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Alterations in rapid social evaluations in individuals with high autism traits

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Abstract

Typically developing adults with low and high Autism spectrum Quotient (AQ) scores made rapid social evaluations of neutral faces when these were primed by briefly presented emotional faces. High AQ participants rated neutral faces as more threatening than low AQ participants, regardless of the prime condition. Both groups rated target neutral faces as more threatening with fear compared with neutral primes, while neither group demonstrated an effect of happy primes on the ratings neutral target faces. These results demonstrate subtle anomalies in rapid visual processing of emotional faces across the broader autism spectrum. They suggest that higher autism traits may be associated with a generalized threat bias in rapid social evaluations.

Keywords: autism spectrum; emotion recognition; social evaluation; rapid visual processing

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Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder with core deficits affecting social communication alongside restrictive and repetitive patterns of behaviour (American Psychiatric Association, 2013). Social impairments include difficulties interpreting social cues, particularly nonverbal cues from body language and facial expressions (American Psychiatric Association 2013; Schultz 2005). Individuals with ASD also tend to engage in atypical eye-movement patterns by spending less time fixating within the face region (Tsang 2018) and directing their gaze to specific facial features rather than the global configuration of those features. They also tend to make less eye contact than typically developing (TD) observers, instead focussing more on the mouth (Klin et al. 2002; Langdell 1978; Pelphrey et al. 2007; Senju and Johnson 2009; Król and Król 2019).

Various studies provide evidence for deficits in the processing of emotional faces in ASD, including electrophysiological (Batty et al. 2011; Dawson et al. 2005; Safar et al. 2020) and behavioural (Adolphs et al. 2001; Yeung and Chan 2020) studies. Meta-analyses have confirmed that behavioural deficits in processing emotional faces in ASD are indeed present overall, across studies that have tested for these differences relative to TD participants (Lozier et al. 2014; Uljarevic and Hamilton 2013). There are, however, conflicting findings. Some emotion recognition studies demonstrate similar performance between ASD and TD participants (Castelli 2005; Piggot et al. 2004; Wang et al. 2004). The inconsistencies may arise from differences in task demands between studies. Namely, ASD participants may yield similar results in face processing tasks as TD participants depending on what they are asked to do and the nature of the task. For example, individuals with ASD have been shown to accurately mimic emotional expressions when asked to do this explicitly, even though their mimicry is much more atypical in implicit conditions (McIntosh et al. 2006; Oberman et al. 2009). Explicit task demands may fail to capture the complex and implicit nature of real-world face perception. Other studies demonstrate typical face-emotion recognition accuracy in participants with ASD despite atypical eye-gaze patterns, slower latencies of electrophysiological signals, and atypical neural activity (Harms et al. 2010). This suggests that the neural circuitry which underpins face emotion recognition may be markedly different from TD populations, despite behavioural performance appearing typical under certain conditions.

The inconsistent findings in emotion recognition across studies may also relate to the exposure time of face photographs. Some studies that find no impairment in ASD used longer exposure times (e.g., 5 seconds: Piggot et al. 2004) for presenting emotional faces to be identified than other studies that demonstrate impairments in ASD (e.g., 500ms: Batty et al. 2011). Longer exposures may allow time for more deliberate, conscious visual processing to occur, enabling participants with ASD to perform as well as TD participants. The ecological validity of such long exposure times should be questioned. Normal social interactions usually involve rapid processing that is automatic and implicit, as opposed to slow processing that is deliberate and performed consciously (Hall et al. 2007; Rellecke et al. 2011).

Prominent theoretical models have linked social communication difficulties in ASD to the amygdala (Bauman and Kemper 1985; Howard et al. 2000; Baron-Cohen et al. 2000). The amygdala is part of a ‘social brain’ network responsible for emotion processing (Hariri et al. 2000). Several functional magnetic resonance (fMRI) studies have found abnormal amygdala function associated with face-emotion processing deficits in ASD (Adolphs et al. 2002; Critchley et al. 2000; Pierce et al. 2001; Sato et al. 2019). Normally, when viewing an emotional expression, the amygdala is responsible for rapidly activating the fusiform face area, a region within the occipito-temporal cortex, which is used to decipher facial emotions (Grelotti et al. 2002; Adolphs 2002). Different patterns of neural dysfunction have been observed depending on whether participants pay explicit attention to the emotion, or are asked to direct attention away from the emotion of faces (e.g., identifying the gender of an emotionally expressive face), usually termed implicit emotion processing (Hubl et al. 2003; Critchley et al. 2000). For example, compared with controls, adults with ASD showed lower activation in the cerebellum and amygdala during implicit emotion processing (Critchley et al. 2000). In the same study, the explicit emotion condition also revealed lower activation in the middle temporal gyrus, which is involved in processing facial features. Similarly, pupillometry research has suggested that when listening to positive or negative prosody in sentences under spontaneous listening conditions with no task instruction, participants with Asperger’s group showed abnormal pupillary responses with increased dilation for negative sentences, while the control participants showed increased dilation for positive sentences (Kuchinke et al. 2011). However, when explicitly instructed to listening for emotional prosody in sentences, the Asperger’s Syndrome and controls both showed increased pupil dilation to emotional sentences. It is possible that the amygdala and related emotion processing regions may function normally with higher levels of conscious attention. This suggests that the face-emotion recognition deficits observed in ASD may not be due to a dysfunction of cortical face processing regions per se, but instead a failure of the amygdala to automatically and rapidly respond to the emotional content of faces.

