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Communication deficits and avoidance of angry faces in children with autism spectrum disorder



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ABSTRACT

Background: Understanding how emotional faces are processed is important to help characterize the social deficits in Autism Spectrum Disorder (ASD).

Aims: We examined: (i) whether attention is modulated by emotional facial expression; (ii) the time course of the attentional preferences (short vs. long stimulus presentation rates); and (iii) the association between attentional biases and autistic symptomatology.

Method and procedures: We applied a dot-probe experiment with emotional faces (happy, sad, and angry). The sample was composed of ASD children without additional language and/or intellectual impairments (n = 29) and age-matched Typically Developing (TD) children (n = 29).

Outcomes and results: When compared to the TD group, the ASD group showed an attentional bias away from angry faces at long presentation rates. No differences between groups were found for happy or sad faces. Furthermore, correlational analyses showed that the higher avoidance of angry faces, the greater are the social communication difficulties of ASD children.

The attentional bias away from angry faces may be an underlying mechanism of social dysfunction in ASD. We discuss the implications of these findings for current theories of emotional processing in ASD.

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What this paper adds?

This paper examines attentional biases to emotional faces in Autism Spectrum Disorders (ASD) children. Previous findings on how attentional biases are modulated by the stimulus emotional relevance are not fully consistent. Whereas some studies reported an attentional bias to distressing stimuli, others failed to show any attentional biases in ASD children. We tested if this apparent discrepancy was due to the type of processing (automatic vs. controlled) of emotional stimuli. Using a dotprobe task, we found an attentional bias away from angry faces during controlled processing, but not during automatic processing in ASD children. Furthermore, unlike typical developing children, the attentional bias away from angry faces was not associated with anxiety but with autistic communication. These results strongly suggest that the processing of distressed faces is impaired in ASD children—in particular during more controlled processing. This impairment may play an import

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http://dx.doi.org/10.1016/j.ridd.2017.02.002 0891-4222/© 2017 Elsevier Ltd. All rights reserved. role in their social functioning in terms of communication difficulties. This finding opens a window of opportunities at an applied level (e.g., can attention training with emotional faces be a useful treatment target in ASD individuals?).

1. Introduction

Autism Spectrum Disorders (ASD) are typically characterized by persistent deficits in communication and social interaction across multiple contexts, together with restricted, repetitive patterns of behavior, interests, or activities (DSM 5;American Psychiatric Association [APA], 2013). It has been posited that the abnormal social behavior in ASD individuals may be explained by reduced attention to emotional facial expressions during childhood (Klin, Jones, Schultz, & Volkmar, 2003)—note that emotional faces should be effectively attended to for an adjusted social functioning (see Waters, Mogg, Bradley, & Pine, 2008). Clearly, the examination of whether children with ASD attend emotional facial information in a biased way (i.e., depending on their valence) may help elucidate the underlying mechanisms of their social dysfunction.

Attentional biases to emotional faces in ASD individuals have been studied with reaction time and eve-tracking techniques. Most of this research focused on ASD children because older individuals may have learned to attend to relevant facial expressions and modulate their social behavior (see Bastiaansen et al., 2011). Among the reaction-time techniques, double cueing or dot-probe tasks are the preferred paradigms to examine how emotional faces capture attention (see Bar-Haim et al., 2007, for review). In the emotional version of the dot-probe task, two cued faces (e.g., one neutral and one emotional) are displayed simultaneously in different locations on a screen (e.g., left and right). Immediately after the faces disappear, a dot probe (target) replaces one of the two cued faces. This cue could be: (i) an emotional face (i.e., an emotion trial) or ii) a neutral face (a neutral trial). Participants are instructed to press a button (left vs. right) to indicate the position in which the dot probe appeared. Faster responses to "emotion trials" would reflect an attentional bias towards emotional faces, whereas faster responses to "neutral trials" would reflect an attentional bias away from emotional faces (see MacLeod, Mathews, & Tata, 1986). Importantly, the dot-probe task allows characterizing whether the selective attention process is automatic or controlled: cue presentation rates briefer than 500 ms have been associated with automatic processing, whereas cue presentation rates longer than 1 s have been associated with controlled processing (see Yiend, 2010). To our knowledge, Uono, Sato, and Toichi (2009) were the first that employed an emotional version of the dot-probe task to examine the attentional bias in ASD adolescents versus typically developing (TD) adolescents. In their version of the dot-probe task, known as gaze cueing task, Uono et al. employed dynamic gaze cues (either to the left or to the right) of fearful or neutral faces displayed during 460 ms. The cueing effect (i.e., faster responses when the eye-direction cue and the target appeared at the same location relative to the opposite location) was greater for fearful than neutral faces in the TD group. However, the ASD group did not show an attention bias towards fearful faces. That is, unlike TD adolescents, fearful faces did not capture the attention of ASD adolescents.

