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ORIGINAL PAPER

Attentional Patterns to Emotional Faces Versus Scenes in Children with Autism Spectrum Disorders

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Abstract

Previous research has shown attentional biases in children with autism spectrum disorders (ASD) when processing distressing information. This study examined these attentional patterns as a function of the type of stimulus (scenes and faces) and the stimulus valence (happy, sad, threatening, neutral) using a within-subject design. A dot-probe was applied to ASD (n = 24) and typically developing (TD) children (n = 24). Results showed no differences between the groups for happy and sad stimuli. Critically, ASD children showed an attentional bias toward threatening scenes but away from threatening faces. Thus, the type of stimuli modulated the direction of attentional biases to distressing information in ASD children. These results are discussed in the framework of current theories on cognitive and emotional processing in ASD.

Keywords Autism spectrum disorders · Childhood · Attentional bias · Emotional information · Dot-probe task

Children with autism spectrum disorder (ASD) are characterized by deficits in social communication and interaction (Rump et al. 2009; Tanaka and Sung 2016), including having trouble in understanding another person's emotions, points of view, or actions in a social situation (American Psychiatric Association 2013). Abnormal attentional processing of emotional information has been claimed to be one of the causes of social deficits in ASD children (Batty et al. 2011). To characterize the abnormal attentional processes in ASD children, it is important to examine how these children react to stimuli with different emotional information (e.g., happy, sad, and threatening) and stimuli with different complexity (e.g., simple faces vs. people in complex situations), thus disentangling the context of the social scene and the emotional facial expression (Nomi and Uddin 2015). Clearly, the examination of the mechanisms underlying the deficits of ASD children in social-emotional reciprocity would allow us to better identify specific targets in social skills interventions, hence improving their effectiveness (Deschamps et al. 2014).

To understand the abnormal attentional patterns to emotional information in ASD children, researchers have designed experiments that measure attentional biases using a variety of stimuli and experimental paradigms. Some of these experiments employed emotional faces as stimuli (García-Blanco et al. 2017a; Matsuda et al. 2015; Uono et al. 2009), while others employed scenes of real life situations depicting facial expressions in an emotional context (García-Blanco et al. 2017b; Santos et al. 2012). These studies also varied in their experimental methodologies: some of them measured reaction times, whereas others recorded the participants' eye movements. To measure the reaction times, the most common paradigm used is the dot-probe task, in which a signal composed of an emotional and a neutral image is presented on a screen followed by a target in the location of one of the images. Participants have to respond when the target appears. If participants respond faster when the target replaces the emotional image, this would reflect a bias towards the emotional image; conversely, if the response time is faster when the target replaces the neutral image then the bias is away from the emotional image. The second methodology uses eye-tracking technology to measure the

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participants' eye movements while displaying emotional and neutral images simultaneously. This method allows researchers to measure a number of dependent variables (e.g., the total time a participant looks at an image, the total number of eye fixations at each image, among others). When viewing times or number of fixations are higher for an emotional image than for a neutral image, this indicates an attentional bias towards the emotional image, and when viewing times or number of fixations are lower for an emotional image than for a neutral image, this indicates an attentional bias away from the emotional image.

A number of experiments have reported an attentional bias away from distressing stimuli (i.e., angry or fearful stimuli) in ASD children (García-Blanco et al. 2017a; Matsuda et al. 2015; Uono et al. 2009). Uono et al. (2009) studied the attentional pattern in ASD using fearful and neutral faces in a dot-probe task. They found an attentional bias towards fearful faces in Typical Development (TD) controls but not in the ASD group. Likewise, Matsuda et al. (2015) examined the eye tracking behavior toward angry, happy, neutral, sad, and surprised faces in ASD children. They found that the less time spent looking at angry faces compared to other faces, the more severe was the autistic symptomatology. More recently, García-Blanco et al. (2017a) conducted a dot-probe experiment that examined the attentional bias to angry, happy, and sad faces. They found that ASD children showed an attentional bias away from angry faces relative to TD children. Of note, García-Blanco et al. (2017a) also found that the higher the attentional bias was away from angry faces, the higher were the social communication deficits in ASD children. Thus, all these studies, which used emotional faces as the stimuli, reported an attentional bias away from distressing faces in ASD children that, importantly, was associated with the severity of ASD symptoms.