In the general population, rapid visual processing has been shown to be more important for broader aspects of social cognition beyond the detection of emotion expression. For example, social evaluations of another person are frequently based on the visual characteristics of their face. Making a first impression of a face has been shown to require as little as 40 ms (Bar et al. 2006). Bar and colleagues presented TD adults with photographs of faces with neutral expressions, asking them to rate how threatening the face appeared. Importantly, the faces did not display an emotional expression, but instead posed with neutral emotional expressions. These subjective threat ratings were compared between groups of participants who viewed the same faces for different durations. The results revealed highly consistent threat judgment ratings between participants who view the neutral faces with presentations as short as 39 ms in duration, when compared with those participants who viewed the faces for 1700 ms. However, shorter durations of 26 ms were much less reliable.

The current study extended this paradigm to study the autism spectrum. Similar to Bar et al. (2006), neutral expression faces to be rated were shown for short durations (100 ms). However, extremely brief (16 ms) priming faces (happy, fearful or neutral expressions) were presented prior to each target neutral face to examine whether activation of rapid emotional processing could influence social evaluations of the subsequently presented faces. Such rapid priming of emotional reactions has been shown to influence preference judgements of unfamiliar objects in TD adults (Faivre et al. 2012; Almeida et al. 2013; Mohan et al. 2016). Almeida et al. (2013) demonstrated that when unfamiliar Chinese characters were primed with happy faces by using backward masking, likeability ratings of the characters were more positive, whereas when angry faces were used as primes, likeability ratings were more negative.

This type of affective priming task has also been conducted in ASD populations. Kamio et al. (2006) found that children with Pervasive Developmental Disorder did not demonstrate any affective priming in both subliminal and supraliminal conditions. The authors of the study suggested that this may reflect an impairment in evaluating the emotional significance of faces. Likewise, Hall et al. (2007) found differences in ASD children's capacity to utilise rapidly presented priming faces in social evaluations of subsequently presented neutral faces. Children with ASD were more likely than control participants to judge a target neutral face primed with an anxious face to be more friendly than the one primed with a happy face.

Previous studies have utilised backward masking techniques in affective priming paradigms to assess non-conscious processing, given that the emotional faces are prevented from reaching conscious awareness (Almeida et al. 2013; Murphy and Zajonc 1993). Studies on affective priming in ASD indicate that there are anomalies in mechanisms that subserve automatic and potentially nonconscious emotional processing, possibly driven by subcortical pathways direct to the amygdala (Hall et al. 2007). Whereas the face priming paradigm of Hall et al. (2007) included relatively long delays between the first prime and the ultimate presentation of a target face to evaluate (>4sec), as well as an unlimited inspection time of targets to be evaluated, these conditions are not likely to preferentially rely on rapid and more automatic processes of emotion processing and social evaluation such as are required in more realistic social interactions. Thus, the current study sought to investigate the immediate effects of briefly presented affective primes on rapid social evaluations of neutral faces.

To examine how these processes might relate to ASD, we took a dimensional approach comparing performance in TD individuals who exhibit high levels of subclinical, autistic-like features with those that exhibit lower levels of these same traits. This approach models ASD and offers several advantages that can outweigh the disadvantage of not examining an ASD population directly (Landry and Chouinard 2016). It is now well-established that autistic behavioural traits extend beyond clinical impairment and into the TD population (Landry and Chouinard 2016; Piven et al. 1997; Baron-Cohen et al. 2001). This in turn allows the study of the traits that characterise ASD across the full spectrum of presentations (Landry and Chouinard 2016). Individuals with higher levels of quantitative autism traits, but who do not have an ASD diagnosis, demonstrate similar – though less pronounced – difficulties in social-communication. For example, participants with higher autism traits demonstrate relative difficulties in emotion recognition when compared with low autism trait individuals (Miu et al. 2012; Poljac et al. 2013). In fact, there is now much research indicating that visual and attentional difficulties related to social and emotional processing extend into the non-clinical population with higher autism traits (Laycock et al. 2019; Laycock et al. 2014; Grinter et al. 2009; Vukusic et al. 2017; Åsberg Johnels et al. 2017). This dimensional approach of studying quantitative autism traits in the general population allows increased ability to control for IQ differences, and comorbidity, which can confound clinical ASD research (e.g., Landry and Chouinard 2016; Hofvander et al. 2009). In summary, there is an increasing appreciation that cognitive, perceptual and behavioural anomalies associated with autism traits in the general population can provide valuable insight into understanding ASD.