Subsequent studies have examined both attentional biases in ASD and their association with other measures such as anxiety (e.g., Hollocks, Ozsivadjian, Matthews, Howlin, & Simonoff, 2013; May, Cornish, & Rinehart, 2015) and degree of autistic social symptoms (e.g., Matsuda, Minagawa, & Yamamoto, 2015). In the Hollocks et al. (2013) experiment, two cued faces were displayed simultaneously on the left and right side of a computer screen for 500 ms. These cues were: (i) an emotional face (angry or happy); and ii) a neutral face. Results showed that neither ASD nor TD children displayed an attentional bias-this was so despite the fact that ASD children had higher levels of anxiety than TD children. That is, while anxious TD children usually show an attentional bias toward angry faces (Bar-Haim et al., 2007), angry faces did not seem to capture the attention of ASD children despite their relatively high levels of anxiety. Likewise, May et al. (2015) employed a dot-probe task similar to the Hollocks et al. (2013) experiment that compared anxious ASD children and non-anxious TD children. Similarly to Hollocks et al. (2013), May et al. (2015) failed to find an attentional bias to emotional faces in either group. Taken together, these response time experiments failed to show an attentional bias toward distressed faces in ASD children. Conversely, Matsuda et al. (2015) examined the association between attentional biases and autistic symptoms. They conducted an eye-tracking experiment with ASD and TD children that examined gaze behavior towards surprised, happy, neutral, angry, and sad faces that were individually displayed for 3 s. Bear in mind that eye movements have been considered an indicator of cognitive processes during visual tasks because shifts in gaze position closely follow-and are guided by-shifts in attentional focus (see Rayner, 2009; for a review). While there were no global differences between the two groups in gaze behavior when looking at faces, Matsuda et al. (2015) found that ASD children with more severe autistic symptomatology showed shorter fixation durations to angry faces than to the other faces. This finding suggests that attentional bias away from angry faces can be used as an indicator of autism severity.

An explanation for the apparent discrepancy between the findings reported by Matsuda et al. (2015) and the findings reported by Uono et al. (2009), Hollocks et al. (2013) and May et al. (2015) is in terms of automatic versus controlled processing—note that this is determined by the presentation rates of the visual cues. Hollocks et al. (2013), May et al. (2015), and Uono et al. (2009) employed cue presentation rates \leq 500 ms—this would be an indicator of automatic processing. In contrast, Matsuda et al. (2015) used longer cue presentation rates—this would be an indicator of controlled processing. Thus, it may be the case that automatic visual attention to emotional facial expression is preserved in ASD children (see May, Cornish, & Rinehart, 2016, for a similar finding with a visual search paradigm; and Yerys et al., 2013; for a similar finding with an attentional blink paradigm). That is, the presence of an attentional bias away from distressed faces in ASD children would occur during controlled processing (i.e., at long presentation rates) rather during automatic processing (i.e., at short presentation rates). To test this hypothesis, it is critical to manipulate the cue presentation rate (short vs. long). The present

Table 1

Demographic and clinical data from the control and the ASD group. Data shown are averages and standard deviations.

