FACIAL PROCESSING AND AUTISTIC TRAITS

INTEGRATION OF GAZE DIRECTION AND FACIAL EXPRESSION IN INDIVIDUALS WITH A HIGH LEVEL OF AUTISTIC TRAITS

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ABSTRACT

We investigated whether individuals with high levels of autistic traits integrate relevant communicative signals, such as facial expression, when decoding eye-gaze direction. Students with high vs. low scores on the Autism Spectrum Quotient (AQ) performed a task in which they responded to the eyes' direction of faces, presented on the left or the right side of the screen, portraying different emotional expressions. In both groups, the identification of gaze direction was faster when the eyes were directed towards the centre of the scene. However, only in the low AQ group, this effect was larger for happy than for neutral faces or faces showing other emotional expressions. High AQ participants were not affected by emotional expressions. These results suggested that individuals with more autistic traits may do not integrate multiple communicative signals based on their emotional value.

Keywords: eye-gaze; emotional expression; attention; autistic traits

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Introduction

Eye-gaze direction signals another person's focus of interest and can orient our attention to potentially relevant locations or objects in the surrounding space (e.g. Friesen and Kingstone, 1998; Marotta, Casagrande and Lupiañez, 2013). Information from different sources are considered when interpreting eye-gaze direction, such as the iris/sclera ratio (Ando, 2002), the head posture (Langton 2000), the presence of object near the fixation point of another person's (Lobmaier, Fischer, and Schwaninger, 2006) and, of relevance for the present study, the emotional facial expression. Facial expressions of other people can help determine the emotional state or motivational intentions, and several evidences indicate that the processing of the gaze direction and emotional expression mutually interact. On the one hand, some studies have observed that the processing of emotionally relevant facial information is modulated by gaze direction modulated: the perception of approach-oriented emotions (anger or joy) is enhanced by direct gaze, while the perception of avoidance-oriented emotions (sadness and fear) is enhanced by averted gaze (Adams and Kleck 2003, 2005). Conversely, the perception of gaze direction is modulated by emotional expressions. Smiling faces are more likely to be interpreted as directed towards the observer than are fearful, angry, and neutral faces (Lobmaier and Perrett 2011; Lobmaier, Tiddeman, and Perrett, 2008). These findings have been explained by the "self-referential positivity bias", according to which people are more likely to believe that they are the source of someone else's happiness, so as to improve self-esteem. Abnormal eye contact is among the clinical symptoms of autism (ASD; American Psychiatric Association, 2013), and it is supposed to be a core feature of this disorder. However, recent studies seem to suggest that it may not depend on the

primary impairment in the interpretation of gaze direction, but that it may rather depend on the encoding of its intentional and referential property. Indeed, some studies have showed that people with ASD are equally adept at correctly identifying the direction of the gaze than TD individuals (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997). However, they seem to present difficulties in integrating gaze direction with communicative and social contexts (Pelphrey, Morris, and McCarthy, 2005; Baron-Cohen, Baldwin, and Crowson, 1997). In particular, of relevance for the present study, Akechi et al. (2009) observed that autistic children were impaired with regard to integrating the information of facial expressions and gaze direction. The main aim of the present study was to investigate whether individuals with high levels of autistic traits integrate facial expression when decoding eye-gaze direction. To achieve this aim, we used the gaze discrimination task elaborated by Cañadas and Lupiáñez (2012) to explore the importance of eye-gaze direction in spatial interference paradigms. These authors demonstrated that gaze direction discrimination is faster and more accurate when gaze is oriented “inwards,” towards the centre of the scene (e.g., right averted gaze presented on the left) than when it is directed outwards (e.g., right averted gaze presented on the right). This effect was opposite to the classical results generally observed with non-social stimuli, such as arrows (e.g., faster reaction time for arrows pointing outwards, Marotta, Caballero, Lupiáñez, 2018) and it was interpreted in terms of eye contact (e.g., a speeding up of responses when the target face seems to look directly at the participants). A further investigation revealed that this effect was modulated by the emotional expression of the face (Jones, 2015) according to the “shared signal hypothesis” (Adams and Kleck 2003, 2005): the inward effect was larger when it was coupled with approach-oriented emotions such as happiness and anger, while it was smaller for the avoidance oriented

emotions such as fear. The predictions of the present study were straightforward: since individuals with ASD present difficulties in integrating gaze direction with communicative and social contexts, the identification of gaze direction should not be affected by the emotional expression of facial stimuli in participants with high levels of autistic traits. In contrast, the inward effect from gaze direction should be modulated in participants with low levels of autistic traits. In particular, in the case of individuals with low autistic traits, there are two possible scenarios. If the emotional expression modulates the identification of gaze direction, according to “shared signal hypothesis” (Adams and Kleck 2003, 2005), then a greater inward effect should be observed with approach-oriented emotions as compared to avoidance oriented emotions. In contrast, if the identification of gaze direction is modulated by emotional expression according to the “self-referential-positivity bias hypothesis” (Lobmaier et al. 2008, Lobmaier and Perrett 2011), then the inward effect should be larger for happy faces than for faces showing other emotional expressions or a neutral expression.