Conversely, other experiments have reported a bias toward distressing stimuli in ASD children (García-Blanco et al. 2017b; Santos et al. 2012). Santos et al. (2012) examined the eye tracking behavior toward social scenes pairs (happy–neutral, neutral–neutral, or threatening–neutral). Participants in their experiment had to look at pictures of social scenes and decide whether they were depicting the same emotion or not. Results of the eye tracking analysis showed that ASD presented an attentional bias—operationalized as the total number of fixations—toward threatening scenes relative to neutral scenes. Recently, García-Blanco et al. (2017b) conducted a dot-probe experiment with three different emotional scenes (happy, sad, and threatening) as emotional cues. ASD children showed an attentional bias toward threatening scenes, whereas the ASD and TD children behaved similarly when presented with happy and sad scenes. Therefore, the studies that reported an attentional bias toward emotional stimuli in ASD children employed distressing scenes.

To sum up, prior research has consistently shown that both the type of stimuli and the stimulus valence modulate the pattern of attentional responses in ASD individuals. Importantly, ASD individuals showed a different bias depending whether the stimuli were distressing faces or scenes: there is an attentional bias away from distressing faces (García-Blanco et al. 2017a; Matsuda et al. 2015; Uono et al. 2009) but an attentional bias toward distressing scenes (García-Blanco et al. 2017b; Santos et al. 2012). Critically, these studies employed *either* faces or scenes as stimuli. A better and more powerful strategy to demonstrate this dissociation in ASD children would be to use both faces and scenes in a single experiment, as we do in the current paper. But before describing in detail the experiment, we first review how attentional biases in ASD children can be accommodated by cognitive and affective theories of autism.

At a theoretical level, autism has often been conceptualized by cognitive and affective theories. Whereas cognitive theories can easily accommodate the manner in which ASD individuals process information of simple and complex stimuli [e.g., the attentional bias away from facial expressions (i.e., simple stimuli) and the attentional bias toward social scenes (i.e., complex stimuli)], affective theories can explain how emotional information modulates attentional processing (i.e., the abnormal attentional bias to distressing information vs. the typical attentional processing of happy or sad information). However, none of these theories alone can separately capture the interaction between the type of stimuli and the stimulus valence in the attentional biases in ASD children.

Among the cognitive theories that can explain the findings on attentional processing of faces and scenes, the Weak Central Coherence Theory (WCC) assumes that ASD individuals attend excessively to specific details and struggle to integrate fragments into a significant whole (Frith 1989; Happé and Frith 2006). A consequence of this atypical pattern of processing (Behrmann et al. 2006) is that ASD individuals may extract information employing a detail-oriented processing rather than a global processing (Ashwin et al. 2006; Behrmann et al. 2006; Krysko and Rutherford 2009). Since faces have a small number of features and they are all relevant, a detail-oriented processing style serves for extracting emotional information quickly. However, given that social scenes have multiple emotionally relevant and non-relevant details, a detail-oriented processing style might divert the extraction of relevant information. Thus, according to the Weak Central Coherence theory, a detail-focused processing style facilitates the extraction of relevant information from simple stimuli but delays the processing of complex stimuli (Worsham et al. 2015).

Among the affective theories that explain the abnormal attention to distressing emotions, the Intense World Theory (IWT; Markram and Markram 2010) posits that negative and high-arousing stimuli can induce an overwhelming response in ASD individuals. The overwhelming distress experienced by ASD individuals as a product of negative and high-arousing stimuli would cause an abnormal attentional response to distressing stimuli in order to regulate the internal response. Therefore, according to the Intense World Theory, ASD children would show an abnormal attention response to distressing stimuli, but not to happy or sad stimuli.