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ASD:Autism Spectrum Disorder; KBIT: Kaufman Brief Intelligence Test; ADIR: Autism Diagnostic Interview Revised; SCAS: Spence Children's Anxiety Scale; GARS 2:Gilliam Autism Rating Scale Second Edition Note : the p values correspond to Chi squared test for sex and to *t*-test for the rest of variables

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experiment intends to fill this gap in the literature. In addition, it is important to examine whether the avoidance of angry faces in ASD children is associated with behavioral measures in terms of autistic behavior (Matsuda et al., 2015) and/or anxiety (Bar-Haim et al., 2007).

The first aim of the present experiment was to examine in detail the attentional bias to emotional faces (i.e., angry, happy, sad) in ASD children during automatic and controlled processing using a dot-probe task—for comparison purposes, we also included a group of TD children. To the best of our knowledge, the present emotional dot-probe experiment is the first to examine the presence of attentional biases in ASD children: (i) for relevant faces (happy, sad, angry faces relative to neutral ones); and (ii) at both short (500 ms) and long (1500 ms) presentation rates. Drawing on the empirical literature, attentional biases to emotionally relevant faces would occur during controlled attentional processing (Matsuda et al., 2015) rather than during automatic processing (Hollocks et al., 2013; May et al., 2015; Uono et al., 2009). The second aim of the current experiment was to examine the association between attentional biases to emotional faces and ASD symptomatology. As indicated above, Hollocks et al. (2013) and May et al. (2015) found that, unlike anxious TD children, individuals with an ASD showed no significant relationship between anxiety and attentional bias to angry faces. However, Matsuda et al. (2015) found that the degree of attentional bias away from angry faces could be an indicator of autism severity in children. Therefore, an attentional bias away from angry faces would be associated with autistic behavior (Matsuda et al., 2015), but not with anxiety (Hollocks et al., 2013; May et al., 2015).

2. Material and methods

2.1. Participants

Fifty-eight children between 6 and 12 years of age took part in the experiment. Twenty-nine children (26 male, 3 female) with a diagnosis of ASD were recruited from the Pediatric Psychology Unit at University Hospital. None of them had language and/or intellectual impairments. An additional group of 29 TD children (22 male, 7 female) was recruited in a local primary school. Parental informed consent was obtained for all participants. Fig. 1 shows the selection process of the final sample.

No participant exhibited IQ or verbal disability scores lower than 80 on full-scale intelligence or the verbal index) as measured by the Kaufman Brief Intelligence Test (K-BIT; Kaufman, 1997), neurological history, major medical disorders, use of medication that could influence cognition (e.g., psychotropic medication, treatment with corticosteroids), or difficulty in distinguishing colors (e.g., color-blindness). There were no statistically significant differences between groups in age, sex, or IQ (see Table 1).

All participants in the clinical group had received the ASD diagnosis prior to the study by the referring clinicians. Autism spectrum diagnoses were based on the ICD-10 criteria F84.0 (WHO, 1992). Additionally, the diagnosis was verified by expert clinical assessment and the Autism Diagnostic Interview—Revised (ADI-R; Lord et al., 1994), which was applied to parents. Other psychiatric diagnoses based on the case note review in ASD children represented additional exclusion criteria. TD children did not have a psychiatric history, as reported by their parents.

To control the anxiety symptomatology in TD children and check its presence in ASD children, every parent completed the Spence Children's Anxiety Scale (SCAS; Spence, 1998). SCAS obtains parents' information on anxiety disorders in their children until 15 years old, through six subscales, which are consistent with Diagnostic and Statistical Manual of Mental Disorders – IV Edition (DSM – IV) constructs of anxiety disorders (generalized anxiety, panic, agoraphobia, specific phobia, social phobia, obsessive-compulsiveness and physical injury fears). The mean for anxiety disorders are 31.4 ± 12.9 and for normal population children 16.0 ± 11.2 . The total scale has a Cronbach's alpha coefficient of 0.73. In addition, clinicians filled out the Gilliam Autism Rating Scale-Second Edition (GARS-2; Gilliam, 2006) to estimate the severity of autism symptomatol-