Method

Participants

Initially, 459 students completed the AQ (mean [M] score = 16.29; standard deviation [SD] = 5.88). Next, students from the upper and lower quartiles of the AQ distribution (using cutoff scores equal or lower of 11 and scores equal or higher than 22) were invited to complete further testing. The characteristics of the resulting high and low AQ groups are outlined in Table 1. The groups did not differ significantly in age distribution, $F(1,34) < 1$. Numerically, there was a higher proportion of females in the high AQ group than in the low AQ group, but this difference was not statistically significant, $\chi^2(1) = 2.09$, $p = .148$.

The Autism-Spectrum Quotient (AQ)

The AQ is a 50-item self-report questionnaire designed for measuring autistic traits in the general population (Baron-Cohen et al., 2001). In particular, it assesses five different domains relevant for autistic traits: social skills, attention to detail, attention switching, communication and imagination. A Spanish version (retrieved from https://www.autismresearchcentre.com/arc_tests) of this instrument has been used specifically for quantifying where are participants situated on the continuum from autism to normality.

Apparatus and Stimuli

The E-Prime 2.0 software was used to control stimuli presentation, timing, and data collection. Stimuli were presented on a 17" screen running at a 1024 pixel $\times$ 768 pixel resolution and consisted of 40 full-color photographs of four males and four females (dimensions= 180 pixels $\times$ 200 pixels or 7.5 cm $\times$ 6.5 cm) displaying either a neutral, angry, sad, fearful, or happy emotional expression. Faces were selected from the Karolinska Directed Emotional Faces (Lundqvist et al., 1998) and were manipulated with Adobe Photoshop CS6 to change gaze directions to the left and right sides.

Procedure

Gaze Discrimination Task. Participants were required to discriminate, as fast and accurately as possible, the direction (left or right) of the eye gaze of the faces presented to the right or the left of a fixation point. They were tested while seated at approximately 60 cm away from the monitor in in a faintly lit room. Each trial started with the onset of a white fixation cross ($0.5^\circ \times 0.5^\circ$) centred on a black computer screen for 500 ms. Then, a face displaying different emotional expressions, was presented either to the right or to the left of the fixation cross and gazing either to the right or to the left (see Figure 1). The distance from the inner edge of the face to the central fixation was approximately 3.02° . Importantly, this design produced inward trials where

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eyes were directed towards the central fixation location (i.e., right averted gaze of faces presented on the left and left averted gaze of faces presented on the left) or outward trials (i.e., left averted gaze presented on the left and right averted gaze presented on the right). Participants had to discriminate the face's gaze direction by pressing, respectively, the "Z" or "M" key of the computer keyboard when the correct answer was left or right. Feedback on no-response or incorrect response trials was provided via a 220-Hz tone for 700 ms. All possible combinations of stimuli, 8 (face identity) $\times$ 5 (emotional expression) $\times$ 2 (presentation side) $\times$ 2 (gaze direction), formed a total of 160 trials. Two blocks of trials with all combinations were presented for a total of 320 trials. Participants completed a practice block of 16 randomly selected trials to familiarize themselves with the task, followed by eight experimental subblocks of 40 randomly selected trials each, with a rest period between blocks.

Emotional Expression Categorization Task. After completing the gaze discrimination task, participants were prompted to pay attention to the screen for one last activity, in which they had to identify the emotional expressions of the same faces presented in the previous task. Faces with a direct gaze displaying either angry, happy, sad, neutral, or fearful emotional expression appeared at the center of the screen for an unlimited time. Participants were required to identify the expression of the faces by typing the answer on a computer keyboard.

Design

The experiment consisted of a 5 (Emotional Expression: happy, angry, fearful, neutral, or sad) $\times$ 2 (Gaze: inward trials vs. outward trials) $\times$ 2 (Group: high AQ vs. low AQ) mixed factor design. Emotional Expression and Gaze were manipulated within participants and the Group was manipulated between participants. Trials with reaction times (RTs) faster than 200 ms (0.2% of the trials) or slower than 1300ms (0.8% of the

trials) as well as incorrect responses (5.5% of the trials), were excluded from the RTs analysis. Mean RTs were computed for each experimental condition using the remaining observations (see Table 2).