The present study aimed to compare the influence of automatic processing of emotional faces on rapid social evaluations in individuals from the general population that had low and high levels of autism traits. Here, the ability for briefly presented affective stimuli to prime the social evaluations of consciously visible, but rapidly presented neutral faces was measured. Participants with high autism traits were hypothesised to judge neutral faces preceded by fearful primes as less threatening than participants with low autism traits, whilst it was hypothesised that participants with high autism traits would judge neutral faces preceded by happy primes as less friendly than participants with autism traits, reflecting a relative difficulty in utilising automatic affective face processing to influence social evaluations.

Method

Participants

Participants were selected through an online screening process by completing the Autism Spectrum Quotient (Baron-Cohen et al. 2001) and a demographic survey. Advertisements were placed around the university campus and online through various social media pages and groups external to the university. From an initial sample of 227, participants were selected if they self-reported no known psychiatric conditions (including no diagnosis of ASD), normal or corrected-to-normal vision, and were between the ages of 18 and 40. All participants who met this criteria and fell within the AQ inclusion criteria were invited to participate in the lab-based study, which resulted in a sample of 56 participants. Cut-off scores for high and low AQ groups (≥ 21 and ≤ 13, respectively) were taken from Miu et al. (2012) who selected participants 1 SD above and below the mean AQ score from an initial larger sample. These cut-off scores are similar to those used in other studies that compared low and high AQ groups (Stevenson and Hart 2017). In the current study, participants completed the AQ online and were invited to participate in the laboratory study if they met the inclusion criteria.

A power analysis was conducted based on the backward masking study completed by Hall et al. (2007) in which a comparison between ASD and control participants established a group effect with a Cohen’s d of 1.11. Conservatively, assuming smaller effects in a non-clinical sample ($d = 0.8$), G*Power (Faul et al. 2009) was used to estimate that a total sample size of 52 ($n = 26$ per AQ group) would be required to observe a significant difference between AQ groups in the current study with $\alpha = 0.05$ and power 0.80. Ultimately, two groups of 28 were recruited, though one participant in the high AQ group was excluded due to a corrupt data file for the main task. Table 1 provides the demographic characteristics of the low and high AQ groups.

(Table 1 here)

Materials

The Autism Spectrum Quotient (AQ). Participants were asked to complete the Autism-Spectrum Quotient (AQ) Questionnaire (Baron-Cohen et al. 2001). The AQ is a 50-item questionnaire that measures traits associated with the autism spectrum, allowing individuals in the general population to be placed on a continuum that extends below the threshold for a clinical diagnosis of ASD. The AQ uses a 4-point Likert scale to rate the extent to which participants agree with statements related to social characteristics associated with the autism spectrum. The binary scoring method described in the original study (Baron-Cohen et al. 2001) was used. Participants received one point for answers which endorse an autism-like trait, with scores ranging from 0-50, and higher overall AQ scores indicating more traits associated with the autism spectrum. The AQ has good psychometric properties, including good test-retest reliability and moderate internal consistency (Baron-Cohen et al. 2001; Cronbach's α varying from .63 to .78).

Face stimuli. A pilot study was conducted to select face stimuli that were perceived as genuinely neutral (i.e., no positive or negative affect), as well as face stimuli reliably rated as either fearful or happy. This was carried out to produce a valid set of images for the main experiment. Two-hundred photographs of neutral faces, one-hundred happy faces, and one-hundred fearful faces were sourced from the Karokinska Directed Emotional Faces database (Lundqvist et al. 1998), the Nimstim set of facial expressions (Tottenham et al. 2009), the Oslo Directed Faces dataset (Chelnokova et al. 2014), and the Radboud Faces database (Langner et al. 2010). Five participants (who were not included in the main experiment) rated each neutral face using a 5-point Likert scale between 1 (positive emotion) and 5 (negative emotion). From this, a final set of 20 faces were selected to be the neutral target faces, with an average rating of 2.97 (SD = 0.07). A second set of 20 faces were selected to be the neutral prime faces, with an average rating of 3.02 (SD = 0.06). Happy and fearful images were also rated on Likert scales ranging from 1 (no happiness/fear) to 8 (extremely happy/fearful), with average ratings of 4.9 (SD= 0.5) and 4.5 (SD = 0.88) for the final set of 20 happy and 20 fear face images, respectively. This final set of faces were cropped, converted to greyscale, and edited to have matching brightness and contrast properties using Photoshop software. Average Photoshop luminance levels for the images across the different prime conditions were evenly matched (fear = 117.05 (SD = 6.03), happy = 117.20 (3.02), neutral = 118.75 (2.10)). Each image subtended 8 x 6 degrees of visual angle with participants seated 57 cm from the monitor.

