented in the AB [Amirault et al., 2009; Rinehart, Tonge, Brereton, & Bradshaw, 2010]. From this we can infer that the general attentional mechanisms responsible for processing rapid sensory inputs are comparable between the two groups. However, differences in AB performance arise when making comparisons between emotionally arousing and neutral target stimuli. In neurotypical children and adults, when T2 is emotionally arousing, the AB is attenuated relative to when T2 is non-arousing [Anderson, 2005; de Oca, Villa, Cervantes, & Welbourne, 2012; Jong et al., 2009; Keil, Ihssen, & Heim, 2006; Maratos, Mogg, & Bradley, 2008; Schwabe et al., 2011; Yerys et al., 2013]. In contrast, results in the ASD literature are mixed. Adults with ASD show no change in performance when T2 is an emotionally arousing word stimulus [Corden, Chilvers, & Skuse, 2008b; Gaigg & Bowler, 2009]. Conversely, children with ASD show an attenuated AB when T2 is an emotionally arousing picture stimulus [Yerys et al., 2013].

In sum then, our study has two primary motivations. First, we wanted to investigate significant questions about the overlap between ASD and high autistic-like traits with respect to the emotional guidance of attention. To do this, we examined task performance on an attentional paradigm that has been examined in ASD individuals, but not in individuals with high levels of autistic-like traits – the attentional blink. Second, we wished to investigate whether emotional face stimuli would produce similar results to those obtained using emotional words with ASD adults [Corden et al., 2008b; Gaigg & Bowler, 2009]. This would provide some suggestive evidence clarifying whether differences between earlier studies with ASD adults and children were attributable to participant age or the type of emotional stimuli (words vs. pictures). To address these questions, we recruited neurotypical adults who displayed low (Low

AQ) or high (High AQ) levels of autistic-like traits and tested them using an AB paradigm in which an angry or neutral face was presented as T2 [see Yerys et al., 2013]. We reasoned that if autistic-like behaviors are on a spectrum that extends to the neurotypical population then, when viewing angry faces in a RSVP, resulting attenuation of the AB should be greater in Low AQ participants relative to High AQ participants, mirroring the dichotomy between neurotypical and ASD adults reported in prior research [Corden et al., 2008b; Gaigg & Bowler, 2009].

Methods

Participants

Three-hundred and sixty-eight second year psychology students (122 male) at the University of Western Australia participated in the study to satisfy part of a course requirement.

Materials

Autism spectrum quotient (AQ). The AQ, developed by Baron-Cohen et al. [2001], is a 50 item self-report questionnaire designed to measure autistic-like traits and behaviors exhibited in a neurotypical sample. The questionnaire uses a four-item forced-choice format and scoring followed the 1–4 method described by Austin [2005]. Following the logic of Austin [2005], we did this to take advantage of the breadth of potentially useful information in each item and to increase variability in total AQ score.

Attentional Blink Task. Stimuli were presented and responses collected using Presentation® software (Version 16.3, Neurobehavioral Systems) running on a PC using Windows 7, connected to a 22″ HP L2245wg monitor. Facial stimuli were identical to those used by Yerys et al. [2013], comprising color headshot photographs, 4.05° high and 3.16° wide, selected from the NimStim set [Tottenham et al., 2009]. Three types of stimuli were used in the task: (i) two photographs of dogs' heads to be used as T1, (ii) 28 photographs of faces with the interior details (e.g., eyes and nose) scrambled and outline preserved to be used as distractors in the RSVP, and (iii) 14 photographs of faces with neutral and angry expressions (seven of each) to be used as T2. Of these 14, there were seven males and seven females, and seven were depicted with their mouths open, and seven with their mouths closed. The scrambled faces were generated by Yerys et al. [2013] using a method devised by Conway et al. [2008].