Results

GAZE DISCRIMINATION TASK

Reaction Times. ANOVA revealed a significant main effect of *Emotional Expression*, $F(4,136)=13.68$, $p<.001$, $\eta^2p=0.29$, with lowest reaction times for fearful faces (645 ms) and highest for angry faces (617 ms). A main effect of *Gaze* was also found, $F(1,34)=48.85$, $p<.001$, $\eta^2p=0.59$, with faster RTs for inward trials (616 ms) than for outward trials (645 ms). Furthermore, significant interactions existed between *Emotional Expression* and *Gaze*, $F(4,136)=3.14$, $p=.016$, $\eta^2p=0.08$, and between *Group*, *Emotional Expression* and *Gaze*, $F(4,136)=5.84$, $p<.001$, $\eta^2p=0.15$ (see figure 2). Partial ANOVAs showed that the *Emotional Expression by Gaze* interaction was only significant in the low AQ group, $F(4,68)=7.12$, $p<.001$, $\eta^2p=0.29$: the inward gaze effect (RT outward trials – RT inward trials) was larger for happy faces than for neutral faces $F(1,17)=20.96$, $p<.001$, $\eta^2p=0.55$, or faces showing other emotional expressions, such as anger $F(1,17)=17.91$, $p<.001$, $\eta^2p=0.51$, fear $F(1,17)=10.58$, $p=.004$, $\eta^2p=0.38$, or sadness $F(1,17)=16.34$, $p<.001$, $\eta^2p=0.49$. In the high AQ group, the *Emotional Expression by Gaze* interaction was not significant, $F(4,68)=1.81$, $p=.137$, $\eta^2p=0.09$: the inward effect observed with neutral faces was not significantly different from that observed with faces expressing emotional expressions, such as happiness, anger, sadness (all $F_s<1$) or fear $F(1,17)=3.89$, $p=.065$, $\eta^2p=0.18$.

Errors. ANOVA revealed a significant main effect of *Emotional Expression*, $F(4,136)=5.56$, $p<.001$, $\eta^2p=0.14$, with the lowest percentage of errors being for fearful faces (4.1 %) and the highest for angry faces (6.9 %). A main effect of *Gaze* was also

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found, $F(1,34)=7.40$, $p=.01$, $\eta^2p=0.18$, with a lower percentage of errors for inward trials (4.2 %) than for outward trials (6.3 %). The main effect of Group was not significant, $F(1,34)=1.53$, $p=.224$, $\eta^2p=0.04$. The *Emotional Expression* x *Group* interaction was also significant, $F(4,136)=2.80$, $p=.028$, $\eta^2p=0.08$. The Low AQ group showed a lower percentage of errors than the High AQ group only for happy faces (3.6 % vs. 8 %), $F(1,34)=5.27$, $p=.028$, $\eta^2p=0.13$. No differences between groups were observed for neutral faces, $F(1,34)=1.44$, $p=.238$, or faces showing other emotional expressions, $F_s < 1$. No other interaction reached significance.

Emotional Expression Identification Task

The analysis of accuracy data indicated a main effect of emotional expression, $F(4,136)=2.80$, $p<.001$, $\eta^2p=0.48$. The highest accuracy was observed for faces displaying happiness (97.9 %) and the lowest for neutral faces (45.1 %). Importantly, the results showed that the Group did not have any effect, $F < 1$, and did not modulate the effects of emotional expression, $F < 1$.

Discussion

The present study examined the modulation of healthy people's autistic traits in the discrimination of the eyes direction displayed by faces expressing different emotions. In particular, our aim was to examine whether the ability to integrate facial expression when decoding eye-gaze direction depend on the extent of autistic-like traits, measured with the AQ. Both low and high AQ groups showed that the identification of gaze direction was faster when the eyes were directed towards the centre of the scene (inward effect). However, this effect was mediated by facial expression only in the group with low levels of autistic traits, so that the inward effect was larger for happy faces than for neutral faces or faces showing other emotional expressions. This finding is in contrast with the pattern of results observed by Jones (2015) in the general population.