Fig. 1. Selection process of the final sample.

ogy through several subscales: Stereotyped Behavior (e.g., "smells or sniffs objects"), Communication (e.g., "avoids looking at speaker when name is called"), and Social Interaction (e.g., "behaves in an unreasonably fearful, frightened manner"). A subscale standard score of 7 or higher indicates very likely autism, 4–6 possibly autism, and 1–3 unlikely autism. The total scale has a Cronbach's alpha coefficient of 0.80. The demographic and clinical data for the final sample are presented in Table 1.

2.2. Materials

The emotional stimuli, which served as cues, were 84 photographs in color of facial expressions (half male) taken from the FACES database (Ebner, Riediger, & Lindenberger, 2010). These faces represented young, middle-aged, and older people. One half of the pictures were of men. Two faces appeared as cues in each trial, namely an emotional face (happy, angry, or sad) and a neutral face. We selected a total of 12 happy, 12 angry, and 12 sad faces and 48 neutral images (36 for control and 12 for practice trials). Each emotional face was matched with the neutral control faces of the same actor. Each participant was presented with three types of experimental trials: 12 happy–neutral, 12 angry–neutral, and 12 sad–neutral cues. Each pair of cued faces was presented three times during the experiment (i.e., there were 36 trials per condition). In addition, six pairs of neutral faces were presented before the experimental trials as a practice block.



until response

Fig. 2. Depiction of the stimulus presentation sequence in a given trial.

2.3. Procedure

Children were individually assessed in a quiet room. Stimulus presentation and recording of responses were controlled by DMDX software (Forster & Forster, 2003). In each trial participants were instructed to look at a fixation point (+) in the screen center, which was presented for 500 ms. Then, two images were presented simultaneously at different screen locations (up and down), which were two cued stimuli with different emotional valences (i.e., one neutral and one emotional) displayed for 500 ms or 1500 ms. The 500 ms and 1500 ms trials were randomly displayed during the experimental session. Then, these images disappeared and a green or red square replaced one of the two pictures—that is, either emotional (i.e., emotion trial) or neutral (i.e., neutral trial). Participants were told to press a button to indicate the color of the square as quickly and as accurately as possible. The sequence of stimulus presentation is shown in Fig. 2.

The task comprised one practice block followed by nine test blocks composed of 12 experimental trials (4 happy-neutral, 4 angry-neutral, and 4 sad-neutral), which were randomly displayed within each block. Thus, a total of 114 trials (108 study + 6 filler) were displayed. The vertical location and the type of face (emotional or neutral) replaced by the square were balanced across trials, with the constraint that each type of face appeared in each two positions on half of the trials and the square replaced the emotional cues on the other half. The presentation order of the blocks was randomized across participants. The variation in the image locations and the randomization of trials guaranteed that the participants were not able to use any predetermined scanning strategy. The whole session lasted approximately 25–30 min.

2.4. Data analyses

Probe response times (RTs) were calculated for correct responses (i.e., errors responses were excluded from further latency analyses). Preliminary analyses showed that both groups showed very low error rates (less than 5%) and there were no differences between groups and conditions (all Fs < 1). Before examining bias scores, the dot-probe data were cleaned following outlined procedures of previous studies on ASD individuals (e.g., see Marotta et al., 2013). To minimize the influence of outliers, we removed very short RTs (RTs less than 200 ms) and RTs that exceeded 2.5 standard deviations beyond the participant's mean in each experimental condition (2.1% and 2.0% of trials in the ASD and TD groups, respectively). For each participant, the mean RT in each condition (for happy, angry, and sad faces at 500 and 1500 ms) was calculated. As suggested by Behrmann et al. (2006), the percent difference between the emotion (i.e., where the probe replaced an emotional face) and neutral trials (i.e., where the probe replaced a neutral face) was calculated to estimate the bias scores [(Mean RT neutral trials/Mean RT emotional trials*100)-100] to control for the RT differences between ASD children and TD children (916 ms and 650 ms, respectively). Positive bias scores indicate an attentional bias towards a particular emotional face, whereas negative bias scores indicate an attentional bias away from the emotional face.