The task consisted of 216 trials divided into three equal blocks, separated by self-paced breaks. Each trial began with the presentation of a fixation cross for 750

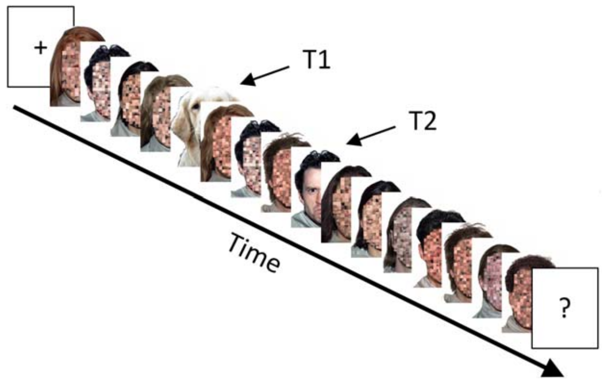

Figure 1. Example of a RSVP with both T1 and T2 stimuli.

ms, followed by a RSVP of 15 images (see Fig. 1). Successive images in the stream were presented at 100 ms intervals (16 ms stimulus; 84 ms blank ISI). Nine different types of trials were presented during the AB task. Three of the types were catch trials with zero or one target, which included: (i) 30 T1-only trials, where only the dog's head was present in the RSVP, (ii) 30 T2-only trials, where only the unscrambled face was present in the RSVP, and (iii) 30 trials where neither T1 or T2 were present in the RSVP. The purpose of these trials was to estimate levels of response bias. The remaining six trial types were the test trials that measured the AB and therefore contained both T1 and T2. The six types were formed by crossing three levels of T1–T2 lag with a neutral or angry T2 face.

The first target, if present, was positioned equally often as the fourth, fifth, or sixth stimulus in the RSVP. The second target, if present, was positioned as either the second, fourth or eighth stimulus in the RSVP following T1 presentation (lag-2, lag-4, and lag-8, respectively; for T2-only catch trials, T2 was placed in a similar position as if T1 were present). Equal numbers of trials were presented at each lag, evenly divided between neutral and angry facial expressions (for test trials, 42 trials per lag; 21 per expression). Presentation order was random with the constraint that identical trial types did not occur more than twice in a row. Each block contained the same number of each trial type. Participants completed 10 practice trials before commencing the test trials.

Procedure

Participants first completed a paper version of the AQ, with scores used to select Low- and High AQ groups for comparison. The AB task immediately followed, with participants seated approximately 500 mm in front of the computer monitor. Participants were instructed to watch closely on each trial for the presentation of a dog (T1) and unscrambled face (T2) in the RSVP stream. Following the RSVP, participants were first prompted to respond if they had observed a dog in the RSVP, and

Table 1. Characteristics of the Low-AQ and High-AQ Comparison Groups (Standard Deviation in Parentheses)

	Low AQ ($n = 75$, 17 male)	High AQ ($n = 71$, 27 male)
Mean age (years)	21.35 (6.82)	20.77 (3.90)
Mean AQ	87.72 (6.36)	124.59 (7.47)

Table 2. Mean Catch Trial and Target 1 Accuracy (Proportion Correct; Standard Deviation in Parentheses)

		Low AQ	High AQ
Mean catch trial accuracy			
No target		91.29 (10.40)	91.13 (9.98)
T1-only		94.22 (5.96)	94.41 (6.64)
T2-only		86.00 (10.46)	86.90 (10.71)
Mean Target 1 accuracy for T1–T2 trials			
Lag-2	Neutral	94.79 (6.12)	94.97 (5.51)
	Angry	95.68 (5.65)	94.77 (6.14)
Lag-4	Neutral	95.05 (7.28)	94.63 (7.76)
	Angry	95.68 (5.81)	95.44 (5.72)
Lag-8	Neutral	96.25 (5.09)	96.04 (6.78)
	Angry	95.81 (6.91)	95.17 (6.90)

then to indicate whether they had observed an unscrambled face. Participants responded to both queries using a keyboard, pressing "Y" to indicate that they had observed a dog/unscrambled face, or "N" to indicate they had not. Participants were allowed 5000 ms to respond to each of the questions, with no response being recorded as an error. The fixation cross marking the start of the next trial was presented immediately following the second response.

Results

Comparison groups were created by selecting participants in the top and bottom quintiles of the distribution of AQ scores. The Low AQ group consisted of students with an AQ score ≤ 95 ($n = 80$), and the high AQ group consisted of students with an AQ score ≥ 116 ($n = 75$). From these initial groups, nine participants (five Low AQ, four High AQ) scoring $\leq 50\%$ accuracy (i.e., chance level) on catch trials were omitted from subsequent analyses. The effect size for the separation in means for the Low and High AQ groups was $r = 0.94$.[1] Descriptive statistics for the resulting groups are presented in Table 1.