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Consistent with the shared signal hypothesis, Jones showed larger inward effects when faces displayed approach-oriented emotions and smaller effects with avoidance oriented emotions. In contrast, our findings showed a distinction between negative and positive emotions and are more coherent with the “self-referential-positivity bias hypothesis”, according to which people prefer to interpreting positive emotions as directed towards them and negative facial expressions as directed away, in order to enhance self-esteem (cf. Lobmaier and Perrett 2011; Lobmaier et al. 2008). However, there are some discrepancies between Jones’ study and ours. For example, Jones (2009) used four facial expressions (happy, angry, fearful, and neutral), while our faces showed happy, angry, fearful, sad, and neutral expressions. Second, our participants were selected according to their autistic traits scores (e.g., students from the upper and lower quartiles of the AQ distribution), while in the Jones’ study, participants were recruited from the general population and were not selected on the basis of their autistic traits. Therefore it can be suggested that the different results of our study compared to Jones's can be traced back to the autistic traits, high or low. However, future studies are needed to elucidate the reasons for these different findings fully. Of relevance, data from the present study further show that participants with high levels of autistic traits were not affected by the facial expression of the stimuli during the decoding of the eye-gaze direction. Note that the current finding cannot be explained by a general difficulty of individuals with high levels of autistic traits in decoding eye-gaze direction because in the gaze discrimination task we did not find any group differences in overall accuracy or RTs. At same time, we did not find any group differences in overall accuracy of the facial emotion identification task, which suggests that the absence of the interaction between emotional expression and gaze direction in participants with high levels of autistic traits cannot be attributed to a general difficulty in decoding facial emotional expressions. Our findings

are in line with studies showing that autistic individuals have difficulties in integrating communicative signals present in the eyes with social and communicative contexts (Pelphrey et al., 2005; Baron-Cohen et al., 1997), and with their emotional value (Akechi et al., 2009). A possible explanation for why participants with high levels of autistic traits do not show a greater inward effect for happy faces may be related to a weaker self-referential-positivity bias of this group as compared to the low AQ group of participants. This is in line with previous research suggesting reduced positive self-evaluations in ASD (Gotlib and Joormann, 2010; Mezulis, Abramson, Hyde, Hankin, 2004; Williamson, Craig, Slinger, 2008) and it is coherent with previous research showing that judgments of persons with ASD appear to be less strongly modulated by the emotional value of the available information (Kuzmanovic, Rigoux, and Vogeley, 2019). An alternative explanation may also be that these results are related to a decreased reward in the social interaction of individuals with high AQ. For this reason, they would appear to be less influenced by happy faces than people with low AQ. This corroborates the current evidence for a reduced reward value of smiling faces in autistic people compared to typical individuals (Sepeta et al., 2012). Self-favoring biases for positive rather than negative information about is normative and adaptive for personal well-being since this behavior promotes self-confidence which may help to moderate low self-esteem (Goldstein, Hayden, & Klein, 2015). In this study, for the first time, we showed that the tendency of people to think that they are the source of somebody else's happiness may be absent or reduced in individuals with high levels of autistic traits.

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Figure 1. Schematic view of a trial sequence from left to right. The examples illustrate, from top to bottom, an incongruent and a congruent trial of a woman with an emotional expression of happiness. The speaker icon represents the auditory feedback given on incorrect answers.

Figure 2. Mean reaction times for Reversed Congruency Effect (RTs differences between congruent and incongruent trials) as a function of emotional expressions and group.

Table1. Male–female ratio, and means (and SDs) for AQ score and age.

Variables	Low AQ			High AQ		
	Mean	SD	N	Mean	SD	N
Gender (male:female)			1:17			4:14
Age (years)	18.89	1.6		20.44	3.01	
AQ score	8.28	1.84		24.61	3.18	

Table 2. Mean correct reaction times (RT, in milliseconds), standard deviations (SD) and percentages of incorrect responses errors (% IR) as a function of Emotional Expression, Congruency and Group (high and low scores on AQ)

Emotions	Congruency	Low AQ			High AQ		
		RT	SDs	%IR	RT	SD	%IR
Happy	Congruent	643.4	73.03	5.579	662.8	84.62	10.778
	Incongruent	585.0	65.55	3.000	638.6	95.18	5.333
Angry	Congruent	632.1	84.27	8.684	682.3	95.95	9.278
	Incongruent	619.0	74.56	6.632	647.8	91.05	4.833
Fearful	Congruent	610.3	67.23	3.842	645.6	86.67	6.444
	Incongruent	582.9	65.70	4.105	628.1	88.33	2.722
Neutral	Congruent	614.2	63.59	3.842	661.5	86.96	5.833
	Incongruent	602.4	78.22	3.895	629.4	94.92	4.167
Sad	Congruent	624.6	72.24	5.053	670.0	95.25	6.778
	Incongruent	596.2	78.37	4.947	628.5	80.85	4.611

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