After considering these theories, the empirical findings discussed above can be explained encompassing the interaction between cognition (simple and complex stimuli) and emotion. Firstly, in the case of distressing faces, the attentional bias to the few negative and high-arousing details may render faces excessively stimulating relative to happy or sad faces (see Isomura et al. 2014). As a result, a detail-oriented processing style can produce an overwhelming response to the emotionally relevant details that may elicit an avoidance strategy (i.e., attention disengagement) to reduce personal distress (Happé and Frith 2006; Isomura et al. 2014; Markram et al. 2007). Secondly, in the case of distressing scenes, the attention to the multiple neutral and non-relevant details in a complex stimulus may result in a distraction that delays the disengagement from the distressing stimuli (Isomura et al. 2015). Thus, a detail-oriented processing style can produce an attenuated avoidance strategy by means of focusing on non-emotional details that may serve as distractors to lessen the arousal (Happé and Frith 2006; Isomura et al. 2015; Markram et al. 2007). That is, ASD children would disengage their attention from distressing details and focus on non-emotional details in complex distressing stimuli (e.g., scenes), but they would disengage entirely from simple distressing stimuli (e.g., faces).

The main aim of the present experiment is to shed some light on the dissociation pattern in attentional biases to emotional stimuli (i.e., happy, sad, threatening) using a within-subject design (i.e., each participant will be presented with both emotional faces and emotional scenes in the same experimental block). Importantly, this design would allow us to disentangle whether the dissociation in the attentional bias to threatening stimuli for faces vs. scenes forms part of an integral attentional response in ASD children or whether it is the result of an attentional strategy when only faces or scenes are presented. If the dissociation of attentional biases for distressing faces and scenes in ASD children does reflect an integral attentional disengagement from distressing details, we expect that ASD participants would show a bias toward distressing complex scenes (García-Blanco et al. 2017b; Santos et al. 2012) together with an attentional bias away from distressing faces (García-Blanco et al. 2017a; Matsuda et al. 2015; Uono et al. 2009).

Method

Participants

Forty-eight children between the ages of 6 and 12 years old took part in the experiment. Children with an ASD diagnosis (n = 24) were recruited at a regional hospital. Additionally, a group of healthy children (n = 24) were recruited from a local primary school according to the patients' age. Informed parental consent was obtained from all participants.

All participants in the clinical group had received ASD diagnosis prior to the study by the referring clinicians. ASD diagnoses were based on the ICD-10 criteria (WHO 1992). Previous to the study, the Autism Diagnostic Interview—Revised (ADI-R; Lord et al. 1994) was applied by a trained clinical psychologist and the diagnosis was verified by expert clinical opinion.

In addition, healthy children were required to report absence of psychiatric history. In order to control the subclinical symptomatology in healthy children and check the presence of empirical syndromes in ASD children, every parent completed the Child Behavior Checklist (CBCL; Achenbach and Edelbrock 1991). CBCL obtains information on problem behavior in children between the ages of 6 and 18 through eight different empirically based syndrome scales (Anxious/Depressed, Withdrawal Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule-Breaking Behavior, Aggressive Behavior).

None of the participants in either group exhibited low intelligence or verbal disability (scoring 80 or less on full-scale intelligence or the verbal index) as measured by the Kaufman Brief Intelligence Test (K-BIT; Kaufman 1997). They also did not present any major medical disorders, neurological history, use of medication that could influence cognition (e.g., psychotropic medications such as psychostimulant drugs, treatment with corticosteroids), or difficulty in distinguishing colors (e.g., color blindness). Psychiatric diagnosis or comorbid disorders in ASD children (e.g., ADHD, epilepsy) represented additional exclusion criteria. As observed in Table 1, there were no statistically significant differences in age, sex or Intelligence Quotient (IQ) between the groups. The demographic and clinical data for the final sample are also presented in Table 1.

Materials

For the complex emotional stimuli, 84 static social scenes were selected from the International Affective Picture System (IAPS; Lang et al. 2005). These were