Social evaluation task: Sixty trials were presented on a 21.5-inch iMac computer with 1920 x 1080 resolution. VPixx software (VPixx Technologies, version 3.20) was used to present the experimental tasks and record response choices. Each trial had the following sequence: a fixation cross (0.7 degrees of visual angle in height and length) was presented on a grey background for 100 ms, a prime face was then presented for 16 ms and was directly followed by a neutral target face for 100 ms (see Figure 1). The neutral target face was removed and a social evaluation Likert rating scale was presented. Participants provided their rating of the target face by keyboard press. Each of the 20 target neutral faces were presented three times during the experiment, each time primed with a different face emotion (happy, neutral, or fearful). The presentation order was randomized separately for each participant. Participants were not informed that priming faces would be presented, and were instead instructed to view the “flashes” and focus on the last image (i.e., the target neutral face).

(Figure 1 here)

Prime Emotion Discrimination Task. After the social evaluation task, participants were informed about the presence of the emotion prime faces, and completed a task with an identical trial sequence to the social evaluation task. In this task however, participants were directed to determine the emotion of the first face in each trial, and used a keyboard to indicate whether this was fearful, happy, or neutral. On each trial subjective awareness was assessed by requiring participants to respond to a second question regarding their confidence in their answer by selecting from the options provided: ‘guess’, ‘believe’ or ‘sure’ (Ohman and Soares 1994).

Data Analysis

The effect of prime faces on subsequent social evaluations was evaluated in two ways. First, the average rating for all neutral targets presented with a fear prime (and then also with happy and neutral primes) was calculated. A mixed design ANOVA with prime emotion (fear, happy, neutral) and AQ group (high, low) was used to assess the effect of primes on ratings of neutral target faces. This approach allowed assessment of the difference in threat ratings of neutral faces between AQ groups, as well as the influence of different primes on these threat ratings. Given each target neutral face may vary slightly in the baseline subjective threatening/friendly rating, there may be some inherent noise in averaging across the different target neutral faces.

The second approach took advantage of the experimental design presenting each neutral target face three times: once with a randomly selected priming face from each emotion condition (i.e., fear, happy, neutral). Thus, the within-target difference in social evaluations due to prime emotion was determined and allowed for the calculation of a fear prime-effect and a happy prime-effect. The fear prime-effect was calculated by determining the change in rating for each target by subtracting the rating following a neutral prime from the rating following a fearful prime. This was then averaged across each of the 20 neutral target faces for each participant. The same approach was taken to calculate a happy prime-effect. A negative score would indicate a more threatening social evaluation when the same neutral target was presented with an emotional than with a neutral prime, whereas a positive score would indicate a more friendly social evaluation when the same neutral target was presented with an emotional than a neutral prime. One sample t-tests were conducted for each AQ group to determine whether there were statistically significant fear and happy prime effects, tested against 0. This second analysis was expected to be more sensitive in detecting any difference in ratings between emotional (fear, happy) and neutral primes. The first analysis, whilst able to test for the effect of prime effects, had as a main advantage the ability to assess the overall social evaluation ratings across all prime conditions.

The Prime Emotion discrimination task objective accuracy scores were analysed using the same mixed design ANOVA approach as above, with prime emotion as the within subjects factor, and AQ group as the between subjects factor. The subjective confidence ratings were also examined using a mixed design ANOVA with confidence level (guess; somewhat sure; sure) and prime emotion (fear, happy, neutral) as within subjects factors and AQ group a between subjects factor.

Results

Social evaluation task

For the first planned analysis, a mixed-design ANOVA revealed no main effect of prime emotion, F (2,106) = 0.63, p = .534 η_p^2 = .012. On the other hand, the main effect of AQ group was significant, F (1, 53) = 8.25, p = .006, η_p^2 = .135, with the high AQ group providing higher overall judgements of threat to the visible neutral face targets than the low AQ group (see Figure 2). The interaction between AQ group and prime emotion was not significant, F (2, 106) = 0.16, p = .83, $\eta_p^2 < .01$ (see Figure 2).