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The mean Response Time (with Standard Deviation)) for each condition in the control	and the ASD groups.
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		Control		ASD	
Valence	Duration	Emotion	Neutral	Emotion	Neutral
Нарру	Short	632.9 (143.1)	634.3 (144.5)	875.0 (329.0)	876.2 (352.7)
	Long	694.2 (140.6)	676.5 (130.4)	921.7 (336.7)	919.4 (333.2)
Sad	Short	631.0 (122.0)	625.4 (119.9)	892.4 (359.4)	902.8 (361.4)
	Long	679.6 (141.8)	672.3 (128.4)	937.1 (357.8)	951.5 (332.0)
Threat	Short	654.5 (170.2)	649.4 (143.9)	842.6 (339.3)	892.4 (407.7)
	Long	691.1 (152.7)	694.1 (153.6)	987.9 (502.4)	882.3 (316.5)

ASD: Autism Spectrum Disorder.

Table 3

Bivariate correlations between the bias score to angry faces at the long stimulus duration and behavioral measures in ASD children.

		GARS – 2	GARS – 2			
	SCAS	Stereotyped behavior	Communication	Social interaction		
r	-0.202	0.276	-0.509	0.081		
р	0.293	0.226	0.005	0.726		

ASD: Autism Spectrum Disorder; SCAS: Spence Children's Anxiety Scale; GARS – 2: Gilliam Autism Rating Scale Second Edition.

Note: the *p*-value adjustment by Bonferroni for multiple tests in bivariate correlations requires p < 0.0125 for significant differences.

First, the percent differences were analyzed in a 2 (Group: ASD, TD) \times 3 (Valence: happy, angry, sad) \times 2 (Cue presentation rate: 500 ms, 1500 ms) omnibus analysis of variance (ANOVA), in which, Group was a between-subjects factor and Valence and Cue presentation rate were within-subject factors. Simple effect tests were conducted in the case of significant interactions. Second, when the Group differences were significant, one-sample *t*-tests were used to determine whether the bias score was statistically different from zero. Third, bivariate correlations were conducted to examine the relation of significant dot-probe bias scores (i.e., those different from zero) and SCAS and GARS symptoms in ASD children. Data were analyzed using SPSS 20.0 for Windows (SPSS Inc., Chicago, Illinois).

3. Results

The RT mean for each condition is shown in Table 2. The mean in percent RT differences is shown in Fig. 3. The ANOVA showed a main effect of Cue presentation rate, F(1,56) = 4.49, p = 0.030, $\eta^2 = 0.07$. The Valence x Cue presentation rate interaction approached significance, F(2,112) = 3.00, p = 0.053, $\eta^2 = 0.05$. More important, we found a significant three-way interaction between Cue presentation rate, Valence, and Group, F(2,112) = 6.22, p = 0.003, $\eta^2 = 0.10$. To examine this interaction, we conducted separate ANOVAs with Valence x Group as factors for each presentation rate (short vs. long).

For the 500 ms presentation rate, we failed to find any significant effects of Group, Valence, or Group x Valence (all *ps* > 0.29). For the 1500 ms presentation rate, the main effects of Group and Valence were not significant (both *ps* > 0.12), but importantly, the Valence x Group interaction was significant, F(2112) = 6.84, p = 0.002, $\eta^2 = 0.11$. This interaction reflected that, for angry faces, the ASD group showed a more negative bias score than the TD group, t(56) = 2.41, p = 0.002, whereas there were no differences between groups for sad or happy faces (both *ps* > 0.10). Thus, we found an attentional bias away from angry faces during controlled processing in ASD children but not in TD children.