Table 1 Demographic and clinical data of participants

	Control (n = 24)	ASD (n = 24)	p	η^2
Female (%)	20.8%	4.2%	0.081	
Age	8.67 (1.27)	9.37 (2.26)	0.284	0.025
K-BIT scores	102.83 (11.49)	105.75 (17.42)	0.339	0.020
Vocabulary subtest	103.50 (13.61)	107.62 (17.41)	0.247	0.029
Matrix subtest	103.71 (7.55)	104.79 (12.89)	0.674	0.004
CBCL scores				
Anxious/depressed	55.00 (5.13)	66.79 (9.78)	0.000	0.373
Withdrawn/depressed	52.25 (4.39)	69.00 (9.38)	0.000	0.577
Somatic complains	54.58 (3.16)	63.83 (8.74)	0.000	0.341
Social problem	53.04 (2.63)	67.25 (7.76)	0.000	0.611
Thought problems	53.54 (2.46)	64.92 (8.32)	0.000	0.428
Attention problems	52.54 (2.47)	68.75 (11.67)	0.000	0.490
Rule-breaking behavior	52.54 (4.23)	59.20 (6.86)	0.000	0.263
Aggressive behavior	53.13 (2.86)	61.12 (6.96)	0.000	0.371

The p values correspond to Chi-squared test for sex and to t-test for the rest of variables

the same happy, neutral, sad, and threatening scenes used by Kellough et al. (2008). These images have been rated on valence and arousal by Kellough et al. (2008). Their results showed a difference in the valence rating of happy (M = 7.3, SD = 0.4) and neutral (M = 5.1, SD = 0.2) images but unpleasant images [sad (M = 2.4, SD = 0.4) and threatening (M = 2.6, SD = 0.6)] were rated equally. In terms of arousal, threating scenes (M = 6.7, SD = 0.6) were rated as high-arousing images compared to happy (M = 4.6, SD = 0.7), neutral (M = 2.8, SD = 0.3), and sad scenes (M = 4.9, SD = 0.5). In our study, two scenes, an emotional scene (happy, sad, or threatening) and a neutral scene appeared as cues in each trial. Thus, there were three types of experimental trials: 12 happy–neutral, 12 sad–neutral cues, and 12 threatening–neutral. The practice trials were 6 neutral–neutral cues. Thus, there were 36 experimental trials composed of 12 happy, 12 sad, 12 threatening, and 48 neutral scenes (36 for the experimental conditions and 12 for practice trials).

The simple emotional stimuli presented were 84 static facial expressions (50% females and 50% males) taken from the FACES database (Ebner et al. 2010). The faces were equally ranged by age and gender representing young, middle age, and older individuals (Ebner et al. 2010). This equal demographic representation was done with the intention to generalize the outcomes through the selected stimuli. An emotional face (angry, happy, or sad) and a neutral face appeared as cues in each trial. Each emotional face was matched with the neutral control faces of the same actor. Thus, there were three groups of experimental trials, as follows: 12 angry–neutral, 12 happy-neutral, and 12 sad–neutral cues. The practice trials were 6 neutral–neutral cues. A total of 12 angry, 12 happy, 12 sad, and 48 neutral faces (36 for control and 12 for practice trials) were chosen.

The IAPS scenes and the FACES stimuli were classified by complexity according to results reported in studies on visual complexity and emotion (Bradley et al. 2007, 2011). Thus, stimuli were classified into figure-ground composition (i.e., simple stimuli) vs. scene (i.e., complex stimuli). The percentage of figure-ground composition average was calculated for each type of stimulus depending on two variables: Stimulus (scenes and faces) and Emotion (happy, sad, or threatening). Of note, all FACES stimuli were classified as figure-ground composition. Regarding IAPS stimuli, the percentage of figure-ground composition was 16.7% for happy stimuli, 27.8% for neutral-control stimuli, 25.0% for sad stimuli and 25.0% for threatening stimuli. Visual complexity did not differ among IAPS stimuli ($\chi^2 = 0.59$, $p = 0.90$). Unsurprisingly, FACES stimuli (100% figure-groups composition stimuli) were simpler than IAPS images (25% figure-groups composition stimuli; $\chi^2 = 86.40$, $p < 0.001$).

Procedure

Stimulus presentation and recording of responses in the experiment were controlled by DMDX software in a Windows computer (Forster and Forster 2003). The experiment was conducted in a quiet room where participants were asked to look at a fixation point (+) that appeared for 500 ms at the center of the computer screen. After the fixation point disappeared, two images were simultaneously displayed for 1250 ms in different screen locations (up and down), which were two random cued stimuli with different emotional information (i.e., one emotional and one neutral). Then, a green or red square substituted either the emotional (i.e., emotion trial) or neutral (i.e., neutral trial) stimuli. Participants were instructed to press the corresponding buttons that indicated the color of the square that appeared in a screen as quickly and as accurately as they possibly could. The stimulus presentation sequence is shown in Fig. 1.