[1] In Ruzich et al. [2015] recent review of studies that have used the AQ, based on the original 0-1 scoring method, they report a mean AQ of 16.94 for non-clinical participants. In order to provide a useful comparison to this norm, we re-scored our participants using this method and found our Low AQ group to have a mean score of 8.93 (SD = 2.54) and the High AQ group to have a mean score of 24.54 (SD = 4.13). Single-sample t-tests revealed that both our groups had means significantly different to 16.94 (both t > 15.51, both $P < 0.001$).

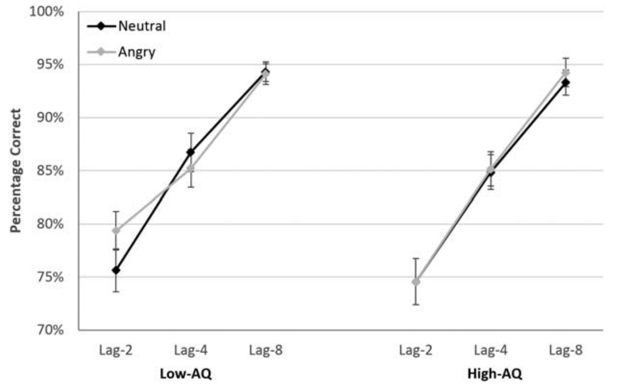

Figure 2. Mean percentage of T2 responses correct given T1 correct, as a function of AQ group (Low and High), T2 Emotion (neutral and angry) and Lag (2, 4, and 8). Error bars represent standard error of the mean.

Catch trial accuracy was similar across groups (for a summary, see Table 2), with independent samples *t*-tests revealing no significant differences (all $t \leq 0.51$, all $P \geq 0.61$). For trials containing both targets, to determine if T1 accuracy varied significantly between conditions, a three-way mixed factorial analysis of variance (ANOVA) was conducted on the means shown in Table 2, with AQ group as a between-groups factor (two levels: Low AQ and High AQ), Lag as a within-groups factor (three levels: 2, 4, and 8) and emotion as a within-groups factor (two levels: neutral and angry). No main effects or interactions were significant (all $F \leq 2.18$, all $P \geq 0.12$; see Table 2 for descriptive statistics).

Second-target accuracy was calculated using only trials for which T1 was correctly identified. This is because the source of T2 errors is unknown if a T1 error is also made [Raymond et al., 1992]. Mean T2 accuracy separated by AQ group, lag and emotion type are presented in Figure 2. These T2 accuracy scores were submitted to a three-way mixed factorial ANOVA with the same factors used in the previous analysis of T1 accuracy. This analysis yielded a significant main effect of Lag, $F(2, 144) = 139.58$, $P < 0.001$, $\eta^2_P = 0.49$, consistent with the AB, a marginal Lag × Emotion interaction, $F(2, 288) = 2.30$, $P = 0.10$, $\eta^2_P = 0.02$, and an AQ Group × Lag × Emotion interaction, $F(2, 288) = 3.43$, $P = 0.03$, $\eta^2_P = 0.02$. No other effects were significant (all $P > 0.31$, all $\eta^2_P < 0.01$). We followed up the significant three-way interaction with post hoc paired samples *t*-tests (see Table 3).

As the paired samples *t*-tests revealed a discrepancy between AQ groups at Lag-2, follow-up independent samples *t*-tests were used to reveal that, though the two groups were comparable at detecting T2 in Lag-2 neutral trials, $t(144) = 0.36$, $P = 0.72$, $r = 0.03$, the Low AQ group was significantly better at reporting T2 in Lag-2 angry trials, $t(144) = 1.70$, $P = 0.05$, $r = 0.14$, one-tailed. Thus there was a facilitative effect of the angry stimuli

Table 3. Results for Paired Samples *t*-Tests Comparing Emotion at Each Lag for Each AQ Group (*P* Values in Parentheses)

	Lag-2	Lag-4	Lag-8
Low AQ	2.80 (<0.01)*	1.26 (0.21)	0.27 (0.79)
High AQ	0.01 (1.00)	0.22 (0.82)	0.98 (0.33)

*Significant at the Bonferroni corrected 0.008 level.

at Lag-2 for Low AQ participants, but not for High AQ participants.