(Figure 2 here)

In the second approach to determining the effect of primes, fear and happy prime effects were analysed (see Figure 3) using an Bonferroni adjusted alpha level of .0125. Both the low and high AQ groups demonstrated significant negative fear prime-effects (low AQ: t(27) = 3.26, p = .003, d = 0.62; high AQ: t(26) = 2.77, p = .010, d = 0.53) with the mean fear effect indicating target neutral faces were rated as more threatening when preceded by fear compared with neutral primes (low AQ: M = -0.16, SD = .26; high AQ: M = -0.17, SD = .32). No significant happy prime-effects were established for the low AQ group, (t(27) = 2.50 p = .019, d = 0.47), or for the high AQ group (t(26) = 0.65. p = .52, d = 0.12).

(Figure 3 here)

Due to a concern about the imbalance of gender within the high and low AQ groups, a mixed design ANOVA was run with prime emotion as within-subjects factor and gender as a between-subjects factor. It was considered that an ANOVA including both AQ group and gender as between-subjects factors would be underpowered due to small cell sizes. There were no main effects of gender (p = .145) or prime emotion (p = .819), and no interaction effect between gender and prime emotion (p = .378).

Prime Emotion Discrimination Task. With regards to the objective accuracy scores, a mixed design ANOVA revealed a main effect of emotion, F (2, 104) = 25.60, p < .001, η_p^2 < .33, no main effect of group, F (1, 52) = 1.87, p = .18, η_p^2 < .03, and no interaction between emotion and group, F (2, 104) = 1.58, p = .212, η_p^2 = .029. Furthermore, accuracy in identifying each emotion was above chance (33.33%) for both the low AQ group (fear: p = .011; happy: p < 001; neutral: p < .001) and the high AQ group (fear: p = .029; happy: p < 001; neutral: p < .001), although the fear condition did not remain significant after correcting for multiple comparisons (adjusted α = .008) (see Figure 4a).

Analysis of the subjective confidence ratings revealed a main effect of confidence level (F (2, 100) = 3.26, p = .043, η_p^2 = .061), with more trials rated as 'believe' than both 'guess' (p = .027) and 'sure' (p = .015). There were no main effects of emotion (F (2, 100) = 1.03, p = .361, η_p^2 = .020) or group (F (1, 50) = 0.14, p = .708, η_p^2 = .003). There were no two-way interactions involving the AQ group factor (confidence level x group: F (2, 100) = 2.22, p = .114, η_p^2 = .042; emotion x group: F (2, 100) = 0.28, p = .756, η_p^2 = .006). There was however a significant interaction between confidence level and emotion (F (4, 200) = 5.43, p < .001, η_p^2 = .098). The three-way interaction between confidence level, emotion, and group was not significant (F (4, 200) = 2.21, p = .084, η_p^2 = .042). Collapsing responses across emotion conditions, Figure 4b illustrates the proportion of responses given for each confidence level.

(Figure 4 here)

It is possible that the variability in the visibility of the primes may have influenced priming effects in the preceding main experiment despite the analyses not revealing a significant group by prime emotion interaction in the Prime Emotion Discrimination task. Nevertheless, Pearson's correlations were run between prime emotion discrimination accuracy and average threat ratings from the main experiment, with the alpha set to a more conservative .01, rather than using Bonferroni correction due to the exploratory nature of the analysis.

Of interest, given the surprising direction of the happy prime effect established in the low AQ group, this correlation analysis revealed a non-significant correlation between the happy prime-effect and accuracy in discriminating happy primes, $r(27) = .356$, $p = .068$, though this was not apparent in the high AQ group, $r(27) = .265$, $p = 0.181$. For all other correlations between emotion discrimination accuracy for each condition and average threat ratings for each prime condition or prime-effects, there were no significant effects established in the low AQ group (all p's >.094; all r's <.329) or in the high AQ group (all p's >.063; all r's <.362).

Discussion

The aim of this study was to examine the relationship between autistic traits and the rapid social judgements of neutral faces, and the effect of briefly presented priming emotional faces on these social judgements. In doing so, it sought to determine whether atypical face processing, common in ASD, could be explained by anomalies in rapid emotional processing in those with high autistic traits. The results revealed that individuals with higher autistic traits, somewhat unexpectedly, demonstrated a more general negative bias in the rapid judgements of neutral faces when compared with those with low autism traits. However, no significant associations between priming and autism traits were established.

Regarding the effect of priming, using rapid presentation (16 ms) of emotional faces, the first analysis did not indicate evidence for any priming across all participants. The second analysis that compared emotional (fear, happy) and neutral primes for the same target stimulus within the same subject, and hence a more sensitive measure of priming, was able to reveal a fear prime-effect in both groups. However, despite the low AQ group demonstrating a moderate happy prime effect, no significant happy prime effects were established in either AQ group. It should be noted that the moderate, though non-significant happy prime-effect revealed by the low AQ participants was in the same direction as that found for the fear prime-effect. That is, the happy primes tended to have the effect of increasing the threatening ratings of the neutral target faces. It was predicted that fear primes would have the effect of increasing threat ratings, whereas happy primes would decrease threat (increasing friendly) ratings (Almeida et al. 2013). Given this unexpected result did not survive Bonferroni correction for multiple comparisons, this finding should not be interpreted further. As it stands, the present results indicate that under the conditions tested, subtle priming effects were evident in both high and low AQ groups for fear primes only.