The task comprised one practice block of 12 practice trials with neutral images (6 neutral–neutral faces and 6 neutral–neutral scenes) followed by 18 experimental blocks composed of 12 experimental trials (2 happy–neutral faces, 2 sad–neutral faces, 2 threatening–neutral faces, 2 happy-neutral scenes, 2 sad–neutral scenes, 2 threatening–neutral scenes), which were randomly displayed within each block. Each pair of cued stimuli was presented three times during the experiment. Thus, a total of 228 trials (216 experimental + 12 practice trials) were displayed. The type of stimulus

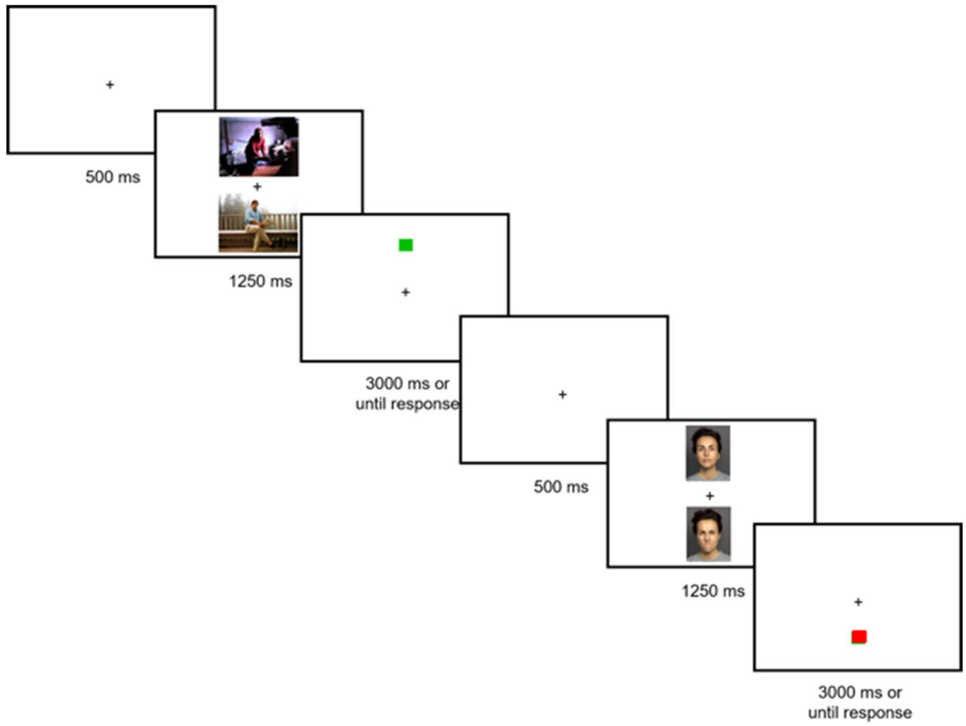

Fig. 1 The stimulus presentation sequence under two threatening conditions (scenes and faces) in two emotional trials

(emotional or neutral) and location (up or down) replaced by a colored square were balanced across trials, with the constraint that each type of stimulus appeared in each two positions 50% of the times and the square replaced the emotional cues 50% of the times. The presentation order of the blocks was randomized across participants. The randomization of trials and image location controlled for tiredness and guaranteed that the participants were not able to use any predetermined scanning strategy. The experimental procedure lasted approximately 40 min including a short break between each of the 18 experimental blocks.