Indeed, at the long presentation rate, one-sample *t*-tests showed that bias scores to angry faces were significantly smaller than zero in the ASD group (t(28) = -3.51, p = 0.002) (i.e., we found a bias away from angry faces). The ASD group did not show any attentional bias towards happy and sad faces at the long presentation rate (all ps > 0.19). Finally, the TD group did not show any bias scores significantly different than zero in angry, happy or sad faces at the long presentation rate (all ps > 0.29).

Finally, bivariate Pearson correlations between the attentional bias to angry faces at the long stimulus duration in ASD children and the SCAS/GARS scores are shown in Table 3–note that Bonferroni *p*-value adjustment for multiple tests in bivariate correlations requires p < 0.0125 (i.e., 0.05/#tests) for significant differences. We found that GARS autistic communication correlated significantly with the bias scores (p = 0.005). That is, higher scores on social communication deficit were associated with a higher bias away from angry faces in the long stimulus duration. No other GARS subscales correlations were significant. Importantly, SCAS scores were not associated to this bias.

4. Discussion

The main finding of the current emotional dot-probe experiment was that ASD children showed an abnormal emotional face processing relative to TD children. Importantly, this difference was modulated by the valence of the face (i.e., ASD children showed an attentional bias away from angry faces) and the stimulus presentation rate (i.e., this attentional bias occurred during controlled processing). A second relevant finding was that the higher attentional avoidance towards angry





faces in ASD children, the higher the communication scores. We now discuss how these findings help to shed some light on the processing of emotional faces as an underlying mechanism of autistic communication.

With respect to how attention is modulated by the emotional salience of the stimuli, the present experiment revealed an attentional bias away from angry faces in ASD children, whereas TD children did not show any attentional biases to emotional faces. Importantly, attentional biases in ASD children were restricted to angry faces (i.e., no biases were found for happy or sad faces). This finding is consistent with previous studies about the presence of attentional bias in ASD children away from high-arousal and negative stimuli (e.g., fearful faces: Uono et al., 2009; angry faces: Matsuda et al., 2015) rather than from middle-arousal and negative stimuli (i.e., sad faces, Matsuda et al., 2015). Therefore, attentional biases to emotional stimuli in ASD children appear to be modulated by arousal rather than negativity (Corden, Chilvers, & Skuse, 2008; García-Blanco, Yáñez, Vázquez, Marcos, & Perea, 2017). With respect to TD children, we did not find any attentional bias—note that these children had no psychiatric history (see Salum et al., 2013; for a similar finding when the presence of symptomatology is controlled in TD children).

At the theoretical level, the Intense World Theory (Markram, Rinaldi, & Markram, 2007) can explain why arousing faces modulate attention capturing. This theory, which is grounded on neuroimaging studies, posits that when ASD individuals process arousing emotional faces, the hyper-functioning in primary sensory areas and the excessively reactive amygdala give rise to an overwhelmingly intense and aversive surrounding perception (see Kleinhans et al., 2010; for evidence with angry and fearful expressions). The amygdala overstimulation would occur because of a defective top-down modulation by prefrontal areas when negative and arousing stimuli are consciously self-evaluated as highly aversive (Zalla & Sperduti, 2014). When overstimulation occurs, negative and high arousal emotions would elicit high distress in ASD individuals and, as a result, they may show an attentional bias away from angry faces (see also Smith, 2009). Therefore, ASD individuals may avoid looking at angry faces in an attempt to regulate their personal distress.