Discussion

This study examined whether deficits in guidance of attention by emotional stimuli, similar to those reported in ASD samples, were present within a high autistic-like trait neurotypical group. By comparing the performance of two groups of low- and high-trait individuals on an AB task that used neutral and threatening faces as targets, we found a pattern of results comparable to those reported using similar paradigms with clinical ASD and neurotypical comparison groups. Specifically, our results mirror those reported by Corden et al. [2008b] and Gaigg and Bowler [2009], who showed little-to-no enhancement for ASD adults in identifying emotionally arousing targets presented within a RSVP. Our findings on visual attention using the AB paradigm complement those reported by Miu et al. [2012] using a gaze-cueing paradigm: high levels of autistic-like traits were associated with reduced interference from emotional faces in Miu et al. [2012] and with reduced ability to capture attention in the present study. In both cases, this implies that the impact of emotional faces on attentional systems is altered in those with high levels of autistic-like traits.

Our findings significantly expand upon previous work by showing that the capture of attention by emotional stimuli is similar for ASD [Ashwin et al., 2006] and high-trait individuals. This outcome may be interpreted in at least two ways. One option is that the failure to obtain emotional guidance of attention in both ASD and high-trait individuals indicates that this deficit is not a unique or defining characteristic of ASD [see Gregory and Plaisted-Grant, 2013]. On this option, instances of reduced emotional guidance in ASD reported in other studies [Ashwin et al., 2006; Corden et al., 2008b; Gaigg & Bowler, 2009] may not be indicative of an ASD-linked "deficit," but rather a behavioral pattern that is also present in many neurotypical individuals. Another option is that our findings provide further support for a dimensional model of ASD, in which ASD and ASD-associated traits exist on a continuum that extends into the neurotypical population [e.g., see Constantino and Todd, 2003]. This interpretation suggests that much may be learned about the mechanisms underlying ASD by studying performance in participants with high levels of autistic-like traits who are considerably greater in number and thus easier to recruit than individuals with an ASD diagnosis.

Importantly, our results also suggest that parallels between ASD and high-trait individuals in the guidance of attention by emotion can be seen in angry as well as fearful faces [Miu et al., 2012]. This is significant because there are plausible reasons to predict that angry faces might be more effective at guiding attention in high-trait/ASD participants. In particular, although both anger and fear are associated with threat, angry faces convey a more "direct" threat, thus capturing attention more efficiently. For example, Palermo and Coltheart [2004] showed that the angry faces from the Nimstim database [Tottenham et al., 2009] are identified faster and more accurately than the fearful faces drawn from the same database (these faces are used here and in Miu et al. [2012]).

To the extent that there are parallels between High AQ and ASD individuals, our results can also comment on the source of earlier differences found in studies of emotional guidance in ASD reported by Corden et al. [2008b], Gaigg and Bowler [2009], and Yerys et al. [2013]. These studies reported no attenuation of the AB for emotional words in adults with ASD [Corden et al., 2008b; Gaigg & Bowler, 2009], but intact attenuation of the AB in children with emotional pictures [Yerys et al., 2013]. Assuming that our findings can be taken as a preliminary indication of the expected pattern of results for an adult ASD and control comparison study, ours and the Yerys et al. [2013] results together suggest there is a developmental change with aging in ASD that impacts the efficient guidance of attention arising from emotional information in faces. This follows from the fact that whereas we reported an absence of beneficial effects on attentional guidance by threatening faces in our High AQ adult group, Yerys et al. [2013] found no differences in attentional guidance between typically developing and autistic children using the same paradigm. Confirmation of this conjecture in a study replicating our methodology with an adult ASD sample would further bolster the suggestion for attentional-related developmental changes.

Given our findings show broad similarities in the way that emotional faces guide attention in ASD and in neurotypical individuals with autistic-like traits, an explanation for our results may usefully be made by looking at how faces are processed in ASD. Notably, the efficient processing of faces is believed to depend largely on the successful development of a holistic or configural processing style [De Sonneville et al., 2002]. Whereas neurotypical individuals tend to develop a more configural processing style for face processing

[Tanaka & Farah, 1993], ASD individuals often show a preference for using more piecemeal processing styles across both facial and non-facial stimuli [Behrmann, Thomas, & Humphreys, 2006; Behrmann et al., 2006; Isomura, Ogawa, Yamada, Shibasaki, & Masataka, 2014; see Happé & Frith, 2006 for a review].