Data Analyses

Incorrect responses were excluded from further analyses. (One participant in the ASD group did not follow instructions [error rate of > 25% on trials] and was replaced.) As in prior research, to ensure that responses were based on actual response to probe location, response times (RTs) of very short duration (< 200 ms) were excluded, as were trials with RTs that exceeded 2.5 standard deviations above the means for each participant (see Ioannou et al. 2017; Whelan 2008). The median RT for each participant was calculated under each condition (for happy, sad, and threatening faces/scenes) (see Marotta et al. 2013, for a similar procedure with ASD individuals). In order to control the RT differences between ASD children and healthy children (935 ms and 677 ms, respectively), the percent difference between the emotion (i.e., where the probe replaced an emotional face or scene) and neutral trials (i.e., where the probe replaced a neutral face or scene) was calculated to estimate the bias scores [(Median RT neutral trials/Median RT emotional trials × 100) − 100] (see Behrmann et al. 2006): positive bias scores indicate an attentional bias towards the emotional stimulus, whereas negative bias scores represent an attentional bias away from the emotional stimulus.[1] As the error rates were low in both groups of participants (less than 6%), we only focused on the percent differences in RT.

The bias score was analyzed in a 2 (Group: ASD, control) × 3 (Emotion: happy, sad, threatening) × 2 (Stimulus: scene, face) omnibus Analysis of Variance (ANOVA), in which Group was a between-subjects factor and Emotion and Stimulus were within-subject factors. To test the presence of attentional biases, the bias score under each condition was tested for the difference from zero using one-sample t-tests. Data were analyzed using SPSS 24.0 for Windows (SPSS 2016).

[1] As in prior research (e.g., García-Blanco et al. <link rid="bib13">2017a</link>, b; Marotta et al. 2013) the RTs of individuals in the ASD group were, on average, 300 ms higher than the individuals in the TD group—this difference has been typically explained in terms of hypo-vigilance to new stimuli (Sacrey et al. 2014; Zhao et al. 2016).

Table 2 The mean response time (with standard error) for each condition in the control and the ASD group

Valence	Stimulus	Control		ASD	
		Emotion	Neutral	Emotion	Neutral
Happy	Scenes	665 (17)	664 (17)	947 (81)	958 (77)
	Faces	694 (30)	667 (27)	902 (67)	883 (64)
Sad	Scenes	659 (15)	677 (15)	960 (77)	960 (77)
	Faces	677 (29)	666 (26)	905 (66)	925 (63)
Threat	Scenes	667 (17)	671 (17)	951 (76)	1010 (90)
	Faces	697 (33)	695 (33)	942(89)	872 (66)

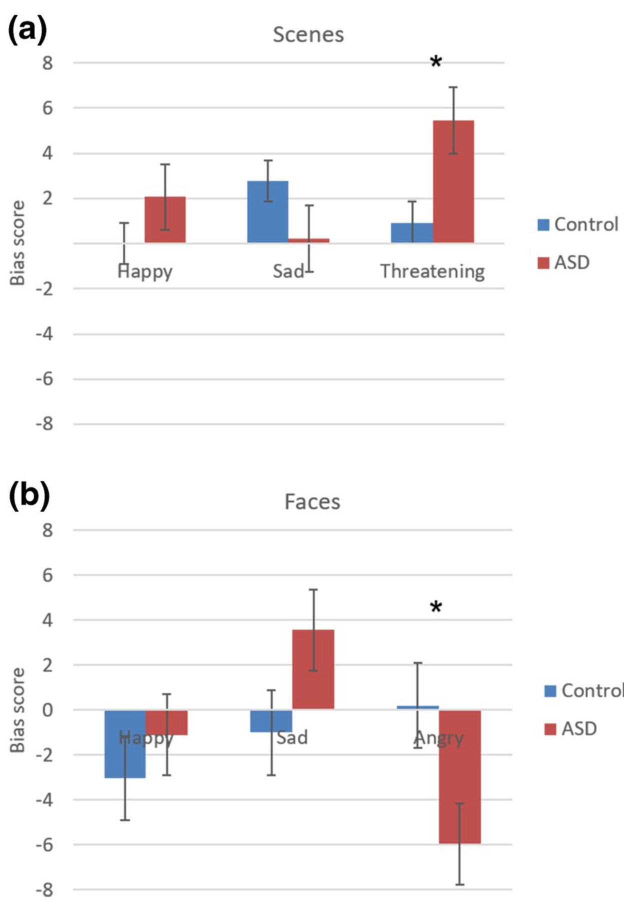

Fig. 2 Bias scores for the autism spectrum disorders (ASD) and the control groups (bars show standard errors); *indicates significant differences between

Results

The mean RT (with standard error [SE]) for each condition is shown in Table 2. The mean (with SE) in the bias score for each emotion are shown in Fig. 2.