The absence of group differences in this type of rapid emotional priming appears inconsistent with some behavioural paradigms which show that social evaluations are less influenced by affective stimuli presented outside of conscious awareness in ASD (Hall et al. 2007). One possibility for this apparent discrepancy is that the visibility of the primes alters the type of processing required. Previous studies that have found anomalies in non-conscious priming associated with ASD used backward masking paradigms in which face stimuli were presented for 16 ms (Stavropoulos et al. 2018; Vukusic et al. 2017). The current study also presented prime faces for 16 ms, followed by the target neutral face which acted as a mask for these prime stimuli. However, the follow-up control task suggested that although the emotions were difficult to discriminate, performance was at above chance levels for all conditions (fear, happy, neutral) in both AQ groups, indicating that the priming effects established could not be specifically attributed to non-conscious mechanisms (whilst not ruling out such mechanisms may be involved). Given the rapid presentation of the prime faces, as well as the relatively brief duration of the target faces (100 ms), it is likely that the priming effects were in some respects automatic rather than reflecting a conscious cognitive mechanism. Thus, we argue that as the amount of conscious processing of emotional prime stimuli is reduced, the greater the deficiency in those with higher autism traits may be evident. This speculation would need to be directly examined in further studies.

An unexpected finding in the current study was that social evaluations of neutral target faces, averaged across all prime conditions, were different between AQ groups. Results indicated that the high AQ group rated rapidly presented neutral faces as more threatening than the low AQ group. This finding is despite the fact that a pilot study utilising a different group of participants selected these neutral target faces on the basis that they lacked any positive or negative emotional valence. The apparent bias in subjective threat evaluations established here could suggest that high autism traits are associated with a social threat bias. A default threat bias toward neutral faces has been shown in individuals who are socially anxious (Yoon and Zinbarg 2008). Given that anxiety is commonly comorbid in ASD (Kerns et al. 2015; Simonoff et al. 2008), and also correlated with AQ scores in the general population (Salmela et al. 2019; Kanne et al. 2009; Kunihira et al. 2006), future research should examine the contribution of anxiety to the relationship between autistic traits and social evaluations of rapidly presented neutral expression faces.

Previous ASD research has examined participant ratings of face trustworthiness, with mixed findings. Some have suggested that adults with ASD rated untrustworthy looking faces as more trustworthy than control participants (Adolphs et al. 2001; Couture et al. 2010). However, in one of these studies, this result was not significant following correction for multiple comparisons (Couture et al. 2010), whilst another study only included a small sample of 8 participants with ASD, with two extreme outliers (Adolphs et al. 2001). On the other hand, a decrease in face trustworthiness ratings has been suggested by Mathersul et al. (2013), though again this behavioural result was not statistically significant. Mathersul et al. also measured skin conductance responses to the neutral faces, and found that although ASD participants demonstrated typical initial responses, these responses did not habituate as was found in the control participants. These results were suggested to indicate that ASD is associated with an abnormality in the allocation of attention and emotional significance to faces.

In the current study, prime faces were presented for 16 ms which may have been presumed to prevent conscious awareness of these stimuli. In fact, previous backwards-masking studies have used duration times of anywhere from 16ms to 33ms when presenting supposedly non-conscious stimuli (Hall et al. 2007; Vukusic et al. 2017). However, it appears from the above chance accuracy in the prime face emotion discrimination task that under the current conditions, even 16 ms may not be brief enough to effectively prevent individuals, regardless of AQ group, from consciously seeing an emotional face. Although this appears to be quite a remarkable achievement, it could be argued that these faces were in fact masked from conscious awareness, and that non-conscious processing allowed above chance accuracy in emotion identification. This explanation seems unlikely given that the emotion discrimination task found that both the low and high AQ groups were either "somewhat sure" or "sure" of their answer on a majority of trials (65% and 70%, respectively), which accords with previous findings that face emotion can be discriminated with 20 ms exposure using both objective sensitivity and subjective awareness ratings (Milders et al. 2008). Hence, this points towards the very rapid processing of face emotion. Indeed, evidence from behavioural studies indicates that faces and emotion-processing are given special precedence, and humans are especially skilled at detecting fearful emotional stimuli, suggesting an evolutionary sensitivity to survival related expressions (Ohman and Mineka 2001; Vuilleumier 2005; Williams et al. 2004). The ability to rapidly form impressions or make judgements of emotional faces may also facilitate survival (Bar et al. 2006). Humans have a greater amount of expertise devoted to face processing compared to other objects, with faces apparently forming a special kind of object, the processing of which is evolutionarily highly important (Crouzet et al. 2010; Peykarjou and Hoehl 2013).