With respect to the temporal course of attentional processing, we found no differences between the individuals in the ASD and TD groups at the short presentation rate (i.e., the bias score for all emotional faces was similar, regardless of which group the children belonged to). The differences between groups occurred at long presentation rates: the ASD group showed lower bias scores to angry faces than the TD group. That is, we found a dissociation between automatic and controlled processing of emotional faces in ASD children (see Moore, Heavey, & Reidy, 2012, for a similar finding with faces compared with non-social images in a dot-probe task). During automatic processing, ASD and TD children showed a similar pattern of data for neutral and emotional faces, as Hollocks et al. (2013) and May et al. (2015) had reported (see also May et al., 2016; and Yerys et al., 2013; for a similar finding with other behavioral paradigms). Thus, at an automatic level of processing, ASD children can pay attention to the environment in a typical manner. In other words, the mechanisms for automatic detection of relevant faces may be intact in autism (see Franco et al., 2014). However, when ASD children can exert an attentional control (i.e., at the long presentation rate), they decrease their attention to angry faces. The Intense World Theory (see Markram et al., 2007; Zalla & Sperduti, 2014) can explain the dissociation between typically automatic processing and abnormal controlled processing of angry faces in ASD. Firstly, during automatic processing, the amygdala would process relevant stimuli normally. Secondly, during controlled processing, prefrontal areas would elicit amygdala overstimulation due to a conscious evaluative process of angry faces as aversive stimuli. The amygdala hyperactivation may lead to an attentional avoidance-this could be the result of the avoidance of the high arousal elicited by distressed faces. Thus, displaying faces during controlled processing (i.e., over 1000 ms presentation rates) would allow an attentional avoidance of distressing stimuli (i.e., angry faces). To sum up, ASD children may show an abnormal controlled processing of distressed stimuli characterized by: i) the hyper-reactivity of primary sensory areas in the presence of distressed faces (i.e., faces evaluated as aversive); and, ii) subsequently, a behavioral avoidance threat-related processing as a defense mechanism faced with an intense surrounding perception (Markram et al., 2007).

Finally, we found that attentional biases away from angry faces were correlated with communication difficulties in ASD children: ASD individuals who had poor communication also showed higher attentional avoidance of angry faces. These findings suggest that impaired processing of distressed faces may be related to deficits in more complex social functions (e.g., communication) (see also Matsuda et al., 2015; for evidence that the abnormal processing of distressed faces is related to greater autism severity). Similarly, Eack et al. (2015) found that abnormal facial emotion perception was associated with poor communication in ASD adults. Likewise, Stagg, Linnell, and Heaton (2014) found ASD children with late language onset paid reduced attention to salient social stimuli. The attention impairment to relevant stimuli of the environment and the self-evaluation of angry faces as aversive (Zalla & Sperduti, 2013) may cause problems in the communication of ASD children because: i) it puts at risk the ability to represent and communicate one's own internal states and feelings, and causes deficits in the self-regulation of behavior (Cunningham et al., 2008); and ii) it may involve a withdrawal behavior that will reduce the chances of social communication with others to solve problems and social interactions (Zercher, Hunt, Schuler, & Webster, 2001). Finally, with respect to the association between attentional bias in ASD and other behavioral measures, our findings indicate that attentional bias away from angry faces are not associated with the presence of anxiety in ASD (see Hollocks et al., 2013; and May et al., 2015; for a similar findings).

We acknowledge that a limitation of the current study is that our findings cannot necessarily generalize to lowerfunctioning individuals with ASD, as only ASD individuals without language and/or intellectual impairments were assessed. In addition, the association between the attentional biases and the severity of autistic behaviors was only investigated within the clinical group. Finally, future research would require a dot-probe design that incorporated eye-tracking technology to monitor attention in an online capacity. This methodology would allow disentangling the selective attention process involved in the attentional bias of ASD individuals. For instance, the low attentional bias scores of ASD individuals could be due to scarcer orientation to angry faces, to more easily in disengaging attention from angry faces, or to both (Salemink et al., 2007).

5. Conclusions

In summary, the present study has revealed an attentional bias away from angry facial expressions in ASD children at long, but not at short, stimulus presentation rates. These results strongly suggest that the processing of distressed faces is impaired in ASD children, and this is especially so during more controlled processing. This impairment may play an important role in their social functioning in terms of communication difficulties (see also Corden et al., 2008). At an applied level, future research should examine whether attention training with emotional faces could be a useful treatment target in ASD individuals (see Beard, Sawyer, & Hofmann, 2012, for a recent meta-analysis on attentional training in several forms of psychopathology).

Conflict of interest

The authors declare that they have no conflict of interest.

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