Do the ASD and Control Groups Differ in Their Attentional Biases?

The ANOVA on the bias score showed a significant main effect of Stimulus, $F(1,46)=11.75$, $p=0.001$, $\eta^2=0.20$. Neither the main effect of Emotion nor the main effect of Group approached significance, both $ps>0.23$. The interaction between Emotion x Stimulus interaction approached significance, $F(2,92)=3.05$, $p=0.052$, $\eta^2=0.06$, whereas the other two-way interactions did not approach significance, both $ps>0.43$. Importantly, we found a significant three-way interaction between Stimulus, Emotion, and Group, $F(2,92)=7.14$, $p=0.001$, $\eta^2=0.13$. To examine this interaction, we conducted separate ANOVAs on the Emotion x Group interaction for each Stimulus type (Scenes, Faces).

When the stimuli were scenes, the Emotion × Group interaction was significant, $F(2,92)=3.61$, $p=0.031$, $\eta^2=0.07$, while the main effects were not significant (both $ps>0.07$). Simple effects t-tests on the interaction showed that, for threatening scenes, the individuals in the ASD group had a higher bias score than the individuals in the control group, $t(46)=2.51$, $p=0.012$, whereas there were no differences in the bias scores across groups for happy or sad scenes (both $ps>0.12$).

When the stimuli were faces, the Emotion × Group interaction was also significant, $F(2,92)=4.40$, $p=0.015$, $\eta^2=0.09$—again, the main effects were not significant (both $ps>0.07$). Simple effects t-tests showed that, for threatening faces, the individuals in the ASD group showed a lower bias score than the individuals in the control group, $t(46)=-2.71$, $p=0.009$, whereas there were no differences for happy or sad faces (both $ps>0.15$).

Are the Bias Scores Different from Zero in the ASD Group and in the Control Group?

In the ASD group, the t-tests showed that the bias score was significantly higher than zero for threatening scenes ($t(23)=3.72$, $p=0.001$) and significantly smaller than zero for threatening faces ($t(23)=-3.302$, $p=0.003$). The ASD group did not show any significant attentional biases towards happy or sad stimuli (all $ps>0.143$) both with scenes and with faces. In the control group, the bias score was significantly higher than zero for sad scenes ($t(23)=4.48$, $p<0.001$)—no other attentional biases were found (all $ps>0.121$).

Discussion

The current study aimed to examine the dissociation of the attentional bias to emotional stimuli (happy, sad, and threatening) depending on the type of stimuli (faces vs.

scenes) in ASD children in a single experiment using a within-subject design. While previous experiments using only faces reported that ASD children showed an attentional bias away from threatening faces (i.e., relatively simple stimuli with emotionally relevant details), the experiments using only scenes reported that ASD children showed an attentional bias toward threatening scenes (i.e., a complex set of stimuli with non-emotional relevant details). We obtained this same dissociation for ASD children using a within-subject design. Thus, our findings strongly suggest that these attentional biases correspond to an integral attentional response in ASD rather than an attentional strategy when only faces or scenes are presented. In addition, the children in the ASD group processed happy and sad stimuli similarly to the children in the control group. Taken together, this pattern of findings confirms and generalizes previous experiments using only faces or scenes as stimuli: the direction of attentional biases depends on the interaction between the type of stimulus and the stimulus valence.