This is of particular relevance to the current study, as differences in configural versus piecemeal processing styles have been reported on numerous occasions when comparing neurotypical individuals with low and high AQ scores [Almeida et al., 2010a, 2010b, 2013; Grinter et al., 2009; Russell-Smith et al., 2010; Sutherland & Crewther, 2010]. Plausibly, then, underlying differences in processing strategies potentially expressed early in childhood [Kaldy, Kraper, Carter, & Blaser, 2011] might lead to differences in the way that emotional faces serve to guide attention in Low and High AQ groups. Analogous to the distinction between holistic and piecemeal face processing styles, studies have found that adults with ASD rely on rule-based processing strategies when processing emotional stimuli to a greater degree than do neurotypical individuals, who employ prototype or template-based matching strategies [Rutherford & McIntosh, 2007; Walsh, Vida, & Rutherford, 2014]. Further, using a rule-based processing style in adults is likely to be more time consuming [Celani et al., 1999]. Thus, in situations such as the AB task, where stimuli must be evaluated quickly, we hypothesize that individuals with high levels of autistic-like traits process emotional information too slowly for it to effectively guide attention.

What neurological processes may underlie the differences in emotion-based attentional guidance in our Low and High AQ groups? The answer to this question may also be gleaned from existing literature on individuals with ASD and individuals with high levels of autistic-like traits. Amygdala dysfunction has been implicated as a key factor underlying relatively poorer processing of emotional stimuli in ASD [see Schultz, 2005, for a review], with the thought that there is a failure to develop the ability to efficiently assign significance to socially meaningful or arousing stimuli [Grelotti, Gauthier, & Schultz, 2002; Schultz, Romanski, & Tsatsanis, 2000; Schultz, 2005; Waterhouse, Fein, & Modahl, 1996]. A number of neuroimaging studies have supported this view, showing relatively reduced activation of the amygdala in ASD individuals when making non-emotional judgments of emotional faces [Baron-Cohen et al., 1999; Corbett et al., 2009; Critchley et al., 2000; Kleinhans et al., 2011; Kliemann et al., 2012; Nickl-Jockschat et al., 2015; Pelphrey, Morris, McCarthy, & LaBar, 2007; Pierce, Haist, Sedaghat, & Courchesne, 2004]. As a result of this dysfunction, the failure to effectively code emotional information in faces may prevent them from efficiently guiding attention. Importantly, there is also evidence for amygdala abnormalities in neurotypical individuals with high levels of autistic-like traits. Iidaka, Miyakoshi, Harada, and Nakai [2012] found an increased volume of white matter connecting the amygdala and the superior temporal gyrus for individuals high in autistic-like traits compared to those with low levels of these traits.

One potential objection to our conclusions might be made on the basis of the fact that we failed to find a main effect of emotion on T2 performance, as in earlier studies with ASD participants [Corden et al., 2008b; Gaigg & Bowler, 2009; Yerys et al., 2013]. However, we suggest that this is in keeping with the relatively small AB magnitude observed in our study (≈20%) compared to these earlier experiments (≈45–60%). This left less room for emotional guidance to improve performance, and also likely reduced the size of our three-way interaction. With this in mind, it is possible that High AQ participants might have shown attentional guidance effects if overall accuracy was lower. This could be examined in future studies by increasing the difficulty of the T1 task in order to boost the magnitude of the AB [Visser, 2007]. However, even if the AB were to be modulated in the High AQ group under these conditions, it is clear from the present findings that the effect of angry faces would still be reduced for High AQ participants relative to Low AQ participants.

In conclusion, we found that the typical modulation of attention by emotional face stimuli is not intact in high autistic-like trait adults in the AB paradigm. This finding is further evidence that ASD-like patterns of behavior are seen in individuals in the neurotypical population who report high levels of autistic-like traits. Notably, to our knowledge, no study has directly investigated emotional modulation of attention in an AB paradigm in conjunction with neuroimaging techniques in ASD or High AQ samples. Such data would aid greatly in clarifying underlying neural mechanisms. Furthermore, the AB studies conducted so far have been limited to the use of negatively valanced stimuli [Corden et al., 2008b; Gaigg & Bowler, 2009]. It would be useful to determine whether positive emotions lead to similar differences in patterns of attentional orienting between ASD/High AQ and control/Low AQ individuals.

Acknowledgments

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