A limitation of the current study was the imbalanced gender ratio between the high and low AQ groups. In the current study, AQ scores were non-significantly ($p = .132$) higher on average in males ($M = 20.5$, $SD = 6.7$) than females ($M = 17.0$, $SD = 9.5$). Although the higher number of males in the high AQ group compared with the low AQ group reflects the pattern of higher AQ scores found in the general population

(Ruzich et al. 2015; Baron-Cohen et al. 2001), as well as the higher incidence of ASD diagnoses in males (Fombonne 2005), there is a remaining concern that the differences reported between AQ groups could be better explained by gender, rather than AQ score. This explanation does not appear to be parsimonious when one considers that our analyses suggested that priming effects on social evaluations were not affected by gender.

Furthermore, the current study recruited participants from the general population, rather than testing individuals with a diagnosed ASD. Thus, we cannot determine if these effects in social evaluations are similarly associated with ASD and autistic traits. Indeed, the dimensional approach taken to understanding ASD in the current study may explain the lack of significant differences between AQ groups in the priming effects. Thus, the absence of a significant effect may reflect that a smaller effect is more difficult to reveal in a non-clinical sample for whom we assume similar though less pronounced visual anomalies are evident. Alternatively, it remains possible that this aspect of rapid emotional priming is qualitatively different between those with a clinically diagnosed ASD and typically developing individuals with higher autism traits.

In conclusion, the current study demonstrated that prime fear faces resulted in an increase in threat ratings of target neutral faces for both the low AQ and high AQ groups. On the other hand, individuals with high and low levels of autistic traits were found to differ in their rapid social evaluations of neutral faces, with the high AQ group being more likely to rate faces as threatening than the low AQ group. This result suggests that the processes which underlie social judgements in individuals with high levels of autistic traits are altered when compared with low autism trait participants. In particular, it suggests that the rapid processes of integrating and interpreting salient social and emotional cues from faces are anomalous across the broader autism spectrum.

Declarations

The authors declare that they have no conflict of interest.

Ethics approval

This study was approved by the RMIT College of Science, Engineering and Health Human Ethics Committee and was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

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Figure Captions

Fig. 1 Trial sequence for the social evaluation task using a backwards masking paradigm. The prime was masked by the target neutral face to which participants were required to evaluate. Following the target, participants were presented with an evaluation prompt consisting of a 6-point Likert scale ranging from 1= very friendly to 6 = very threatening.

Fig. 2 Mean social evaluation scores of target neutral faces as a function of AQ group and prime condition. High scores indicate neutral faces were rated as more threatening while lower scores indicate that the faces were rated as more friendly. Error bars represent standard errors around the mean.

Fig. 3 Mean prime effects indicating the change in social evaluation of neutral target faces due to emotional versus neutral primes, as a function of AQ group. Positive prime effects indicate emotional primes resulted in higher ratings of threat when compared to neutral primes. Negative prime effects indicate emotional primes resulted in higher ratings of friendliness when compared to neutral primes. Error bars represent standard errors around the mean. Asterisks (*) indicate significant one-sample t-test against 0, $p < .01$.

Fig. 4 (a) Accuracy scores on the Emotion Discrimination Task for identifying each emotion. (b) The proportion responses given for each confidence rating, across all trials and emotion conditions.

Figure 1:

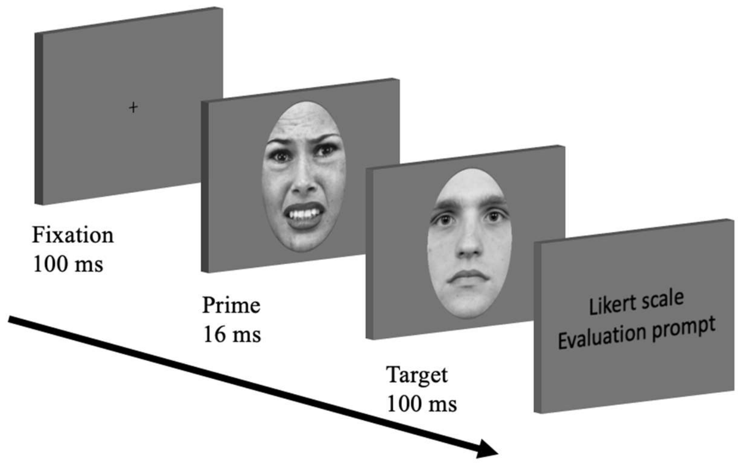
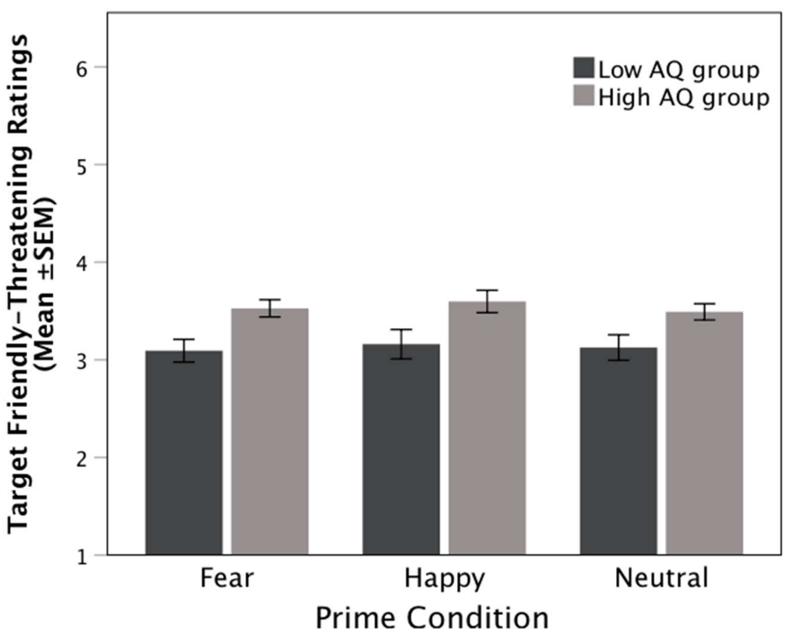


Figure 2:



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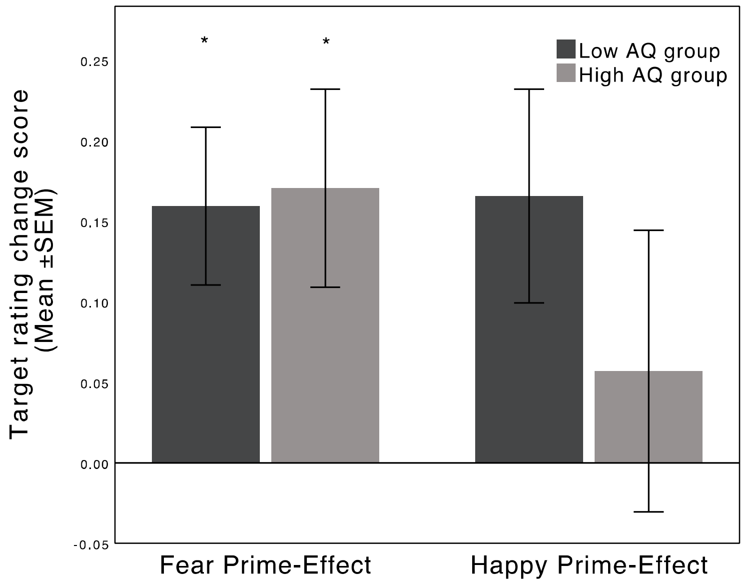

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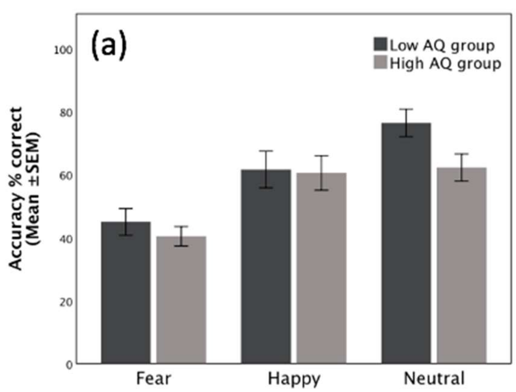

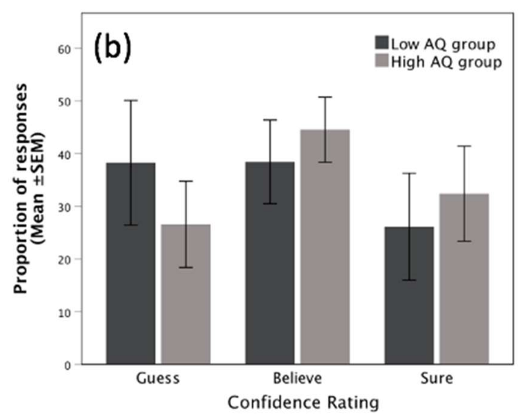

Table 1.

Group Descriptive Statistics

AQ Group	N	Mean Age (SD)	Gender Ratio (M:F)	Mean AQ Score (SD)
Low	28	25.29 (5.36)	5:23	10.00 (2.96)
High	27	25.89 (5.35)	11:16	26.22 (4.37)