When presented with emotional faces, ASD children showed an attentional bias away from threatening faces. Furthermore, relative to the control group, ASD participants paid less attention to threatening faces. In contrast, there were no differences in the attentional processing of happy faces, and only a nonsignificant bias in the processing of sad faces between the ASD and control groups (see García-Blanco et al. 2017a; Matsuda et al. 2015; Uono et al. 2009, for similar results). Thus, an abnormal attentional pattern was found only when a high-arousing distressing facial stimulus was presented. To explain this attentional bias away from distressing facial stimuli, it is necessary to consider an integration of the Weak Central Coherence theory and the Intense World Theory—neither of these theories alone can accommodate this pattern (Frith 1989; Happé and Frith 2006; Markram and Markram 2010). Accordingly, ASD children would employ a detail-focused perceptual style for processing any type of information, including facial emotions (Frith 1989; Happé and Frith 2006; Isomura et al. 2014). Faces are relatively simple stimuli that contain mostly emotionally relevant details. This type of stimuli, when compared to scenes, can be rapidly processed because faces have fewer details compared to the numerous, both emotionally relevant and non-relevant, details in scenes. Consequently, when faces show negative and high-arousing details, as in distressed faces, a detail-oriented processing style can elicit an overwhelming emotional response in ASD children (Isomura et al. 2014; Markram et al. 2007), thus producing an attentional bias away from the emotional stimulus. This attentional bias would function as an avoidance response to calm the intense emotional response (Kleinhans et al. 2010). Likewise, as a reviewer suggested, this bias can also be interpreted as an attention towards neutral stimuli (e.g., neutral faces in the current experiment) as they could produce a calming effect.

In contrast, when presented with social scenes, ASD children showed an attentional bias towards threatening social scenes—this bias did not occur with the children in the control group. In addition, when presented with happy and sad scenes, ASD children behaved similarly to TD children (see García-Blanco et al. 2017b, for a similar finding)—note, however, that the TD group showed a bias toward sad scenes different from zero in an intra-group analysis (see Kisley et al. 2007, for a similar finding with healthy individuals). As suggested by a reviewer, the detail-oriented process of extracting information from faces could be, to a large extent, similar for both isolated faces and complex scenes. When information from the stimuli is extracted and distress is detected, a disengagement of attention would occur. For faces, the only option for disengagement—in the setup of the experiment—is to attend the neutral face. For scenes, there would be disengagement toward other, more neutral, details of the scene. Indeed, Isomura et al. (2014) highlighted that a detail-focused perceptual style is more pronounced in threatening scenes with multiple non-distressing details that serve as distractors. Thus, the attentional bias towards distressing scenes can be interpreted as a delayed disengagement and an attenuated avoidance from the threatening details in complex stimuli by an increased focus on the non-emotional details in the stimulus.

We acknowledge that this study has some limitations. First, all ASD children had IQs > 80 and did not have any verbal disability. As a result, our findings may not be generalizable to ASD children with verbal disabilities or with a lower IQ. Second, the databases of the scenes/faces in the experiment do not have ratings comparing the arousal of faces and scenes, and this makes it difficult to compare them. Third, the distressing faces were always composed by angry faces, hence we cannot generalize our findings to other types of distressing faces (e.g., fearful faces)—note that ASD children have deficits at processing and recognizing fearful faces, but not angry faces (Deschamps et al. 2014; Rump et al. 2009; Humphreys et al. 2007; Ashwin et al. 2006). Finally, we acknowledge that additional experimentation using eye tracking technology may offer additional valuable information not only on the time course of the effects but also to determine whether the ASD children focused on emotionally relevant information or on distracting details in scenes (see Isomura et al. 2014).

To sum up, we found an attentional bias to emotional information in ASD children to threatening stimuli (scenes and faces) and not to other emotions (happy or sad): with the same participants, threatening social scenes produced an attentional bias towards these stimuli, whereas threatening facial expressions produced an attentional bias away from these stimuli. The avoidance response to threatening faces may reflect the difficulties in emotion regulation in ASD children, whereas the attentional bias toward threatening social scenes may reflect the focus on irrelevant details of social contexts. These attentional biases may hinder the chances to solve rapidly distressful problems in real social situations (Cunningham et al. 2008; Zercher et al. 2001). For this reason, it is important to consider these findings on attentional biases in therapeutic interventions that aim to help people with ASD in their social understanding and functioning. To minimize the biases with threatening stimuli, clinicians should design specific treatments that target threat desensitization and management to cope with real life threatening situations.

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Author Contributions AGB and MP conceived of the study, participated in its design, coordination, data collection, statistical analyses and supervised manuscript editing. JC, MAV, NY, IM, and MV contributed to conception of the study, recruitment of participants, and data interpretation. RS and FG conceived of the study, participated in data collection and drafted the manuscript. All authors read and approved the final manuscript.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent was obtained from all the parents of the participants included in the study.

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